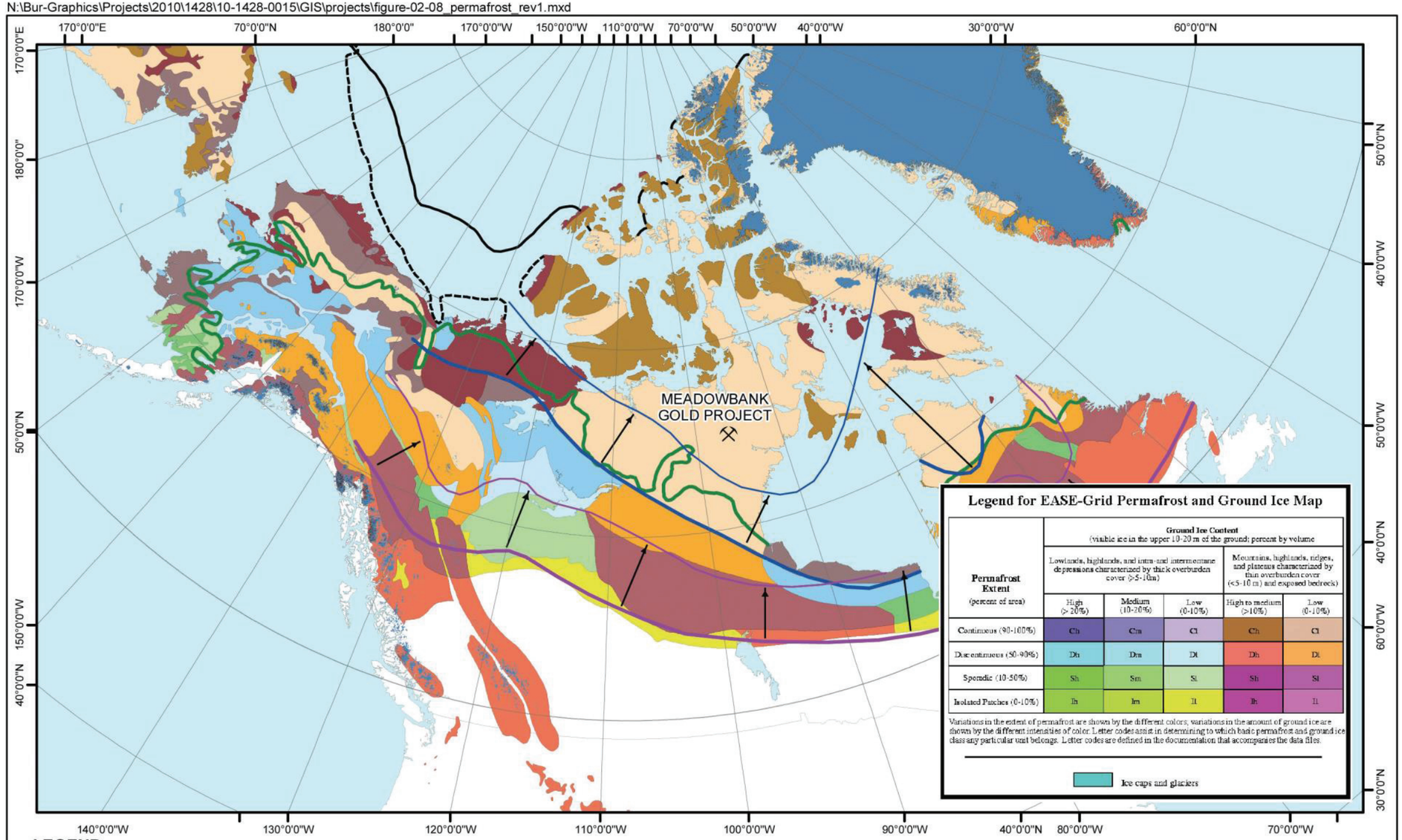
N:\Bur-Graphics\Projects\2010\1428\10-1428-0015\GIS\projects\figure-02-08_permafrost_rev1.mxd



LEGEND

- TREELINE
- SEA-ICE EDGE LIMIT
- SUBSEA PERMAFROST LIMIT
- SOUTHERN BOUNDARY OF DISCONTINUOUS PERMAFROST - PRESENT
- SOUTHERN BOUNDARY OF DISCONTINUOUS PERMAFROST - PREDICTED
- SOUTHERN BOUNDARY OF CONTINUOUS PERMAFROST - PRESENT
- SOUTHERN BOUNDARY OF CONTINUOUS PERMAFROST - PREDICTED
- PREDICTED MOVEMENT OF PERMAFROST BOUNDARIES

NOTES

1) PROJECTION: LAMBERT AZIMUTHAL EQUAL AREA

0 300 600 900 1,200 1,500

Scale in Kilometres

REFERENCES

1) CIRCUM-ARCTIC MAP OF PERMAFROST AND GROUND-ICE CONDITIONS. BOULDER, CO: NATIONAL SNOW AND ICE DATA CENTER/WORLD DATA CENTER FOR GLACIOLOGY. DIGITAL MEDIA. (BROWN ET AL. 1998)
2) PREDICTED PERMAFROST BOUNDARIES. (WOO ET AL. 1992)

AGNICO EAGLE MINES LIMITED

MEADOWBANK GOLD PROJECT
NUNAVUT

PERMAFROST MAP OF CANADA

Source: Cumberland 2005b

Appendix J

Meadowbank Geology, Seismic Zone, Groundwater Flow and Bathymetry

(Golder, 2014)

630000
635000
640000
645000
650000
7230000
7225000
7220000
7215000

PDF
VAULT
PORTAGE
GOOSE ISLAND
PIPEDREAM LAKE
FARSIDE LAKE
WALLY LAKE
THIRD PORTAGE LAKE
SECOND PORTAGE FAULT
BAY ZONE FAULT

N

LEGEND

Lake
Gold Deposit
Fault Line

ROCK TYPE

- Granite, Granodiorite
- Gabbro
- Quartzite, Conglomerate
- Quartz arenite, metasediments
- Ultramafic
- Foliated Diorite, Gabbro
- Intermediate to Felsic Volcaniclastics
- Iron Formation
- Felsic Volcanics
- Mafic Volcanics

REFERENCE

Data provided by Cumberland Resources Ltd.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 14

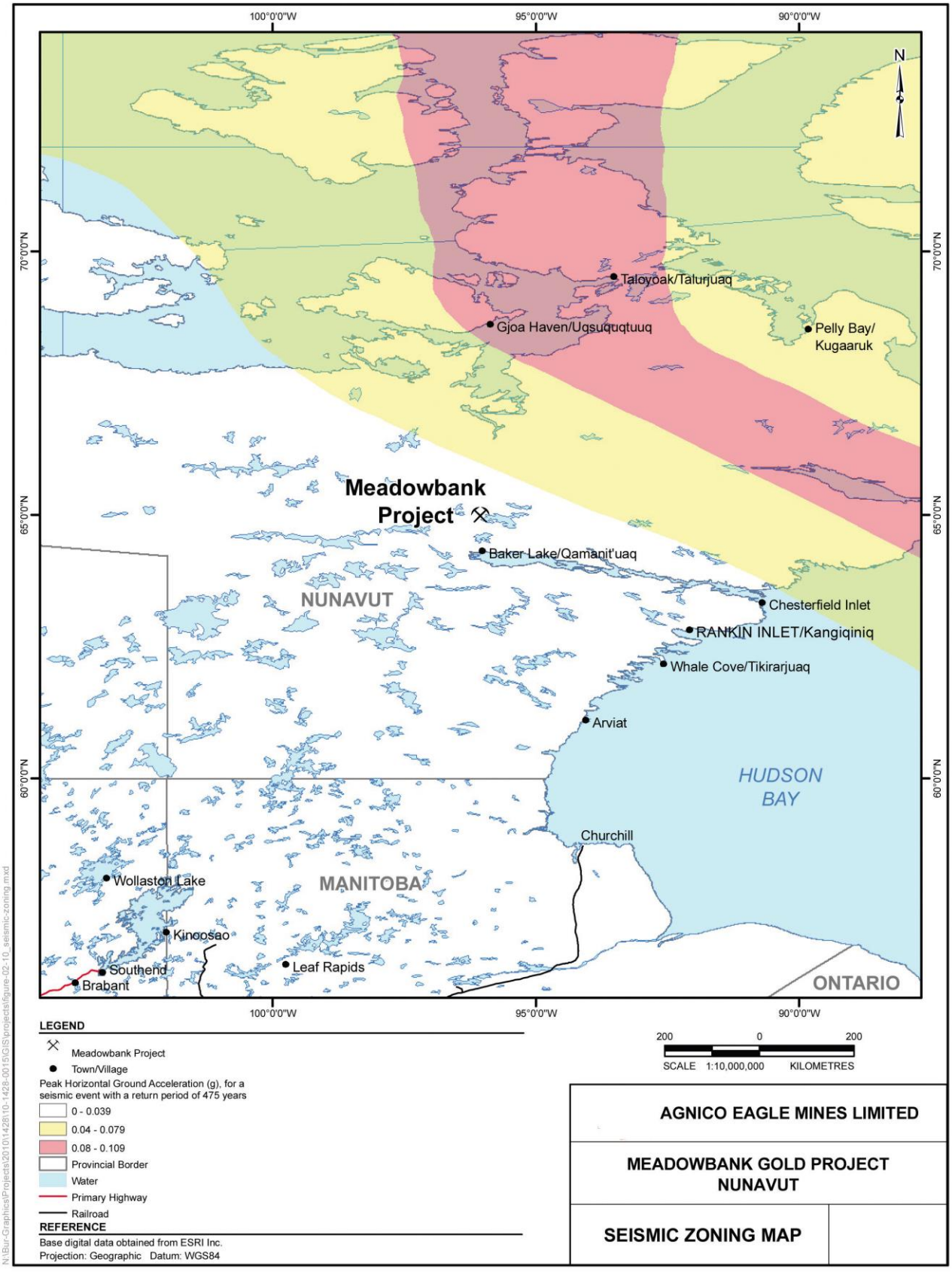
0 800 1,600 3,200
SCALE 1:80,000 METRE

AGNICO EAGLE MINES LIMITED

MEADOWBANK GOLD PROJECT
NUNAVUT

REGIONAL GEOLOGY

N:\Bur-Graphics\Projects\2010\1428\10-1428-0015\GIS\projects\figure-02-09_regional-geology.mxd



LEGEND

- Meadowbank Project
- Town/Village

Peak Horizontal Ground Acceleration (g), for a seismic event with a return period of 475 years

- 0 - 0.039
- 0.04 - 0.079
- 0.08 - 0.109
- Provincial Border
- Water
- Primary Highway
- Railroad

REFERENCE

Base digital data obtained from ESRI Inc.
Projection: Geographic Datum: WGS84

200 0 200
SCALE 1:10,000,000 KILOMETRES

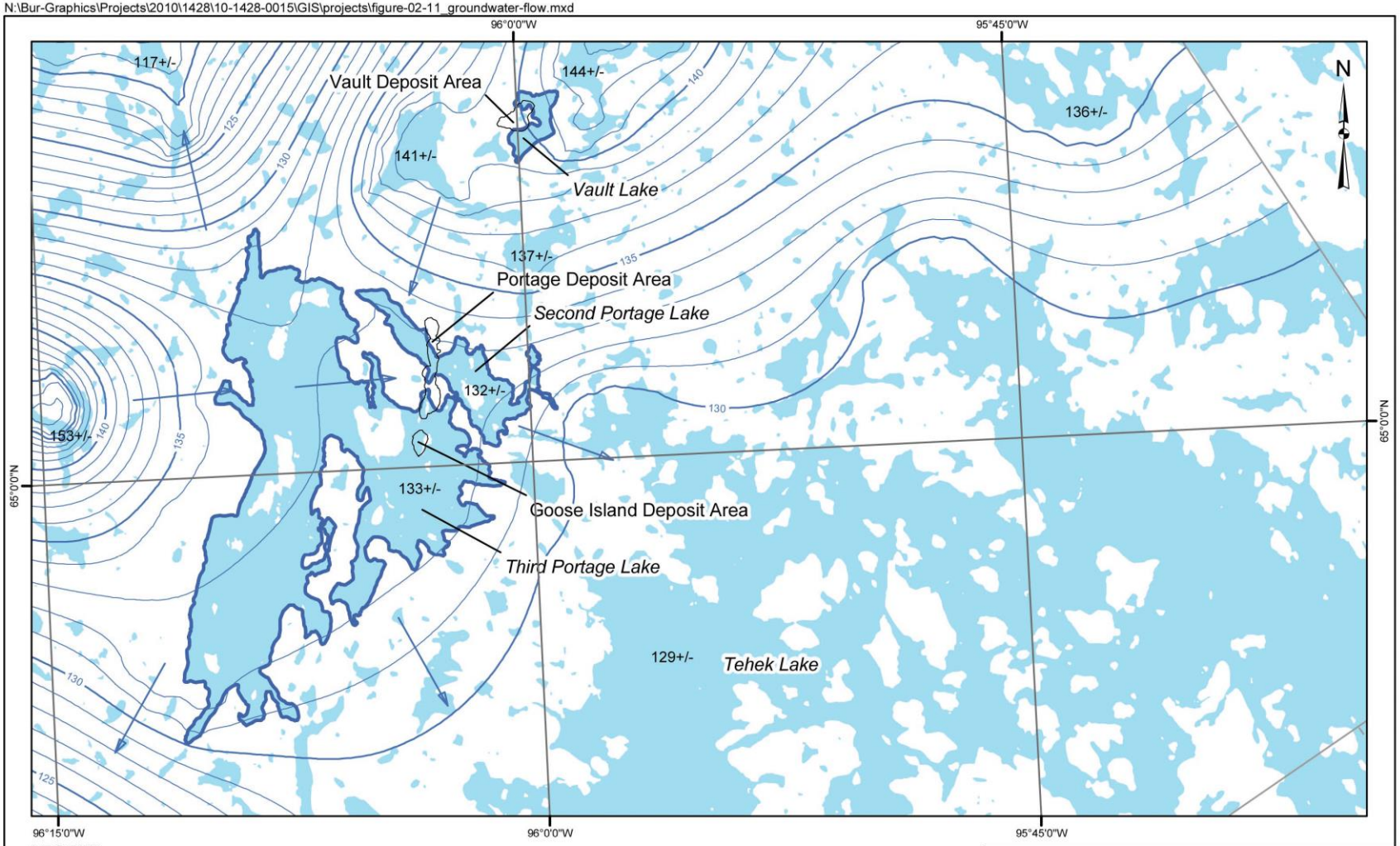
AGNICO EAGLE MINES LIMITED

MEADOWBANK GOLD PROJECT
NUNAVUT

SEISMIC ZONING MAP

N:\Bur-Graphics\Projects\2010\1428\10-1428-0015\GIS\projects\figure-02-10_seismic-zoning.mxd

N:\Bur-Graphics\Projects\2010\1428\10-1428-0015\GIS\projects\figure-02-11_groundwater-flow.mxd



LEGEND

- Proposed Open Pit Crest
- Inferred Groundwater Contour (1 m interval)
- Inferred Groundwater Contour (5 m interval)
- Inferred Groundwater Flow Line
- 133 Waterbody (elevation in masl)

REFERENCE

District of Keewatin, Northwest Territories, Department of Energy, Mines and Resources, Mapsheets 66A/16, 56E/04, 66H/01, 56D/13. Pit Footprint obtained from Golder Drawing 1.2. Datum: NAD83 Projection: UTM Zone 14

0 1,000 2,000 4,000 Meters

Scale - 1:125,000

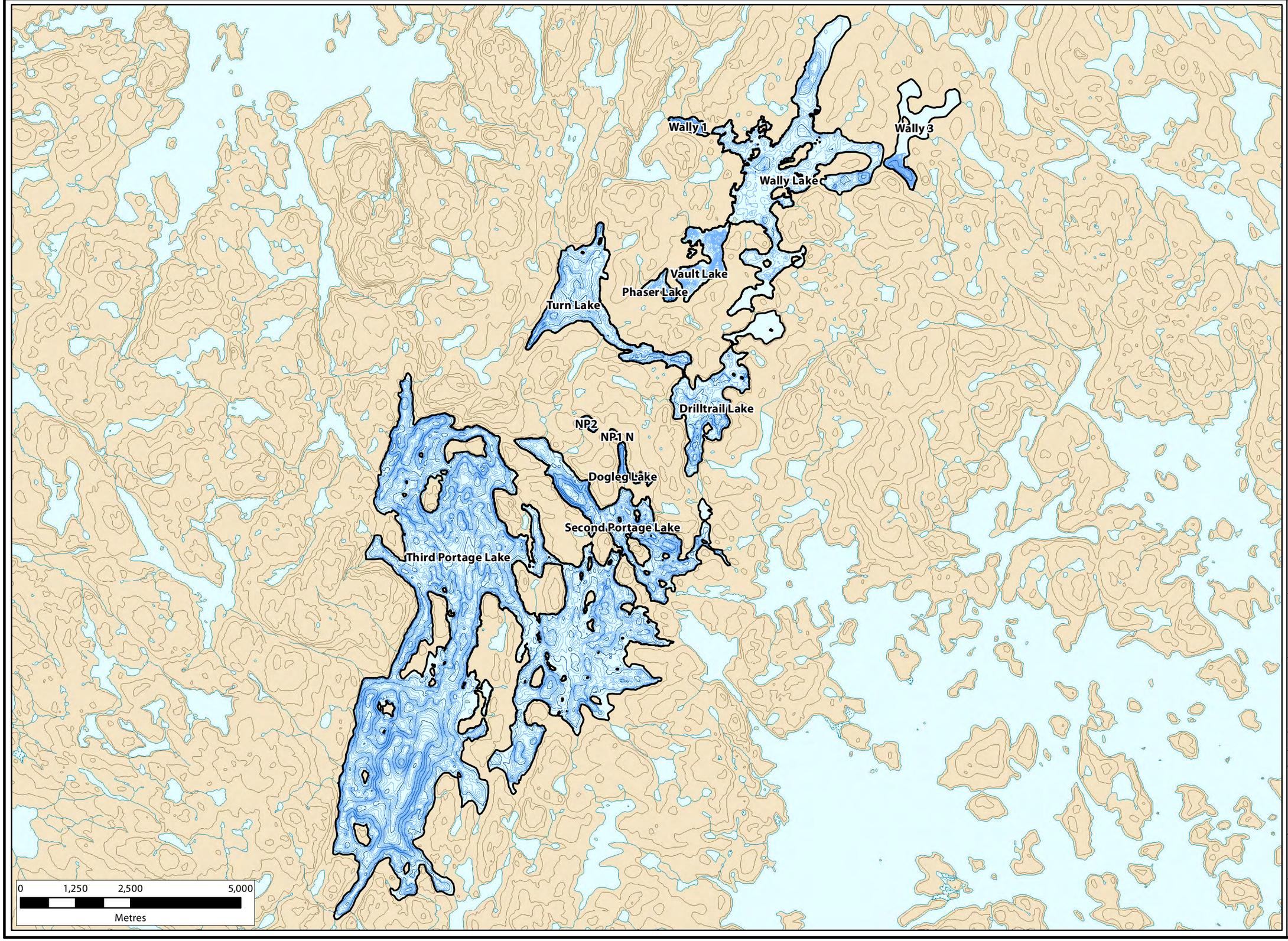
NOTE

Water levels vary annually and may differ from recently surveyed elevations.

AGNICO EAGLE MINES LIMITED

MEADOWBANK GOLD PROJECT
NUNAVUT

INFERRED REGIONAL GROUNDWATER FLOW



Legend

- Study Lakes
- Major Contour
- Minor Contour

Bathymetry Contours

DOUGAN & ASSOCIATES
ECOLOGICAL CONSULTING & DESIGN
77 Wyndham Street South • Guelph ON N1E 5R3
T 519.822.1609 • F 519.822.5389 • www.dougan.ca

PROJECT: DA11-062-02

CLIENT: Agnico-Eagle Mines Ltd., Meadowbank Div.

N / W / E / S

UTM Zone 14 NAD83

DATE: FEBRUARY 2011

SCALE: 1:80,000

DRAWN BY: LW

CHECKED BY:

FIGURE:

A1

The information displayed on this map has been compiled from various sources. While every effort has been made to accurately depict the information, this map should not be relied on as being a precise indicator of locations, features, or roads, nor as a guide to navigation. MNR data provided by Queen's Printer of Ontario. Use of the data in any derivative product does not constitute an endorsement by the MNR or the Ontario Government of such products.

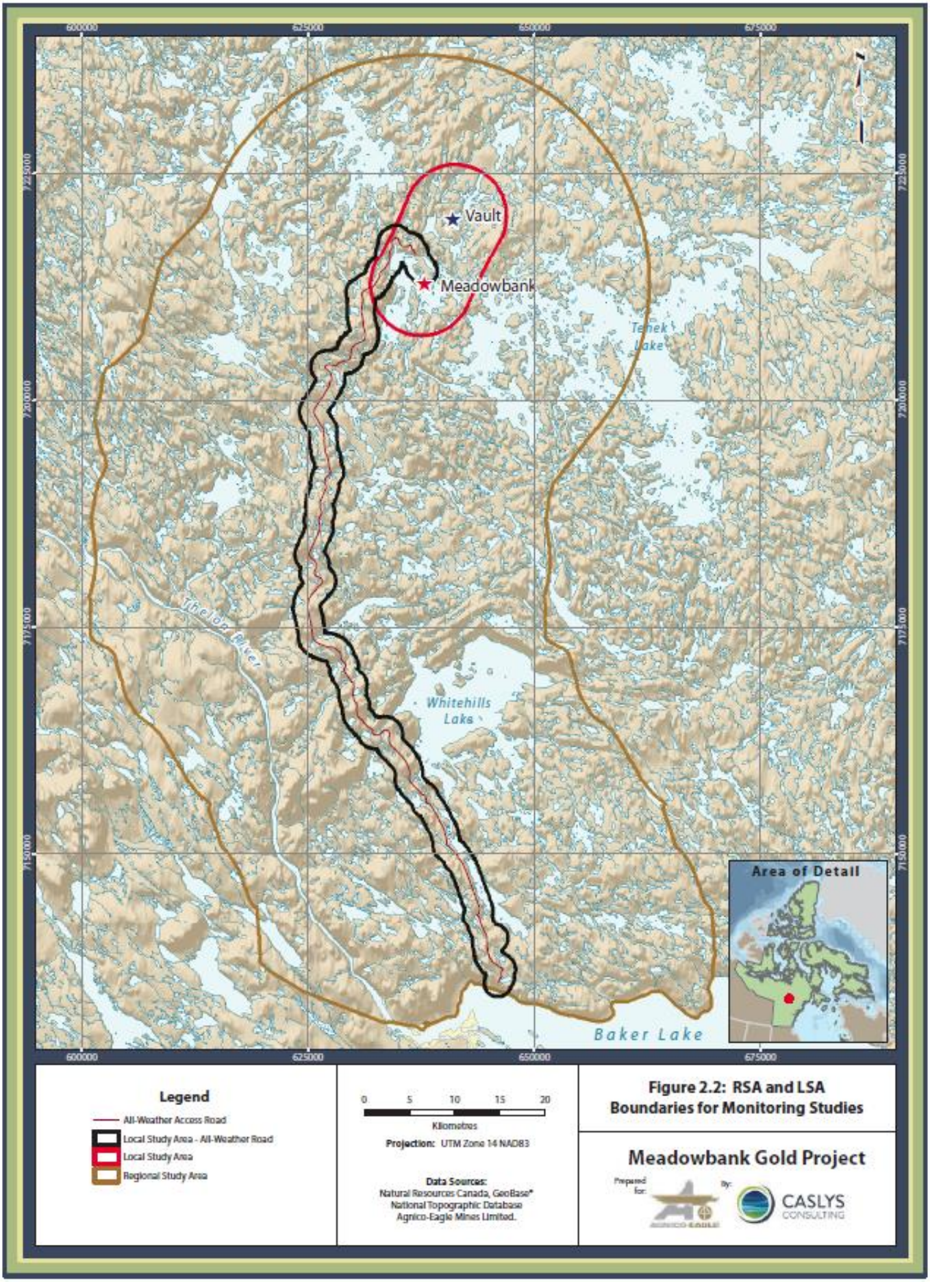
Appendix K

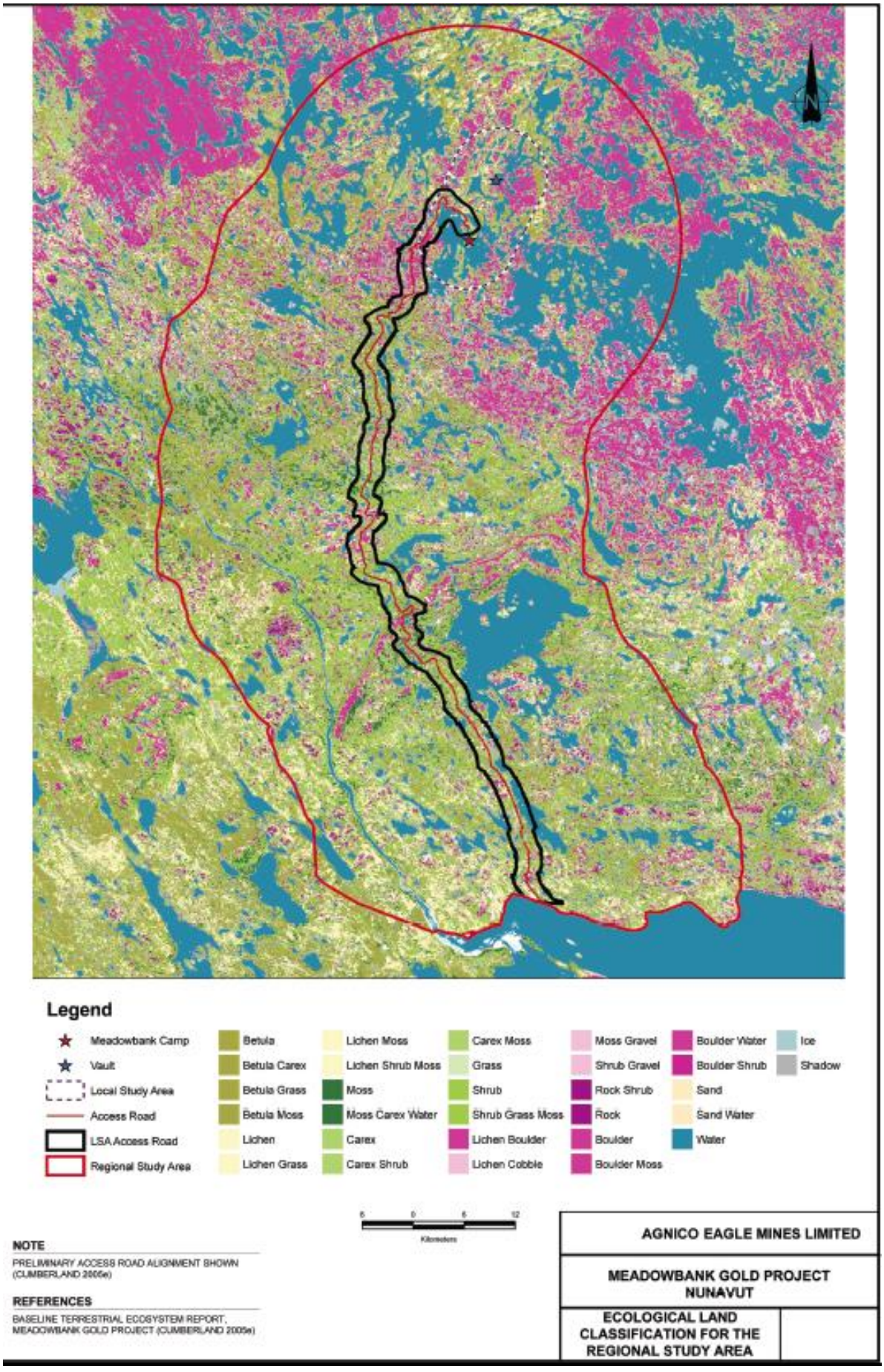
Water Balance

Stand per 31.12.2025

Appendix L

Ecological Land


600000
625000
650000
675000
7225000
7200000
7175000
7150000
Vault
Meadowbank
Tehek Lake
Thelon River
Whitehills Lake
Baker Lake
Area of Detail
Legend
All-Weather Access Road
Local Study Area - All-Weather Road
Local Study Area
Regional Study Area
0 5 10 15 20
Kilometres
Projection: UTM Zone 14 NAD83
Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Figure 2.2: RSA and LSA Boundaries for Monitoring Studies
Meadowbank Gold Project
Prepared for:
By:
CASLYS CONSULTING



Source : Cumberland, 2005e

Table L-1: Ecological Land Classification Unit Definition (Cumberland, 2005)

ECL Unit	Definition
Betula Community	The Betula (dwarf birch) community is associated with sites with near mesic regimes on a variety of slope positions; this unit is characterized by a moderate to high cover of dwarf birch.
Betula–Carex Community	The dwarf birch-sedge community is associated with sites with near mesic to hygric moisture regimes. It is found on flat (level) to gently sloping sites with hummocky or tussocky surfaces. Dwarf birch is a dominant species; a number of sedge species may be present in the troughs.
Betula–Grass Community	The dwarf birch-grass community is characterized by sites that have dwarf birch and grass (Hierochloe sp.) as dominant species.
Betula–Moss Community	The dwarf birch-moss community is also found on sites with near mesic moisture regimes often with a hummocky surface expression. These sites generally have a moderate cover of dwarf birch (>20%), however at least one other shrub is also dominant along with mosses.
Boulder	Exposed boulders have a very high reflectance value in imagery, and are very easy to identify. The variable size and shape of boulders add texture to the imagery that allows it to be distinguished from the bedrock association. Lichens are generally associated with the boulders.
Boulder–Moss	This unit is similar to the boulder unit in texture, however mosses are found in spaces between the boulders.
Boulder–Water	This unit is also similar to the boulder unit in texture, however standing (or flowing) water is found in interstitial spaces between the boulders. It is situated in depressions or adjacent to water bodies.
Boulder – Shrub Community	The boulder-shrub unit consists of boulder fields where the spaces between the clusters or individual boulders have become covered with mats of heath forming plants. Various shrubs (i.e., crowberry, bearberry, bilberry, dwarf birch) as well as lichens are present in the spaces.
Carex Community	Carex (sedge) communities generally occur in poorly drained areas and around water features. The vegetation composition and the high water content characteristics provide a unique spectral signature that is easily recognizable from other vegetation classes; however, this ELC unit can be highly confused with

	shallow water. These sites are generally dominated by sedges and/or cotton-grasses.
Carex –Shrub Community	Sedge-shrub communities generally occur in flat, poorly drained areas and around water features. Sedges are dominant along with willows.
Carex –Moss Community	Sedge-moss communities generally occur in flat, poorly drained areas and around water features. Sedges are dominant along with mosses.
Grass Community	The grass community is found on mesic sites. *Hierochloe alpina (*alpine holygrass) is the dominant plant species.
Lichen Community	The lichen community occurs on a variety of well-drained landforms on xeric to submesic sites. Lichens generally occupy over 60% of the ground surface.
Lichen–Boulder Community	The lichen-boulder community is found in boulder fields and on morainal deposits throughout the project area. The surface is rough and broken. Boulder cover varies form between 20 to 80%. Hair lichens can be common on the "tundra" between the boulders while crustose lichens are found on the boulder surfaces.
Lichen–Cobble Community	This unit is similar to the lichen-boulder community; however, the surface is not as rough. The cover of vascular plants is low in this unit.
Lichen–Grass Community	This ground cover in this community is dominated by a combination of lichens and grasses; alpine holygrass is generally common.

ECL Unit	Definition
Lichen–Moss Community	The lichen-moss community generally occurs on well-drained morainal material. The ground surface is covered by a variety of lichens and mosses; the cover of vascular plants is low.
Lichen–Shrub-Moss Community	This unit is found on morainal material on mesic sites. It is somewhat similar to the Shrub and Moss units. The lichen and moss layers each cover over 20% of the ground surface. The moderately developed shrub layer is dominated by Labrador tea with lesser amounts of lingonberry and cloudberry and a low cover of dwarf birch.
Moss –Carex - Water	This community is associated with level sites and depressions. It is often found on the edge of ponds and lakes.
Moss Community	The moss community occurs on a variety of landforms but most often on mesic sites on moraine. Mosses are a dominant ground cover; most sites have a moderate cover of ericaceous shrubs (no single species is a dominant) and low cover of dwarf birch, herbs, graminoids and lichens.
Moss -Gravel Community	The moss-gravel community occurs on well-drained sites. It is characterised by a high cover of exposed gravel on the soil surface and with moss cover over 20%.
Rock	Bedrock outcrops have a very high reflectance value in imagery, similar to boulders. The outcrops are generally in a linear orientation and make up a relatively small proportion of the total classified area. Lichens and a variety of low shrubs are generally associated with bedrock.
Rock – Shrub Community	The rock-shrub community occurs on areas of bedrock outcrop on upper and crest of slope positions. Bedrock cover is generally greater than 40%; *Empetrum nigricans* (crowberry) is usually a dominant although the cover of ericaceous shrubs also is greater than 20%.
Sand – Water	Beaches, sand banks and shallow water deltas are identified in the image. Sand has a very high reflectance value and is easily identified in the classification.
Shadow	Shadows in the image are generally from cloud cover and tend to black out the spectral signature of the land beneath it. Areas under shadows cannot be
Shrub Community	The shrub community is generally found on xeric to mesic sites on morainal parent material. Low shrubs are dominant in this unit; however, any one of several shrub species may be common on an individual site. These sites also have a low to moderate cover of forbs, graminoids, lichens, and mosses.
Shrub – Grass – Moss	This community is found on mesic sites. It is dominated by a combination of shrubs, graminoids, and mosses.
Shrub – Gravel Community	The shrub-gravel community is uncommon and is found on well drained, coarse textured soils. It is associated with eskers or gravelly, morainal ridges.
Water	Characterized by standing water. Deepwater areas are easily interpreted due to the spectral energy being absorbed by the water with very little reflectance. However, shallow water (2 m or less) can be confused with wetlands. In areas of shallow water, the bottom of the waterbody reflects the spectral energy. Shallow water is very closely related to the wetland community class (sedge community) because of the high water content, therefore, the separation of these classes can be highly confused.
Disturbed Sites	There is very little disturbed land in the area being classified. The class includes any urban area (Baker Lake) or camp settlements large enough to be detected in the imagery. Due to the characteristics of this class, it cannot be automatically classified; therefore, these areas were added manually. This class represents a very small proportion of the total classified area.
Ice	Ice has a very high reflectance value and is easily identified in the classification. There are a few areas with ice floating on waterbodies.
Unclassified	A very small percentage of cells within the imagery do not fall within a defined class. These cells have been grouped as unclassified.
Ridge Crest Community	This ELC unit is typically associated with eskers. Vegetation cover is often non-contiguous as the environment is dry and unstable. Two associations were mapped in the LSA (i.e., ridge crest community – sand association and ridge crest community – cobble association). The vegetation in this unit occurs in dense mats, which may include bog blueberry, lingonberry, crowberry, black bearberry, or prickly saxifrage. Moss campion, snow cinquefoil, grasses (e.g., purple reedgrass), and xeric woodrushes (e.g., confused woodrush) may be present. Lichens are sparse in this unit. The ridge crest community - cobble association is similar to the lichen-rock community – boulder association.

Appendix M

Baseline Water Quality Results

Table M-1 Average Baseline Water Quality in Third Portage, Second Portage and Wally (Golder, 2014)

Parameter	Units	Third Portage Lake (N=18)	Second Portage Lake (N=14)	Wally Lake (N=3)
Conventional parameters				
Hardness	mg/L	5.3	8.9	17.2
pH	pH units	6.8	7.5	7.3
Dissolved anions				
Total alkalinity	mg/L	4	7	13
Chloride	mg/L	0.5	0.6	0.7
Fluoride	mg/L	0.07	0.07	0.05
Sulphate	mg/L	1.3	2.8	5.3
Nutrients				
Ammonia nitrogen	mg/L	0.01	0.02	0.02
Total kjeldahl nitrogen	mg/L	0.09	0.08	0.11
Nitrate nitrogen	mg/L	0.004	0.007	0.024
Nitrite nitrogen	mg/L	0.001	0.001	0.001
Total phosphate	mg/L	0.002	0.003	0.003
Total phosphorus	mg/L	0.002	0.003	0.003
Organic parameters				
Dissolved organic carbon	mg/L	1.4	1.7	2.2
Cyanides				
Total cyanide	mg/L	<0.005	<0.005	<0.005
Total metals				
Aluminum	mg/L	0.006	0.007	0.008
Antimony	mg/L	<0.0005	<0.0005	<0.0005
Arsenic	mg/L	<0.0005	<0.0005	<0.0005
Barium	mg/L	<0.02	<0.02	<0.02
Beryllium	mg/L	<0.001	<0.001	<0.001
Boron	mg/L	0.1		0.1
Cadmium	mg/L	<0.00005	<0.00005	<0.00005
Calcium	mg/L	1.2	2.3	4.6
Chromium	mg/L	<0.001	<0.001	<0.001
Cobalt	mg/L	<0.0003	<0.0003	<0.0003
Copper	mg/L	0.001	0.001	0.002
Iron	mg/L	<0.03	<0.03	<0.03
Lead	mg/L	0.0006	0.0009	0.0007
Lithium	mg/L	<0.005	<0.005	<0.005
Magnesium	mg/L	0.5	0.8	1.3
Manganese	mg/L	0.001	0.0016	0.0013
Mercury	mg/L	<0.00005	<0.00005	<0.00005

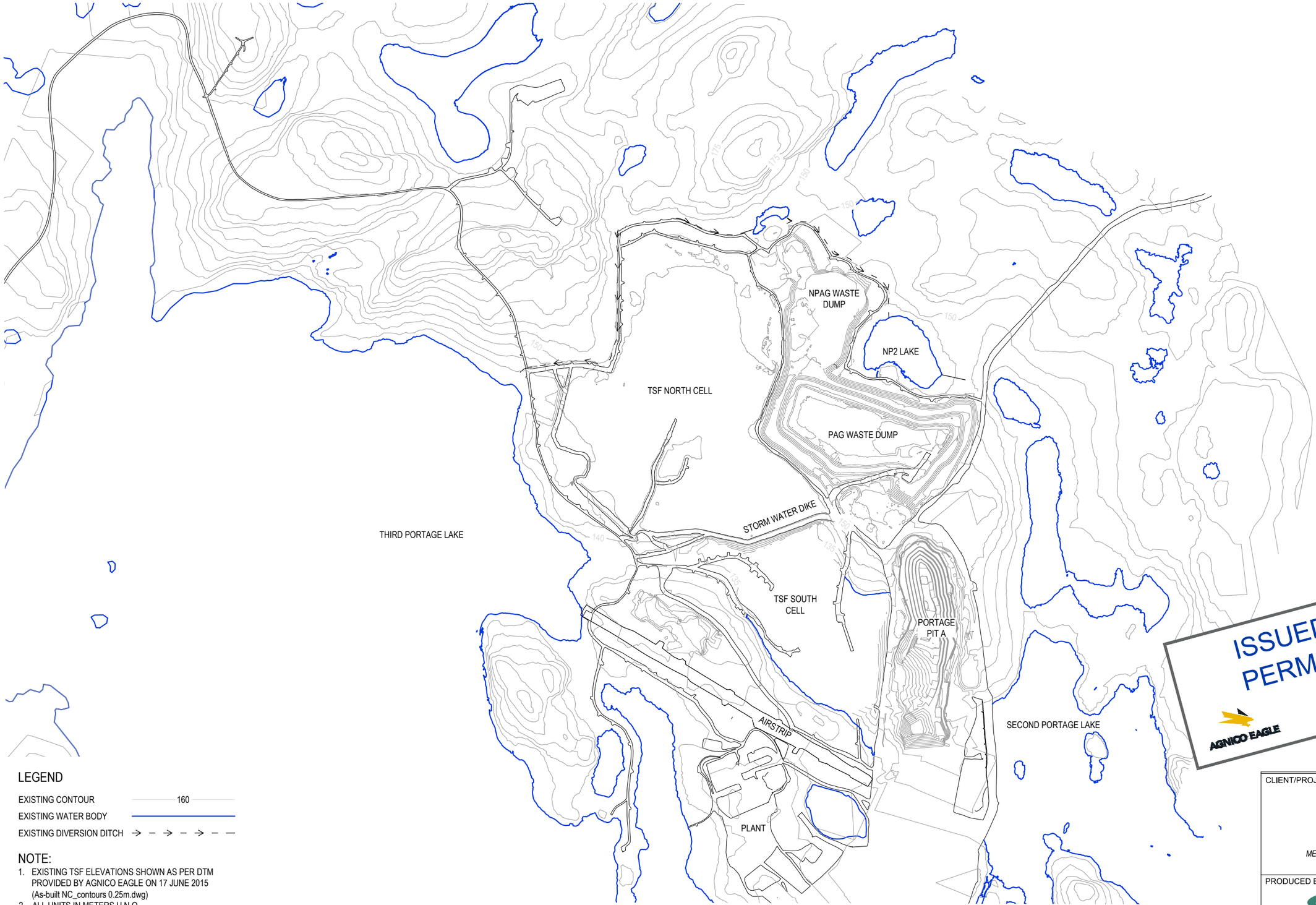
Table M-1 Average Baseline Water Quality in Third Portage, Second Portage and Wally (Golder, 2014), continued

Parameter	Units	Third Portage Lake (N=18)	Second Portage Lake (N=14)	Wally Lake (N=3)
Molybdenum	mg/L	<0.001	<0.001	<0.001
Nickel	mg/L	<0.001	<0.001	<0.001
Potassium	mg/L	2	2	2
Selenium	mg/L	<0.001	<0.001	<0.001
Silver	mg/L	<0.00002	<0.00002	<0.00002
Sodium	mg/L	2	2	2
Thallium	mg/L	<0.0002	<0.0002	<0.0002
Tin	mg/L	<0.0006	<0.0005	<0.0005
Titanium	mg/L	<0.01	<0.01	<0.01
Uranium	mg/L	<0.0002	<0.0002	<0.0002
Vanadium	mg/L	<0.03	<0.03	<0.03
Zinc	mg/L	0.005	0.005	0.013

Note: N = number of samples used to calculate average values.

Appendix N

Internal Structures



EXISTING FEATURES PLAN
1:20,000

200 100 0 200 400 600 800 1000m
SCALE 1:20000

LEGEND

EXISTING CONTOUR 160
EXISTING WATER BODY
EXISTING DIVERSION DITCH

NOTE:

1. EXISTING TSF ELEVATIONS SHOWN AS PER DTM PROVIDED BY AGNICO EAGLE ON 17 JUNE 2015 (As-built NC_contours 0.25m.dwg)
2. ALL UNITS IN METERS U.N.O.
3. DO NOT SCALE.

ISSUED FOR PERMITTING
AGNICO EAGLE
DATE : 2016-04-27

CLIENT/PROJECT:
AGNICO EAGLE
MEADOWBANK TAILINGS STORAGE FACILITY
NORTH CELL EXPANSION

PRODUCED BY:
O'Kane Consultants Inc.
Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

EXISTING FEATURES PLAN

DRG NUM: 948/2-001 Rev: B

REFERENCE

DWG. NO.	DESCRIPTION

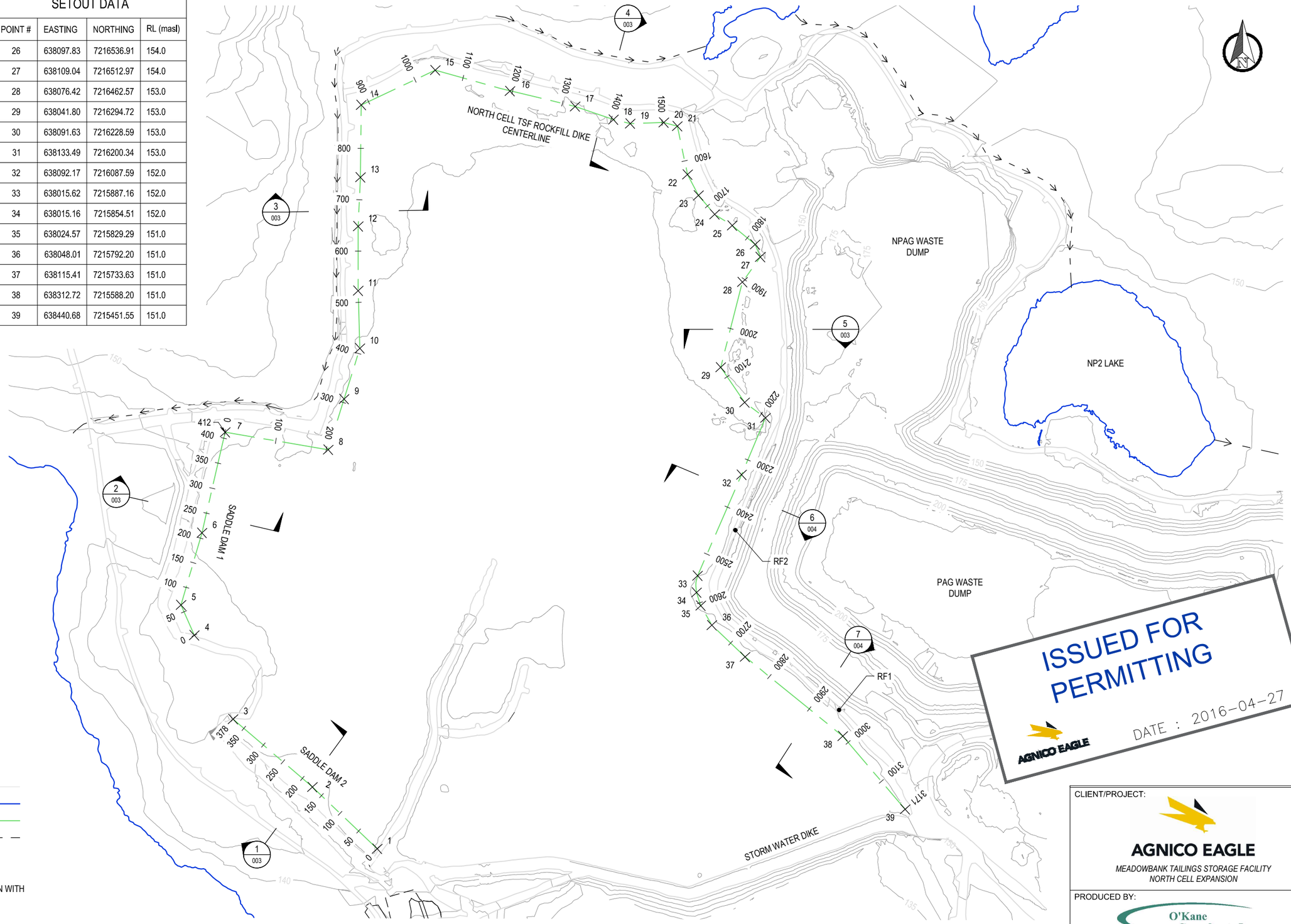
REVISIONS

NO.	DESCRIPTION	DRN. BY:	DATE
A	ISSUED FOR CLIENT REVIEW.	HSC	01.15.16
B	ISSUED FOR PERMITTING.	HSC	04.27.16

REVD. BY:	P. GARNEAU	DATE:	01.15.16
APPD. BY:	M. O'KANE	DATE:	01.15.16
SCALE:	AS SHOWN	REPORT NUM:	948/2-01

SETOUT DATA			
POINT #	EASTING	NORTHING	RL (masl)
1	637416.88	7215327.07	152.0
2	637285.24	7215441.23	152.0
3	637124.73	7215566.12	152.0
4	637041.67	7215725.89	152.0
5	637013.09	7215783.62	152.0
6	637047.26	7215925.78	152.0
7	637083.42	7216123.70	154.0
8	637285.47	7216098.99	154.0
9	637311.70	7216199.01	154.0
10	637337.93	7216299.03	154.0
11	637329.40	7216411.02	154.0
12	637323.60	7216536.35	154.0
13	637323.60	7216631.99	154.0
14	637318.58	7216772.60	154.0
15	637459.53	7216847.10	154.0
16	637606.79	7216813.15	154.0
17	637735.01	7216789.14	154.0
18	637810.73	7216767.03	154.0
19	637843.73	7216760.82	154.0
20	637908.97	7216765.86	154.0
21	637935.76	7216760.04	154.0
22	637959.84	7216666.92	154.0
23	637983.08	7216627.25	154.0
24	638016.31	7216591.73	154.0
25	638051.47	7216571.66	154.0

SETOUT DATA			
POINT #	EASTING	NORTHING	RL (masl)
26	638097.83	7216536.91	154.0
27	638109.04	7216512.97	154.0
28	638076.42	7216462.57	153.0
29	638041.80	7216294.72	153.0
30	638091.63	7216228.59	153.0
31	638133.49	7216200.34	153.0
32	638092.17	7216087.59	152.0
33	638015.62	7215887.16	152.0
34	638015.16	7215854.51	152.0
35	638024.57	7215829.29	151.0
36	638048.01	7215792.20	151.0
37	638115.41	7215733.63	151.0
38	638312.72	7215588.20	151.0
39	638440.68	7215451.55	151.0



ISSUED FOR PERMITTING

DATE : 2016-04-27

AGNICO EAGLE

LEGEND

- EXISTING CONTOUR 160
- EXISTING WATER BODY
- ROCK FILL DIKE CENTERLINE
- EXISTING DIVERSION DITCH
- SETOUT POINT LOCATION

NOTE:

1. THIS DRAWINGS IS TO BE READ IN CONJUNCTION WITH OKC REPORT No. 948/2-01 DATED DEC 2015.
2. EXISTING TSF ELEVATIONS SHOWN AS PER DTM PROVIDED BY AGNICO EAGLE ON 17 JUNE 2015 (As-built NC_contours 0.25m.dwg)
3. ALL UNITS IN METERS U.N.O.
4. DO NOT SCALE.

GENERAL ARRANGEMENT PLAN
1:7,500

0 75 150 225 300 375 450 525 600m
SCALE 1:7500

CLIENT/PROJECT:
AGNICO EAGLE
MEADOWBANK TAILINGS STORAGE FACILITY
NORTH CELL EXPANSION

PRODUCED BY:
O'Kane Consultants Inc.
Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

ROCKFILL DIKE ALIGNMENT LAYOUT PLAN

DRG NUM: 948/2-002 Rev: B

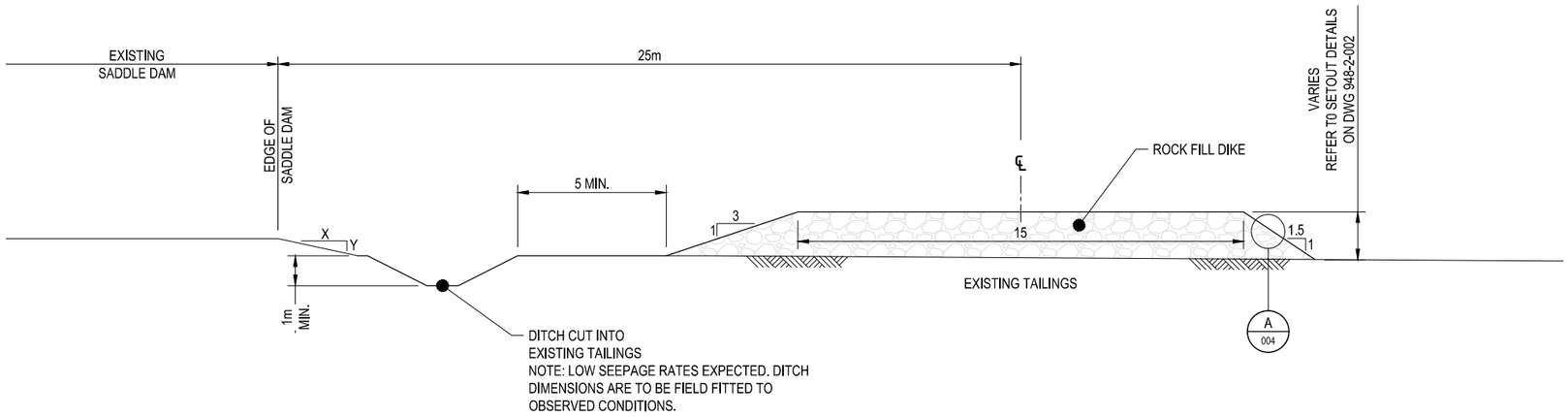
REVD. BY: P. GARNEAU DATE: 01.15.16
APPD. BY: M. O'KANE DATE: 01.15.16
SCALE: AS SHOWN REPORT NUM: 948/2-01

REFERENCE

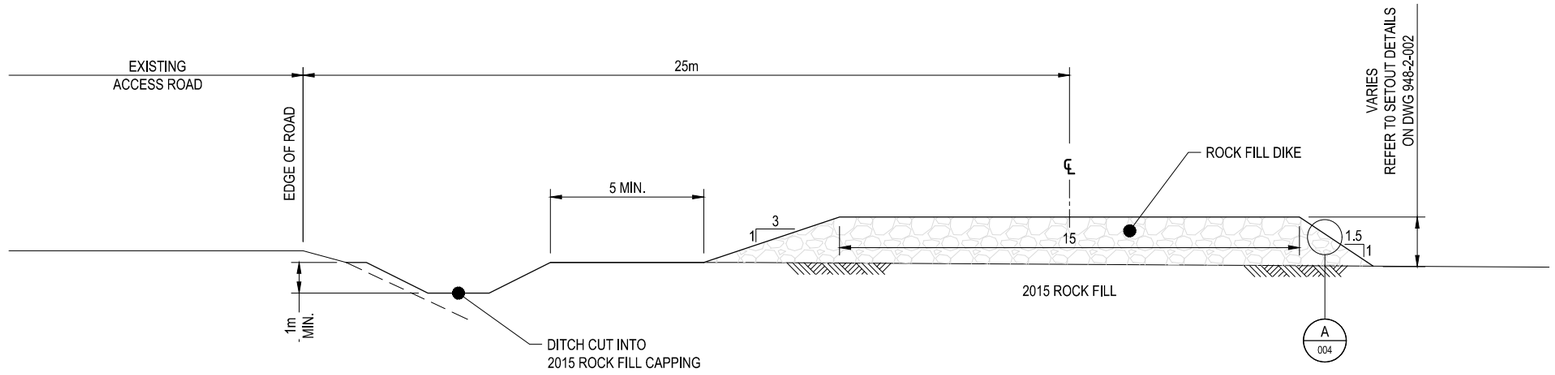
DWG. NO.	DESCRIPTION

REVISIONS

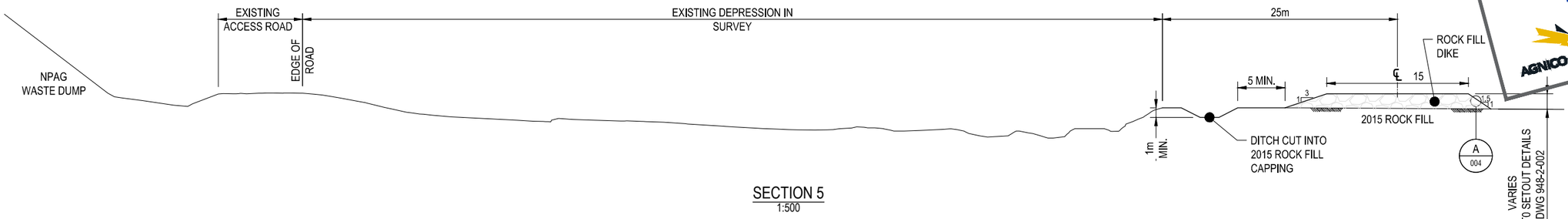
NO.	DESCRIPTION	DRN. BY:	DATE
A	ISSUED FOR CLIENT REVIEW.	HSC	01.15.16
B	ISSUED FOR PERMITTING.	HSC	04.27.16



SECTION 1 & 2
1:200



SECTION 3 & 4
1:200



SECTION 5
1:500

ISSUED FOR PERMITTING
AGNICO EAGLE
DATE : 2016-04-27

NOTE:
1. THIS DRAWINGS IS TO BE READ IN CONJUNCTION WITH OKC REPORT No. 948/2-01 DATED DEC 2015.
2. ALL UNITS IN METERS U.N.O.
3. DO NOT SCALE.

REFERENCE	DWG. NO.	DESCRIPTION

REVISIONS	NO.	DESCRIPTION	DRN. BY:	DATE
	A	ISSUED FOR CLIENT REVIEW.	HSC	01.15.16
	B	ISSUED FOR PERMITTING.	HSC	04.27.16

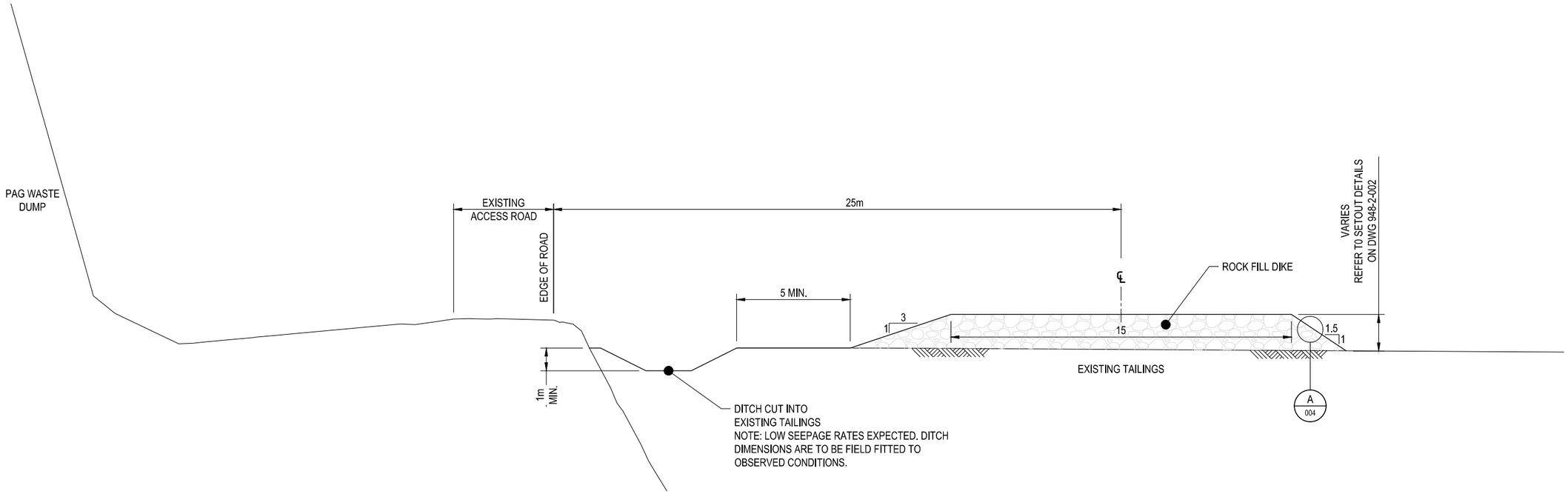
REVD. BY:	P. GARNEAU	DATE:	01.15.16
APPD. BY:	M. O'KANE	DATE:	01.15.16
SCALE:	AS SHOWN	REPORT NUM:	948/2-01

CLIENT/PROJECT:
AGNICO EAGLE
MEADOWBANK TAILINGS STORAGE FACILITY
NORTH CELL EXPANSION

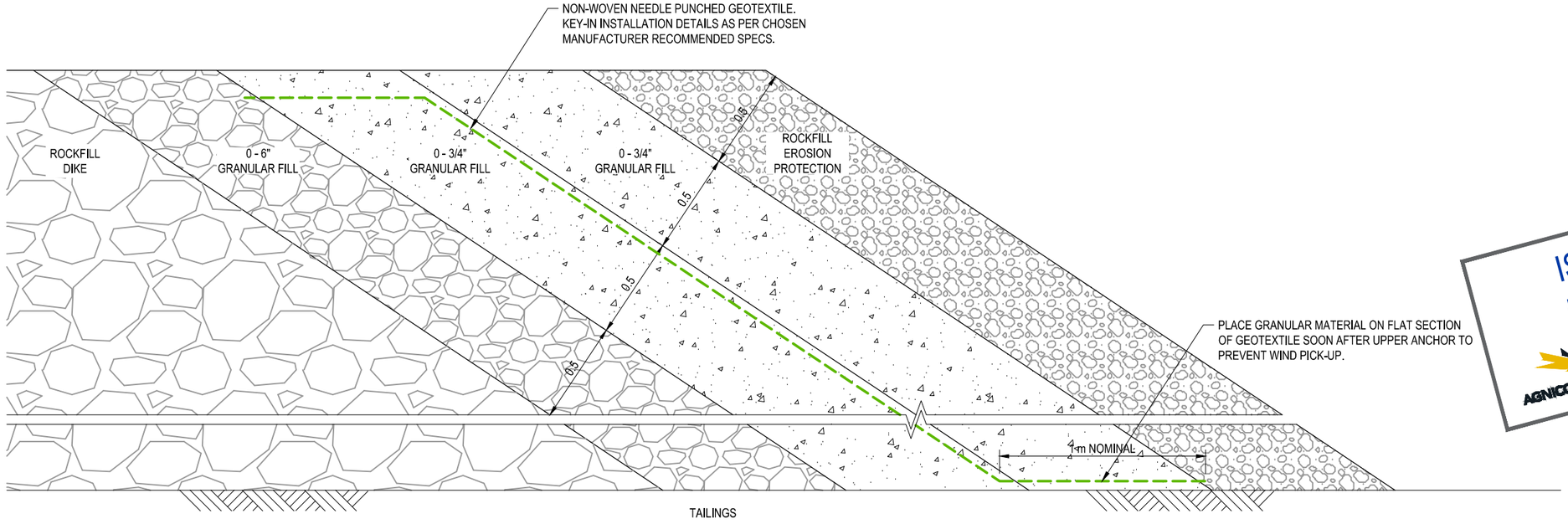
PRODUCED BY:
O'Kane Consultants Inc.
Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

ROCKFILL DIKE
SECTIONS 1-5

DRG NUM: 948/2-003 | Rev: B



SECTION 6 & 7
1:200



DETAIL A
1:20

ISSUED FOR PERMITTING
AGNICO EAGLE
DATE : 2016-04-27

NOTE:
1. THIS DRAWINGS IS TO BE READ IN CONJUNCTION WITH OKC REPORT No. 948/2-01 DATED DEC 2015.
2. ALL UNITS IN METERS U.N.O.
3. DO NOT SCALE.

REFERENCE	DWG. NO.	DESCRIPTION

REVISIONS	NO.	DESCRIPTION	DRN. BY:	DATE
	A	ISSUED FOR CLIENT REVIEW.	HSC	01.15.16
	B	ISSUED FOR PERMITTING.	HSC	04.27.16

REVD. BY:	P. GARNEAU	DATE:	01.15.16
APPD. BY:	M. O'KANE	DATE:	01.15.16
SCALE:	AS SHOWN	REPORT NUM:	948/2-01

CLIENT/PROJECT:
AGNICO EAGLE
MEADOWBANK TAILINGS STORAGE FACILITY
NORTH CELL EXPANSION

PRODUCED BY:
O'Kane Consultants Inc.
Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology

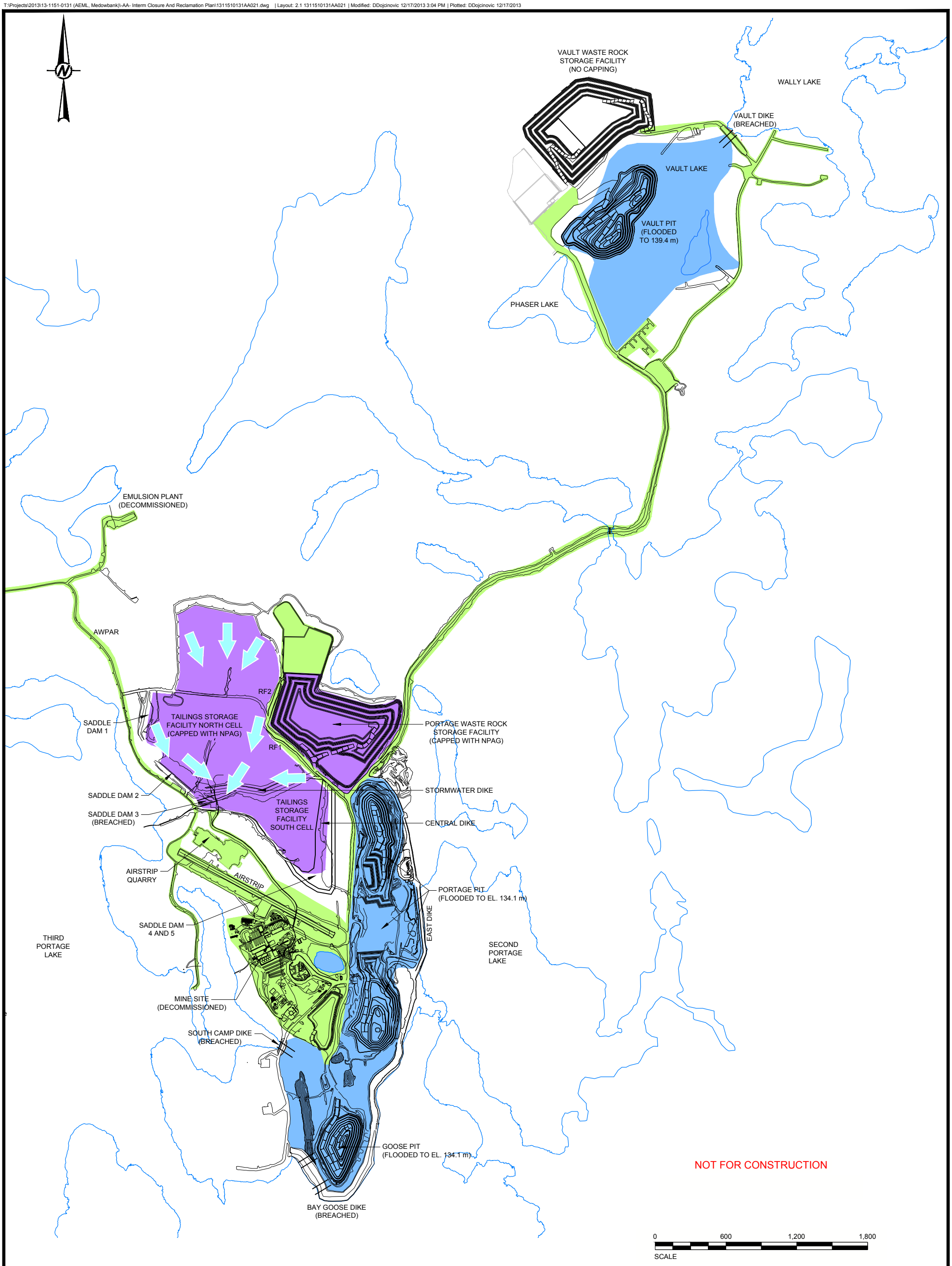
ROCKFILL DIKE
SECTIONS 6-7 & DETAIL A

DRG NUM: 948/2-004 Rev: B

Appendix O

Post Closure General Site Layout

(Golder, 2014)



REFERENCE

- NPAG COVER
- REHABILITATED DISTURBED AREA
- PIT LAKES/POND
- BREACHED DIKES/DAMS
- DIRECTION OF SURFACE RUNOFF FLOW

NOTES

1. BASE PLAN PROVIDED IN DIGITAL FORMAT BY AGNICO EAGLE MINES LTD., FILE NO. PORTAGE_GOOSE_VAULT_END2018_LOM2013_V4D-WITH LABEL.DWG, RECEIVED OCTOBER 7, 2013.

PROJECT

AGNICO EAGLE MINES LTD.
MEADOWBANK GOLD PROJECT
INTERIM CLOSURE AND RECLAMATION PLAN

TITLE

GENERAL MINE LAYOUT POST - CLOSURE

Golder Associates

PROJECT No.		13-1151-0131	FILE No.		1311510131AA021
DESIGN			SCALE		AS SHOWN
CADD	DD	2013-12-17	FIGURE		2.1
CHECK	BR	2013-12-17			
REVIEW	RG	2013-12-17			

Appendix P

Closure Integrated Schedule

Meadowbank - Closure and Post-Closure Schedule

Main Project Facilities	Operations/Closure Main Phases	2017	2018 Q1/Q2/Q3	2018 Q4	2019 - Q1/Q2	2019 Q3/Q4	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
		Operations at MBK		Transition Period		Operations at WT (ore processing at Meadowbank)			Demolition								Dike Reconnection	AWAR Closure										
		Progressive Closure							Active Closure/Closure Monitoring									Post-Closure Monitoring										
Open Pits	Goose - Pit Flooding					Flooding																						
	Portage - Pit Flooding						Flooding																					
	Portage - Pit Flooding Reclaim Water Transfer								Reclaim Transfer																			
	Vault - Pit Flooding					Flooding																						
	Phaser/BB Phaser- Pit Flooding					Flooding (natural)																						
	Water Treatment Plan (if required)								Water Treatment																			
Dikes and Dams	Dike and Dam Reconnection (Baygoose, South Camp, Vault, SD3)																Reconnection											
RSF	Portage RSF Operations	RSF Operation																										
	Portage RSF- NPAG Cover	Cover Construction										Cover Construction																
	NPAG RSFs - Waste rock reclaim for closure			NPAG Reclaim					NPAG Reclaim																			
TSF	North Cell - Tailings Deposition					Deposition																						
	North Cell - NPAG cover	Cover Construction							Cover Construction																			
	South Cell - Tailings Deposition	Deposition																										
	South Cell - NPAG cover								Cover Construction																			
Water Management	Mine Site Water Management in Closure - TSF and Open Pits								Water Management																			
	Water Management Facilities Closure				Closure of Unused Facilities																							
Waste Management Facilities	Demolition Landfill Operation								Waste Deposition																			
	Closure Landfill - NPAG Cover and Closure											Cover Construction																
	Landfarm Operation								Contaminated Soil Treatment																			
	Closure Landfill - NPAG Cover and Closure											Cover Construction																
	Hazmat Management - Closure								Hazmat Management for Closure																			
	Surface Infrastructures Demolition - Mill, Power Plant, Services Building								Demolition																			
Meadowbank Infrastructures	Accommodations								Demolition																			
	Equipment Demobilization								Demobilization or Landfilled								Demob.											
	Fuel tanks and others facilities								Demolition																			
	Site roads and Vault Road									Road Closure																		
	Airstrip																Closure											
Baker Lake Facilities	Surface Infrastructures Demolition - Marshalling area and fuel tanks								Closure of Unused Facilities																			
AWAR	AWAR, Roads, Quarries and Pads Dismantling																	AWAR closure										
Monitoring	Closure Active Monitoring								Active Closure/Closure Monitoring																			
	Post-closure Monitoring																	Post-Closure Monitoring										

Notes:
1. It is anticipated that the schedule will be refined throughout the Project life as the designs for closure are advanced and the closure methods and strategies are further developed. The schedule is subjected to changes following mine plans and development as well as market conditions.
2. Only the main closure activities are presented in this schedule.
3. Water treatment if required will be for the reclaim water prior to transfer in the pit.
4. Pit flooding includes natural pit flooding (runoff, groundwater inflow and seepage) and active flooding (pumping water from adjacent lake).
5. Water management is required in operations; this schedule only presents the water management related to closure activities.
6. Waste management is required in operations; this schedule only presents the water management related to closure activities.
7. Baker Lake facilities will be decommissioned as required in active closure and closure.
8, Whale Tail operations expected from Q3 2019 to January 2022.

Appendix Q

Financial Security Cost Estimate Assumptions and RECLAIM Spreadsheets

SNC-LAVALIN INC.

5500 des Galeries Blvd., Suite 200
Quebec (Qc)
Canada G2K 2E2
Tel: (418) 621-5500
Fax: (418) 621-8887

Memorandum

Certifiée ISO 9001

TO:	Mrs. Nancy Duquet-Harvey Agnico Eagle Mines Ltd.	**DATE:**	June 29, 2018
C.C.:	Dominic Tremblay, SNC Lavalin		
FROM:	Erika Voyer, Philipe Lemieux, Alain Lebel SNC Lavalin	**REF.:**	654769-5000-4EER-0001_00
SUBJECT:	Meadowbank ICRP 2018 Appendix Q – Financial Security Cost Estimate Assumptions		

1.0 INTRODUCTION

Agnico Eagle Mines Ltd. (Agnico Eagle) Meadowbank gold open pit mine (Meadowbank, or the Project) currently in operation, located 70 km north of Baker Lake, Nunavut, achieved commercial production in March 2010. The mine plan at Meadowbank mine is expected to extend the production into January 2022, with the processing and tailings deposition of ore coming from Whale Tail Pit.

Agnico Eagle is required to submit a detailed financial security cost estimate for the Meadowbank Gold Project Interim Closure and Reclamation Plan (ICRP) to Indigenous and Northern Affairs Canada (INAC) and to the Kivallik Inuit Association (KIA) to support land use and water licensing requirements. RECLAIM 7.0 workbook has been used for this estimate, as per the Guidelines for Closure and Reclamation Cost Estimates for Mines, issued by Indigenous and Northern Affairs Canada, Mackenzie Valley Land and Water Board and the Government of the Northwest Territories (INAC, MVLWB, GNWT, 2017).

As the Whale Tail project is going through the permitting process, it is understood that all operations components of Whale Tail Pit and Amaruq Exploration/Hauling Road are included specifically in the Whale Tail Interim Closure and Reclamation Plan (Golder, 2016). Only the activities covered under the Meadowbank Type A Water License 2 AM-MEA1525 are included in the updated Meadowbank Interim Closure and Reclamation Plan (ICRP)—Update 2018 and in the herein financial security cost estimate.

2.0 CLOSURE MEASURES AND CONSIDERATIONS

The cost estimate presented in this memo covers the closure and reclamation of all facilities currently identified within the Meadowbank Project property including the following:

- Open pits;
- Tailings Storage Facilities (TSF);
- Rock Storage Facilities (RSF);
- Support facilities on the property including accommodations, process plant (mill), power plant, bulk fuel storage facility, service building, contractor facilities, warehouses and cold storage, assay Lab, emulsions plant, incinerators, airstrip, borrow areas, on-site roads and laydown areas;
- The Baker Lake Site Facilities and All Weather Access Road (AWAR).

The present updated Meadowbank ICRP and cost estimate are based on the current Life of Mine (LOM) of Meadowbank, including the mining activities planned at the Meadowbank site, as well as the activities related to

ore processing and tailings deposition. The additional ore from Whale Tail Pit processed and its tailings deposited at Meadowbank are also considered in the update of the Meadowbank ICRP 2018.

This cost estimate provides for the closure measures described in detail in the Meadowbank ICRP-Update 2018. Most closure activities will occur within the active closure period, from 2022 to 2024. The schedule of closure activities presented in Appendix Q of the Meadowbank ICRP-Update 2018 outlines the major closure measures and their expected timeline.

For the purpose of this financial security cost estimate, only progressive rehabilitation measures which have already been completed to date are considered in the calculations.

3.0 COST ESTIMATE

3.1 Model

RECLAIM is a model developed in Microsoft Excel used to calculate the estimation of reclamation costs for mine sites in Northern Canada. It provides line items for each reclamation activity which might be required at a given site. For each, the model presents the "quantity" of work multiplied by the appropriate "Unit Cost" provided in the model.

RECLAIM version 7.0 consists of eleven (11) reclamation costing worksheets used to compute the overall closure cost estimate. These include direct costs associated with the following mine components:

- Open pit;
- Underground mine;
- Tailings impoundment;
- Rock pile;
- Buildings and equipment;
- Chemicals, hazardous materials and contaminated soils;
- Water treatment;
- Water management;
- Interim care and maintenance.

It also includes the following indirect costs:

- Post-closure monitoring and maintenance;
- Mobilization and demobilization.

Additional cost factors such as contingency, engineering, project management, health and safety/QA-QC/engagement and bonding are automatically calculated in the cost summary worksheet, with percentages applied to the total direct cost.

3.2 Summary of Costs

The updated 2018 estimated closure and reclamation costs for the Meadowbank Project using RECLAIM Version 7.0 represents a total of $83,569,898. This total includes $57,883,238 of direct costs and $25,686,660 of indirect costs. The costs are summarized in Table 1 presented below.

SNC·LAVALIN

Table 1 Summary Financial Security Cost Estimate

Cost Item	Subtotal (Land and Water Liability)
Direct Costs	
Open pit	$6,480
Portage	*$3,240*
Goose	*$1,080*
Vault	*$1,080*
Phaser	*$1,080*
Underground Mine	$0
Tailings Facility	$34,873,338
Rock Pile	$2,737,534
Portage	*$2,707,534*
Vault	*$30,000*
Buildings and Equipment	10,659,256 $
Meadowbank	*$8,005,508*
Baker Lake	*$1,660,670*
AWAR	*$993,078*
Chemicals and Contaminated Soil Management	$1,316,981
Surface and Groundwater Management	$6,430,945
Interim Care and Maintenance	$1,858,705
Subtotal Direct Costs	**$57,883,238**
Indirect Costs	
Mobilization/Demobilization	$5,345,830
Post-Closure Monitoring and Maintenance	$4,133,524
Engineering (5%)	$2,894,162
Project Management (5%)	$2,894,162
Health and Safety Plans/Monitoring, QA/QC and Engagement Costs (2%)	$1,157,665
Bonding/Insurance (1%)	$578,832
Contingency (15%)	$8,682,486
Market Price Factor Adjustment (0%)	$0
Subtotal Indirect Costs	**$25,686,660**
GRAND TOTAL	**$83,569,898**

Refer to Appendix A for the RECLAIM spreadsheets, presenting the detailed breakdown of closure costs by mine components.

The assumptions used for the calculations of the direct costs and the indirect cost calculations are explained in the sections below.

3.3 Direct Cost Assumptions

The direct costs include the cost related to the physical work activities to be completed for the various project components, as well as the care and maintenance requirements.

In most cases, costs have been developed using unit rates provided by the RECLAIM 7.0 template applied to calculated quantities. Where an appropriate RECLAIM supplied rate was not available, an independent rate was used from Meadowbank operational data or from precedent data for similarly sized projects located in similar conditions. Unit rates used assume third party contractor pricing.

Specific assumptions and quantities used for the financial security cost estimate are provided for each closure component in sections 3.3.1 to 3.3.8.

3.3.1 Open Pits

For this component, it is assumed that the entrance and some perimeter areas of each pit will be blocked with non-acid generating material (NPAG) berms to control access of wildlife and motorized vehicles in the open pits during flooding. The length of berms was estimated from “MBK Site map FEB 2018 for NI43101.dwg” provided by Agnico Eagle, April 2018. Berms are assumed to be 1.5 m high, with 2H:1V side slopes, and made of NPAG rockfill.

Berms at ramp entrances and at exposed Portage Pit crest:

- 300 m long x 1.5 m tall with 2H:1V side slopes = 1350 m³;

Berms at Goose, Vault and Phaser ramp entrances:

- 100 m long x 1.5 m tall with 2H:1V side slopes = 450 m³.

3.3.2 Tailings Storage Facilities

TSF configuration from the last interim closure and reclamation plan were reviewed and adjusted with the projected elevation of tailings at closure with the new LOM. Preliminary design work was completed for the TSF cover in 2015 and 2016. The tailings cover will consist of NPAG waste rock, with a minimum thickness of 2.0 m. The cover for the South and North Cell will include landforms to promote water shedding and consists of two watersheds for North Cell and one watershed for South Cell. The nominal cover thickness over most of the landforms will be well over the minimum, as a thickness variation is required to obtain the designed landforms and promote adequate water management.

Quantities of rockfill required for the cover of the North Cell was adjusted to consider the construction of the internal structure required for the tailings deposition of Whale Tail Pit. These structures and the additional tailings deposited will reduce the quantity of NPAG material required for the construction of the cover and the landforms. For the South Cell, quantities were calculated to cover an area with tailings at El. 149.5 m.

For the TSF North Cell cover, the cover portion constructed between 2015 and 2017 in progressive closure was considered and subtracted from the total material required.

The construction of water diversion ditches within the cover and sedimentation ponds for management of the runoff water over the TSF were also included in the calculation. The runoff water from the cover system will convey towards a reclaim pond located upstream Saddle Dam 3. The water will then be released into Third Portage Lake once the runoff water quality meets discharge criteria. To release runoff water, the Saddle Dam 3 will be opened, which is also considered in the calculations. The quantities considered in the calculations for the construction are presented below.

Finally, it is assumed that 11.5 km (11,500 m) the tailings discharge piping will be dismantled, decontaminated and buried in the on-site landfill. The booster pump will also be dismantled.

Geotechnical instrument installation or maintenance of the existing instruments was also considered in the estimate.

NPAG Cover Tailings Storage Facility:

North Cell:

- Tailings maximum elevation considered at El. 153.5 m;
- Volume of NPAG rockfill required for North Cell NPAG cover: 6,376,000 m³;
- Volume of NPAG cover constructed between 2015 and 2017 (progressive closure): 750,743 m³;
- Volume of internal structure and tailings deposition to El.153.5m: 2,397,535 m³;
- Remaining volume NPAG rockfill required for North Cell NPAG cover: 3,227,722 m³ (data provided by Agnico Eagle, 2018).

South Cell:

- Tailings maximum elevation considered at El. 149.5 m;
- Volume NPAG rockfill required for South Cell NPAG cover for tailings at El.149.5 m: 2,783,838 m³.

Runoff Water Ditches:

North Cell:

- Volume of till excavation: 6,428 m³;
- Volume of rock excavation: 23,512 m³;
- Volume of NPAG waste rockfill: 9,935 m³.

South Cell:

- Volume of till excavation: 20,764 m³;
- Volume of rock excavation: 31,745 m³;
- Volume of NPAG waste rockfill: 25,527 m³.

Sedimentation Ponds:

North Cell:

- Volume of till excavation: 17,428 m³;
- Volume of rock excavation: 32,472 m³;
- Volume of NPAG waste rockfill: 3,510 m³.

SNC·LAVALIN

South Cell:

- Volume of till excavation: 36,176 m³;
- Volume of rock excavation: 74,308 m³;
- Volume of NPAG waste rockfill: 5,394 m³.

Saddle Dam 3 Opening:

- Volume of opening excavation: 25,000 m³;
- Volume of NPAG waste rockfill: 9,000 m³.

Removal of Tailings Discharge Line:

- Provided for removal of 11.5 km of HDPE, with on-site disposal;
- Lump sum of $15,630 for decommissioning of associated booster pump system/building.

Specialized Items:

- Lump sum of $50,000 for the installation/or maintenance of instrumentation.

3.3.3 Rock Storage Facilities

The configuration of the Portage RSF has not changed since 2014. The Portage RSF cover occurred progressively during operations between 2011 and 2017. Presently, it is considered that 84% of the RSF PAG area has been covered with 4.0 m of NPAG material (data from Agnico Eagle, May 2018). No cover is considered required for Vault RSF as the waste rock is mainly NPAG, and the portion of PAG material is encapsulated in the center of the RSF as needed.

The cost estimate also includes the cover of collection sumps around the Portage RSF.

Geotechnical instrument installation or maintenance of the existing instruments was also considered in the estimate.

Cover Portage Rock Storage Facility:

- Volume of NPAG cover required (total): 3,214,286 m³;
- Volume of NPAG cover constructed between 2011 and 2017 (progressive closure): 2,700,000 m³;
- Volume of NPAG cover remaining: 514,285 m³.

Cover Portage Rock Storage Sumps:

- Additional 6,800 m³ of cover provided for backfilling/covering sumps WEP1, WEP2 and RSF (ST-16) sumps.

Specialized Items:

- Lump sum of $50,000 for installation/or maintenance of instrumentation at Portage RSF;
- Lump sum of $30,000 for installation/or maintenance of instrumentation at Vault WRSF.

SNC·LAVALIN

3.3.4 Buildings and Equipment

The areas and footprints of buildings and infrastructures for Meadowbank site and Baker Lake provided in the ICRP 2014 were reviewed and adjusted if changes were required. The following changes were made:

- The airstrip area was increased due to the extension completed in 2013;
- The site road area was increased due to additional access roads built;
- The number of containers (sea cans) remaining on-site after closure is estimated at 1,400 containers;
- A total of 18 Jet-A Fuel tanks at Baker Lake;
- A total of 38 culverts and 9 bridges are considered for the AWAR.

Building and infrastructures footprints are listed in Table 2 available at the end of this memo (modified from Golder, 2014).

Removal of Buildings and Scarification of Foundations:

- Building footprints are listed in Table 2, with demolition areas scaled for heights assuming 3 m stories. Buildings with concrete foundations requiring puncturing assumed;
- A total of 18 Jet-A Fuel tanks at Baker Lake is considered instead of 20 tanks, as 2 were demobilized in 2016.

Reclaim Roads and Laydown Areas:

- Road/Laydown areas for the mine site and Baker Lake are listed in Table 2 and will be scarified. The AWAR will be ripped to promote natural revegetation and re-contoured to promote natural drainage;
- The airstrip length increase from 1495 to 1752 m, for an additional area of 6,000 m² and a total area of 4.1 ha;
- The site road area was increased by 20,000 m² due to additional access roads built estimated at 2.0 km, for a total area of 12 ha;
- Removal of 15 culverts on site including Vault area is considered with a lump sum allowance of $4,000 per culvert removal. Lump sum allowance of $40,000 for the installation of water breaks and erosion control is also provided.

Containers:

- In 2015, the total number of containers estimated on site represented 4,850 containers. It is estimated that between 2015 and 2022, 250 containers per year will be sent south (for a total of 2,000 containers) and that 250 containers will be donated to the community. For demobilization during 2023, 2024 and 2025, 400 containers per year will be required to transport some material and waste. At the end of active closure period, it is estimated that 1,400 containers will have to be disposed in the on-site landfill. Assuming 2.5 metric tons per container, this represents a total of 3,500 metric tons to cut and landfill.

Reclaim Quarries:

- Quarry slopes setback to 1H:1V slope, assuming cut/fill with blasted rock from the upper slope used to form lower slope;
- A total volume of 14,319 m^3 of blasted rock will be required. No change was made from ICRP 2014 (Golder, 2014) in the blasted rock quantities for the rehabilitation of quarries along the AWAR;

AWAR Water Crossing Removal:

- Lump sum allowances of $4,000 per culvert removal and $25,000 per bridge removal. A total of 38 culverts and 9 bridges are considered for the AWAR.

Decontaminate and Dispose Mobile Equipment in Landfill:

- Assumed a number of 136 mobile equipment, with 8 hours per equipment to decontaminate and disposed in the on-site landfill (1088 hours total), with 50% of equipment transferred to the local community or relocalized (Golder, 2014).

3.3.5 Chemicals and Soil Management

Chemicals and soil management were reviewed in accordance with the information available in the Landfarm Design and Management Plan (Agnico Eagle, 2017), the Hazardous Materials Management Plan (Agnico Eagle, 2013) and the Meadowbank Annual Report 2017 (Agnico Eagle, 2018).

Building Decontamination:

- Building decontamination was considered for the maintenance shop, the power plant, the fuel storage and the emulsion plant. A total cost of $33,000 was estimated for decontamination including 33 mandays.

Hazardous Material:

- No waste oil is considered in the cost estimate as the oil will be burned progressively for energy during operations;
- Fuel dregs assumed to be 0.5% of bulk fuel storage capacity (60 million liters of diesel and 1.8 million liters of Jet Fuel) and burned on site with waste oil, for a total of 309,000 liters;
- One year accumulation of oily and glycol contaminated waste water is considered, for a total of 58,456 liters (as per the Meadowbank Annual Report 2017, Agnico Eagle 2018);
- A lump sum of $3,000 is considered for battery disposal;
- Mill and water treatment reagents at closure assumed to be 5% of annual consumption and are summarized in Table 3 at the end of this memo;
- A total of 10,000 kg of assay lab and environmental reagents are assumed (Golder, 2014);
- A lump sum of $20,000 is considered for the disposal of various waste such as machine shop paints, solvents and filters;
- A total of 16,170 liters of glycol is considered based on the quantity on site reported (Hazardous Materials Management Plan, Agnico Eagle, 2013).

Contaminated soil:

- A contingency of 2,745 m^3 of hydrocarbon contaminated soil requiring on-site remediation at closure is considered, based on the reported total for 2017 (Meadowbank Annual Report 2017, Agnico Eagle 2018);
- An allowance of 5% of the total contaminated soil (137 m^3) is considered for heavily contaminated soil not treatable on site, to be managed as hazmat material;

Audit

- An allowance of $7,500 and $50,000 has been provided for Audit Phase 1 and 2 investigations, respectively. Hazmat removal audit is considered covered under these audits.

3.3.6 Water Management

The cost estimate includes the open pits flooding, the construction of the dike reconnections (opening) and closure of the water management facilities.

The volume of water required for Portage, Goose and Vault pits flooding and the period of flooding were adjusted with the information provided in the site water balance (Agnico Eagle, 2018). The operation and the maintenance of the pumping system were considered for an active flooding period of 7 years.

The preliminary design of the dike reconnections for Baygoose, South Camp and Vault dikes was developed in 2016. The construction quantities required for the reconnections were estimated from the preliminary design.

Correction work on the diversion ditches was considered required in closure to ensure long term stability and minimize snow management.

The fresh water barge and pipeline for the fresh water intake will be decommissioned. Water management pipelines will also be removed and landfilled, as well as the Third Portage Lake and Wally Lake diffusers.

The construction of a water treatment plant to treat the reclaim water prior to its transfer to Portage Pit is considered in the estimate, as well as its decommissioning. Due to the water quality forecast results, the additional parameters that may require treatment and the technology, the cost estimate for the water treatment plant was adjusted compared to the ICRP 2014 (Golder, 2014).

The annual cost for operation of the water treatment plant is also calculated. However, the annual cost, considered for a period of 3 years, is included in the “Interim Care and Maintenance” portion of the cost estimate, and presented in Section 3.3.7.

Portage, Goose and Vault Pits Flooding:

- Data extracted from the site water balance of 2018 (Agnico Eagle, 2018);
- Total volume of water pumped to Portage Pit over 7 years (2020–2026): 31.71 Mm³
  - 31,179,343 m³ of water pumped from Third Portage Lake and;
  - 531,266 m³ of water pumped from the Reclaim Pond (2022).
- Total volume of water pumped to Goose Pit over 1 year (2019): 3.18 Mm³ of water pumped from Third Portage Lake;
- Total volume of water pumped to Vault Pit over 7 years (2019–2025): 28.05 Mm³ of water pumped from Wally Lake;
- Remaining volume of flooding for the open pits will be covered by natural flooding (groundwater inflows, seepage, runoff), with no cost associated;
- Phaser and BB Phaser Pits will be flooded by natural flooding, with no cost associated;
- Considered pumping unit cost of $0.02/m³ (Golder, 2014);
- For pump maintenance and operation—2 (two) labourers working 12-hour days, 7 days per week, during active pumping period (4 months/year over 7 years), with associated accommodation costs;
- Annual pump servicing provided by two (2) manufacturer consultants for 1 week site visit per year over 7 years, with associated travel allowance costs.

SNC·LAVALIN

Dike Opening:

Bay-Goose Dike Reconnection (South, East and North):

- Opening of the dike with the lake to 3 m below design minimum water level to allow year-round fish passage, facilitate water exchange, and facilitate water movement within the former impoundment;
- Reconnection at two locations, with an alternate third location to access Portage Pit Lake;
- Reconnection width of 10 m with 3:1 side slopes;
- Erosion protection on exposed shoreline and appropriately sized substrate in reconnection base to satisfy fish habitat requirements for this structure;
- Volume of reconnection excavation = 94,000 m³;
- Volume of rock placement for capping and transition material, shoreline protection and fish substrate = 27,900 m³.

South Camp Dike Reconnection:

- Opening of the dike with the lake to 1 m below design minimum water level to allow for seasonal fish passage;
- Reconnection width of 10 m with 3:1 side slopes;
- Erosion protection on exposed shoreline and appropriately sized substrate in reconnection base to satisfy fish habitat requirements for this structure;
- Volume of reconnection excavation = 24,000 m³;
- Volume of rock placement for capping and transition material, shoreline protection and fish substrate = 9,500 m³.

Vault Pit to North Phaser Pit Channel:

- Channel invert 7 m below design minimum water level to allow for year-round fish passage;
- Opening width of 10 m with 3:1 side slopes;
- Erosion protection on exposed shoreline and appropriately sized substrate in opening base to satisfy fish habitat requirements for this structure;
- Volume of channel excavation = 7,000 m³;
- Volume of rock placement for capping and transition material, shoreline protection and fish substrate = 2,300 m³.

Vault Dike Reconnection:

- Channel invert 3 m below design minimum water level to allow for year-round fish passage;
- Reconnection width of 10 m through dike, channel width of 5 m, with 3:1 side slopes;
- Erosion protection on exposed shoreline and appropriately sized substrate in opening base to satisfy fish habitat requirements for this structure;
- Volume of channel excavation = 27,000 m³;
- Volume of rock placement for capping and transition material, shoreline protection and fish substrate = = 10,800 m³.

Removal or Correction of Water Management Structures:

- Volume for correction work on the diversion ditches—backfill/recountour (consider work on 1000 m of diversion ditch, on an area of 4 m^2 per linear meter, 1 m deep excavation) = 4,000 m^3;
- Lump sum for removal of the fresh water barge of $3,000;
- Lump sum for removal of each diffuser of $3,000;
- Length of pipeline to remove: 1,000 m for the fresh water supply system and 2,000 m for general water pipelines.

Temporary Water Treatment Plant Construction:

- Installation assumes repurposing an existing structure;
- The cost estimated for the tanks and mechanical components in the ICRP 2014 (Golder, 2014) was increased to account for the type of technology required for treatment, for a total of $1,240,000;
- Piping, electrical, instrumentation and controls, and equipment installation costs have been estimated as percentages of the total tanks and equipment cost, for respectively 30%, 15%, 15% and 35%, for a total of $1,178,000;
- The decommissioning is accounted for demolishing a structure of 1,500 m^2 and scarification of the footprint;
- The decommissioning of the system includes 540 man hours (3 labours,12 hours/day for 15 days), with associated accommodation costs.

Temporary Water Treatment Plant Operation:

- Operation of the temporary water treatment plant considered for treatment of reclaim water during 6 months per year, over 3 years (treatment required of 531,266 m^3 over 3 years, for 177,089 m^3/year);
- Considered pumping unit cost of $0.07/$m^3$ with diesel pump;
- A lump sum allowance of $150,000 for reagents is provided, based on the costs presented in the ICRP 2014 (Golder, 2014) increased by 50% to account for the type of technology required for treatment;
- For operation, one (1) skilled labour considered for 12 hours/day during 6 months per year over 3 years;
- Annual plant servicing provided by two (2) manufacturer consultants for a 7 days site visit per year (168h) over 3 years, with associated travel allowance costs.

3.3.7 Interim Care and Maintenance

Interim care and maintenance is considered in this cost estimate as this is a requirement from INAC. The estimate is based on a 3 years period and includes the annual water treatment operation cost and annual surveillance, surveillance and monitoring costs (active closure), presented in the “Post-Closure Monitoring and Maintenance”, in Section 3.4.2.

- The annual operational cost for the interim water treatment is estimated at $336,968;
- The annual cost related maintenance, surveillance, monitoring and inspection of the active closure period is estimated at $282,600 (as presented in the” Post Closure Monitoring and Maintenance”);
- The total cost for 3 years of care and maintenance is evaluated at $1,858,705.

3.4 Indirect Costs

The indirect costs include the cost related to post-closure monitoring and maintenance, mobilization and demobilization, as well as some cost factors such as contingency, engineering, project management, health and safety/QA-QC/engagement costs, bonding/insurance and contingency.

3.4.1 Mobilization/Demobilization

During the active closure stage, mobilization costs have been accounted for by allowing costs for mobilization and demobilization of equipment from Baker Lake, the mobilization of workers to perform the closure work, in addition to one barge trip into and out of Baker Lake exclusively for Meadowbank closure.

- Mobilization and demobilization of heavy mobile equipment for demolition is based on a distance of 110km along the AWAR from Baker Lake to Meadowbank;
- A seasonal work force of 50 workers over 3 years (2022 to 2024) for a 6 months per year demolition/rehabilitation seasons is considered, with associated accommodation and transportation costs (4 trips per year at $2,500 both ways, with 6 hours paid per trip);
- Lump sum for one barge trip into and out of Baker Lake of $1,000,000 is considered.

3.4.2 Post-Closure

The post-closure costs are separated in two (2) main periods; the active closure/closure from 2022 to 2030 (9 years) and the post-closure from 2031 to 2041 (11 years). The costs related to site monitoring/inspection and maintenance/surveillance are presented below.

The annual operation cost of the interim water treatment plan is not included in the post-closure costs as it is already accounted for in “Interim care and maintenance” for the required period of 3 years.

Monitoring and Inspection Active Closure/Closure (2022 to 2030):

- An annual lump sum of $100,000 for general monitoring programs (i.e. aquatic, wildlife, air quality, noise monitoring program) is considered;
- One annual geotechnical inspection if planned per year for $20,800—one week visit by one engineer, 7 days, 12h per day at $150/hour, plus $5,000 of reporting and associated travel and accommodation fees;
- A lump sum of $10,000 for groundwater monitoring;
- A lump sum of $15,500 of regulatory fees including annual reporting, management plans and progress reports;
- An estimated annual cost of $73,100 for the water quality monitoring on site, based on operational laboratory costs and the Meadowbank Water License 2 AM-MEA1525 requirements (Schedule 1, Table 2), as presented in Table 4.

Monitoring and Inspection Post-Closure (2031 to 2041):

- A lump sum of $100,000 every 2 years for general monitoring programs (i.e. aquatic, wildlife, air quality, noise monitoring program) is considered;

- One annual geotechnical inspection if planned per year for $20,800—one week visit of one engineer, 7 days, 12h per day at $150/hour, plus $5,000 of reporting and associated travel and accommodation fees);
- A lump sum of $10,000 for groundwater monitoring;
- A lump sum of $15,500 of regulatory fees including annual reporting, management plans and progress reports;
- An estimated annual cost of $49,432 for the water quality monitoring on site, based on operational laboratory costs and the Meadowbank Water License 2 AM-MEA1525 requirements (Schedule 1, Table 2), as presented in Table 4.

Maintenance and Surveillance:

- Two (2) site caretakers provided with biweekly overnight visits, 12 hours per day, 5 months of the year, along with annual allowances for a site vehicle and equipment ($20,000) and site maintenance ($10,000).

The discount rate for calculation of net present value of post-closure cost is considered at 3%.

3.4.3 Other Indirect Costs

Other indirect costs are calculated based on the direct costs total. The percentage for each indirect cost is automatically imposed by the RECLAIM model.

- Project management and engineering fees are assumed at 5% each of the direct closure costs;
- Health and safety plans/monitoring, QA&QC and engagement costs (communication with stakeholders from the community) are assumed as 2% of the direct closure costs;
- Bonding/insurance fees are assumed as 1% of the direct closure costs;
- Finally, due to the current level of engineering and uncertainties, a contingency of 15% of the direct closure costs has been provided for.

3.5 Comparison with 2014 Estimate

Table 5 lists the key differences between this cost estimate and the cost estimate prepared in the 2014 ICRP (Golder, 2014).

4.0 REFERENCES

Agnico Eagle. 2013. Hazardous Materials Management, Meadowbank Mine Site & Baker Lake Facilities, v3. Prepared by Agnico Eagle Mines Limited, Meadowbank Division.

Agnico Eagle 2017. Landfarm Design and Management Plan, version 4, Agnico-Eagle Mines, March 2017.

Agnico Eagle 2018. MEADOWBANK GOLD PROJECT 2017 Annual Report, May 2018.

Guidelines for Closure and Reclamation Cost Estimates for Mines. 2017. Indigenous and Northern Affairs Canada, Mackenzie Valley Land and Water Board, Government of the Northwest Territories. November, 2017.

Golder, 2014. Interim Closure and Reclamation Plan. Report No. 13-1151-0131 to Agnico Eagle Mines Ltd. January 2014. 115 p.

Golder, 2016. Whale Tail Interim Closure and Reclamation Plan. Report No. 1,541,520. Report to Agnico Eagle Mines Ltd. June 2016.

MBK Site map FEB 2018 for NI43101.dwg provided by Agnico Eagle, April 26, 2018.

Agnico Eagle. 2018 Water Balance (Excel Table).

SNC·LAVALIN

Table 2 Buildings List and Dimensions

Building/Infrastructure	Footprint (m^2)	Stories (3 m Height)	Total Demolition Volume Scaled for Height (m^3)	Concrete Foundation Area (m^2)
Meadowbank				
Mill	7,560	5	37,800	4,560
Leech Tanks (10)	2,500	5	12,500	2,500
Primary and Secondary Crusher	246	3	740	246
Pebble Crusher	325	2	650	325
Conveyors	975	2	1,950	
Assay Lab	440	1	440	
Accommodation Complex (Inc. Nova Camp)	11,744	1	11,744	
Kitchen and Cafeteria	2,630	2	5,259	
Services Building	3,270	4	13,080	3,270
Site Services Building	500	1	500	3,270
Dome Warehouse	1,427	2	2,854	
Ore Dome	3,000	7	21,000	
Power Plant	2,485	3	7,455	
Cat Warehouse	1,345	2	2,690	
Toromont Facilities	925	1	925	
Fountain Tire	330	1	330	
White Coverall	1,395	2	2,790	
Batch Plant	1,050	2	2,100	
Environmental Office	140	1	140	
Dike Dewatering Shop	755	1	755	
Incinerator	280	1	280	
Talbon Shop	235	1	235	

SNC·LAVALIN

Table 2 Buildings List and Dimensions (cont.)

Building/Infrastructure	Footprint (m^2)	Stories (3 m height)	Total Demolition Volume Scaled for Height (m^3)	Concrete Foundation Area (m^2)
Blue Coverall	354	2	710	
Gate House	100	1	100	
Fuel Dispensing Station	165	1	165	
Emulsion Plant	1,000	2	2,000	
5.6 ML Bulk Fuel Tank	955	2	1,910	
Airstrip	41,000			
Access roads (~10 m x 12 km)	120,000			
Haul roads (~25 m x 14.5 km)	363,000			
Portage/Goose Disturbed Area	406,000			
Vault Disturbed Area	65,000			
Sea cans (each)	1,432			
Baker Lake				
10 ML Bulk Fuel Tanks (6 tanks)	5,295	4	21,180	6,095
100,000 L Jet Fuel Tanks (18 tanks)	720	1	720	
Scarify laydown areas	500,000			
AWAR				
Road surface (8 m x 105 km)	840,000			
Remove culverts (each)	34			
Remove bridge (each)	11			
Reclaim quarries (m^3)	14,319			

Source: Modified from Golder 2014, Operational data from Agnico Eagle.

SNC·LAVALIN

Table 3 Mill and Water Treatment Reagent Consumption

Assuming 5% of annual consumption	Annual usage (t)	5% assumed at closure (t)
Activated Carbon	140	7
Anti-Scalant	10	0.5
Borax	22	1.1
Silica	11	0.55
Calcium Oxide (Quicklime)	3150	157.5
Calcium Peroxide	1	0.05
Copper Sulfate	585	29.25
Flocculant	120	6
Hydrochloric Acid	75	3.75
Hydrochloric Acid[1]	1825 gallons	0.35
Hydrogen Peroxide	1	0.05
Lead Acid Batteries	24	1.2
Nitric Acid	18	0.9
Paints[1]	100 gallons	0.02
Sodium Cyanide	1540	77
Sodium Hydroxide	8	0.4
	Total	**286**

Source: ICRP 2014 (Golder, 2014), verified with Hazardous Materials Management Plan (Agnico Eagle, 2013).

SNC·LAVALIN

Table 4 Water Quality Monitoring Estimated Costs

Station	Closure	Post-Closure
	Cost $/Year	Cost $/Year
Drinking water	$ 3,120	$ 3,120
EEM2 a	$ 508	$ 508
EEM3 a	$ 508	$ 508
EEM2 b	$ 7,748	$ 7,748
EEM2c (TPN/Wally Lake)	$ 3,136	$ 3,136
EEM3c (SPL)	$ 1,568	$ 1,568
Incinerator ash	$ 400	$ —
ST-37	$ 324	$ —
ST-5	$ 1,875	$ 1,875
ST-6	$ 1,875	$ 1,875
ST-8	$ 162	$ 162
ST-20 Pit Lake	$ 3,279	$ 3,279
ST-24	$ 1,527	$ 1,527
ST-40.1 ST- 40.2 ST-38	$ 1,458	$ —
ST-MMER 3a	$ 15,548	$ 15,548
ST-MMER 3b	$ 4,518	$ 4,518
STP	$ 5 616	$ -
ST-S- 2	$ 1,527	$ —
ST-S-5	$ 4,242	$ —
ST-16	$ 4,242	$ —
Mill Seepage	$ 4,242	
WEP	$ 1,527	$ —
Ground water	$ 4,060	$ 4,060
Total	**$ 73,010**	**$ 49,432**

Based on operational laboratory costs and the Meadowbank Water License 2 AM-MEA1525 requirements (Schedule 1, Table 2).

SNC·LAVALIN

Table 5 Comparison between 2014 and 2018 ICRP Cost Estimate

Component Group	ICRP 2018 - Cost Estimate ($)	ICRP 2014 (Golder, 2014) - Cost Estimate ($)	Differences between 2018 and 2014 estimates ($)	Main Difference Explanations between 2018 and 2014 estimates
Open pit	$6,480	$5,400	$1,080	
Portage	*$3,240*	*$2,700*	*$540*	Length of safety berms reviewed in 2018 and berms included for Vault and Phaser.
Goose	*$1,080*	*$2,700*	*-$1,620*	
Vault	*$1,080*	*$0*	*$1,080*	
Phaser	*$1,080*	*$0*	*$1,080*	
Underground Mine	$0	$0	$0	
Tailings Facility	$34,873,338	$38,716,200	-$3,842,862	Current TSF configuration and tailings elevation considered in 2018. For the North Cell, integration of the Internal Structure and progressive reclamation from 2015 to 2017 (750,743 m3) on the NPAG cover construction considered with the preliminary cover design including landforms. For the South Cell, preliminary cover design including landforms considered and adjusted for the maximum tailings elevation. Water management structures and SD3 reconnection from preliminary cover design considered in 2018. Removal costs for tailings pipes and booster pump reviewed in 2018. Instrumentation installation and maintenance for closure included in 2018.
Rock Pile	$2,737,534	$6,004,827	-$3,267,293	
Portage	*$2,707,534*	*$6,004,827*	*-$3,297,293*	Considered in 2018 that 84% of the RSF PAG area have been covered in progressive reclamation with 4.0m of NPAG material between 2011 and 2017 (2,700,000 m^3) and subtracted from the total cover required. Cover for Portage RSF sumps reviewed in 2018. Instrumentation installation and maintenance for closure included in 2018.
Vault	*$30,000*	*$0*	*$30,000*	Instrumentation installation and maintenance for closure included in 2018.
Buildings and Equipment	$10,659,256	$10,574,770	$84,486	
Meadowbank	*$8,005,508*	*$7,919,428*	*$86,080*	The airstrip area was increased in 2018 by 6,000m² due to the extension completed in 2013. The site road area was increased in 2018 by 20,000m² due to additional access roads built estimated at 2.0 km. The number of containers remaining on site after closure is estimated at 1400 containers in 2018.
Baker Lake	*$1,660,670*	*$1,664,270*	*-$3,600*	A total of 18 Jet-A Fuel tanks at Baker Lake is considered in 2018 instead of 20 tanks.
AWAR	*$993,078*	*$991,072*	*$2,006*	Lump sum allowances of 4,000$ (instead of 10,000$ in 2014) per culvert removal and $25,000 per bridge removal is considered in 2018. A total of 38 culverts and 9 bridges are considered for the AWAR in 2018, compared to 15 culverts and 9 bridges in 2014.
Chemicals and Contaminated Soil Management	$1,316,981	$1,208,184	$108,797	Building decontamination was considered for some infrastructures in 2018. Hazmat costs reviewed in 2018, no waste oil considered. Contaminated soil increased in 2018 (1245 m^3 additional), including an allowance for heavily contaminated soil.
Surface and Groundwater Management	$6,430,945	$5,198,311	$1,232,634	Pits flooding volumes adjusted (decreased compared to 2014) with water balance in 2018. Dike reconnection preliminary design quantities considered in 2018. Cost for WTP construction and operation increased in 2018 due to the type of technology that may be required for treatment of reclaim water prior to transfer in the pits.
Interim Care and Maintenance	$1,858,705	$0	$1,858,705	Interim care and maintenance considered in 2018, as this is a requirement from INAC. Cost estimate based on annual water treatment cost and annual surveillance and monitoring (active closure), for a 3 years period.
Subtotal Direct Costs	**$57,883,238**	**$61,707,692**	**-$3,824,454**	

SNC·LAVALIN

Table 5 Comparison between 2014 and 2018 ICRP Cost Estimate (cont.)

Component Group	ICRP 2018 - Cost Estimate ($)	ICRP 2014 (Golder, 2014) - Cost Estimate ($)	Differences between 2018 and 2014 estimate ($)	Main Difference Explanations
Mobilization/Demobilization	$5,345,830	$4,762,500	$583,330	Mobilization and demobilization of equipment from Baker Lake considered in 2018. Cost of barge increased in 2018.
Post-Closure Monitoring and Maintenance	$4,133,524	$2,972,373	$1,161,151	In 2018, 2 main periods considered for monitoring from 2022 to 2030 and from 2031 to 2041. Cost for general monitoring programs included in 2018 - annually in closure and every 2 years post-closure. Cost for geotechnical inspection reviewed in 2018. Cost for water quality monitoring reviewed in 2018.
Engineering (5%)	$2,894,162	$3,085,385	-$191,223	Adjusted with direct costs in 2018.
Project Management (5%)	$2,894,162	$3,085,385	-$191,223	Adjusted with direct costs in 2018.
Health and Safety Plans/Monitoring, QA/QC and Engagement Costs (2%)	$1,157,665	$0	$1,157,665	Not considered in 2014, 2% of direct costs considered in 2018, including engagement costs with stakeholders.
Bonding/Insurance (1%)	$578,832	$0	$578,832	Not considered in 2014, 1% of direct costs considered in 2018.
Contingency (15%)	$8,682,486	$9,256,154	-$573,668	Considered 15% of direct costs in 2014 and 2018. Adjusted with direct costs in 2018.
Market Price Factor Adjustment (0%)	$0	$0	$0	No change.
Subtotal Indirect Costs	**$25,686,660**	**$23,161,796**	**$2,524,865**	
GRAND TOTAL	**$83,569,898**	**$84,869,488**	**-$1,299,590**	

SNC·LAVALIN

Appendix A—RECLAIM 7.0 Spreadsheets

SUMMARY OF COSTS

CAPITAL COSTS	COMPONENT NAME	COST	LAND LIABILITY	WATER LIABILITY
OPEN PIT	Portage	$3 240	$1 620	$1 620
	Goose	$1 080	$540	$540
	Vault	$1 080	$540	$540
	Phaser	$1 080	$540	$540
UNDERGROUND MINE		$0	$0	$0
TAILINGS FACILITY		$34 873 338	$17 436 669	$17 436 669
ROCK PILE	Portage	$2 707 534	$1 353 767	$1 353 767
	Vault	$30 000	$15 000	$15 000
BUILDINGS AND EQUIPMENT	Meadowbank	$8 005 508	$4 002 754	$4 002 754
	Baker Lake	$1 660 670	$830 335	$830 335
	AWAR	$993 078	$496 539	$496 539
CHEMICALS AND CONTAMINATED SOIL MANAGEMENT		$1 316 981	$658 491	$658 491
SURFACE AND GROUNDWATER MANAGEMENT		$6 430 945	-	$6 430 945
INTERIM CARE AND MAINTENANCE		$1 858 705	-	$1 858 705
	SUBTOTAL: Capital Costs	**$57 883 238**	**$24 796 794**	**$33 086 444**
	PERCENT OF SUBTOTAL		**43%**	**57%**

INDIRECT COSTS		COST	LAND LIABILITY	WATER LIABILITY
MOBILIZATION/DEMOBILIZATION		$5 345 830	$2 290 118	$3 055 712
POST-CLOSURE MONITORING AND MAINTENANCE		$4 133 524	$1 770 774	$2 362 750
ENGINEERING	5%	$2 894 162	$1 239 840	$1 654 322
PROJECT MANAGEMENT	5%	$2 894 162	$1 239 840	$1 654 322
HEALTH AND SAFETY PLANS/MONITORING, QA/QC & ENGAGEMENT COSTS	2%	$1 157 665	$495 936	$661 729
BONDING/INSURANCE	1%	$578 832	$247 968	$330 864
CONTINGENCY	15%	$8 682 486	$3 719 519	$4 962 967
MARKET PRICE FACTOR ADJUSTMENT	0%	$0	$0	$0
	SUBTOTAL: Indirect Costs	**$25 686 660**	**$11 003 994**	**$14 682 666**

TOTAL COSTS	**$83 569 898**	**$35 800 789**	**$47 769 110**

4 **Open Pit Name:** **Portage** **Pit # 1**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
CONTROL ACCESS									
Fence		m		#N/A	$0,00	$0		$0	$0
Signs		each		#N/A	$0,00	$0		$0	$0
Berm at crest and rock barricade at ramp		m3	1350	DRH	$2,40	$3 240	50%	$1 620	$1 620
Block roads		m3							
Other				#N/A	$0,00	$0		$0	$0
STABILITY STUDY									
Conduct stability and setback study		allow		#N/A	$0,00	$0		$0	$0
STABILIZE SLOPES									
Off-load crest, soil A		m3		#N/A	$0,00	$0		$0	$0
Off-load crest, soil B		m3		#N/A	$0,00	$0		$0	$0
Doze/trim overburden at crest		m3		#N/A	$0,00	$0		$0	$0
Drill & blast pit crest		m3		#N/A	$0,00	$0		$0	$0
Buttress slope		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER/CONTOUR SLOPES									
Place fill, soil A		m3		#N/A	$0,00	$0		$0	$0
Place fill, soil B		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Vegetate slopes		ha		#N/A	$0,00	$0		$0	$0
Vegetate pit floor		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0,00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0,00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0,00	$0		$0	$0
CONSTRUCT SPILLWAY									
Excavate channel		m3		#N/A	$0,00	$0		$0	$0
Concrete		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
RECLAIM QUARRIES									
Contour slopes		m3		#N/A	$0,00	$0		$0	$0
Place overburden		m3		#N/A	$0,00	$0		$0	$0
Vegetate		m3		#N/A	$0,00	$0		$0	$0
FLOOD PIT-Captital									
Remove stationary equipment (sump pumps)		each		#N/A	$0,00	$0		$0	$0
Remove dewatering pipeline		m		#N/A	$0,00	$0		$0	$0
Remove power lines		each		#N/A	$0,00	$0		$0	$0
Construct diversion ditches		m3		#N/A	$0,00	$0		$0	$0
-Ditch, mat'l A		m3		#N/A	$0,00	$0		$0	$0
-Ditch, mat'l B		m3		#N/A	$0,00	$0		$0	$0
Construct embankment/dam		m3		#N/A	$0,00	$0		$0	$0
Supply/install pump station		each		#N/A	$0,00	$0		$0	$0
Supply/install piping system		m		#N/A	$0,00	$0		$0	$0
Remove pump post-closure		each		#N/A	$0,00	$0		$0	$0
Remove pipeline post-closure		m		#N/A	$0,00	$0		$0	$0
FLOOD PIT-Annual Cost									
Operate pumps (power)		m3		#N/A	$0,00	$0		$0	$0
Maintain pump/pipeline		allow		#N/A	$0,00	$0		$0	$0
Labour:fuel management, comissioning/decom		$/h		#N/A	$0,00	$0		$0	$0
Chemical addition, _____ kg/m3 of water		tonne		#N/A	$0,00	$0		$0	$0
Chemicals, purchase and shipping		tonne		#N/A	$0,00	$0		$0	$0
Passive/biological additives		$/ha		#N/A	$0,00	$0		$0	$0
Passive additives purchase and shipping		tonne		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
				Annual pumping costs		$0			
Number of years of pump flooding		years							
				Total pumping costs		$0		$0	$0
					Total	$3 240		$1 620	$1 620
					% of Total			50%	50%

Open Pit Name: **Goose** **Pit # 2**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
CONTROL ACCESS									
Fence		m		#N/A	$0,00	$0		$0	$0
Signs		each		#N/A	$0,00	$0		$0	$0
Berm at crest and Rock barricade at ramp		m3	450	DRH	$2,40	$1 080	50%	$540	$540
Block roads		m3							
Other				#N/A	$0,00	$0		$0	$0
STABILITY STUDY									
Conduct stability and setback study		allow		#N/A	$0,00	$0		$0	$0
STABILIZE SLOPES									
Off-load crest, soil A		m3		#N/A	$0,00	$0		$0	$0
Off-load crest, soil B		m3		#N/A	$0,00	$0		$0	$0
Doze/trim overburden at crest		m3		#N/A	$0,00	$0		$0	$0
Drill & blast pit crest		m3		#N/A	$0,00	$0		$0	$0
Buttress slope		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER/CONTOUR SLOPES									
Place fill, soil A		m3		#N/A	$0,00	$0		$0	$0
Place fill, soil B		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Vegetate slopes		ha		#N/A	$0,00	$0		$0	$0
Vegetate pit floor		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0,00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0,00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0,00	$0		$0	$0
CONSTRUCT SPILLWAY									
Excavate channel		m3		#N/A	$0,00	$0		$0	$0
Concrete		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
RECLAIM QUARRIES									
Contour slopes		m3		#N/A	$0,00	$0		$0	$0
Place overburden		m3		#N/A	$0,00	$0		$0	$0
Vegetate		m3		#N/A	$0,00	$0		$0	$0
FLOOD PIT-Captital									
Remove stationary equipment (sump pumps)		each		#N/A	$0,00	$0		$0	$0
Remove dewatering pipeline		m		#N/A	$0,00	$0		$0	$0
Remove power lines		each		#N/A	$0,00	$0		$0	$0
Construct diversion ditches		m3		#N/A	$0,00	$0		$0	$0
-Ditch, mat'l A		m3		#N/A	$0,00	$0		$0	$0
-Ditch, mat'l B		m3		#N/A	$0,00	$0		$0	$0
Construct embankment/dam		m3		#N/A	$0,00	$0		$0	$0
Supply/install pump station		each		#N/A	$0,00	$0		$0	$0
Supply/install piping system		m		#N/A	$0,00	$0		$0	$0
Remove pump post-closure		each		#N/A	$0,00	$0		$0	$0
Remove pipeline post-closure		m		#N/A	$0,00	$0		$0	$0
FLOOD PIT-Annual Cost									
Operate pumps (power)		m3		#N/A	$0,00	$0		$0	$0
Maintain pump/pipeline		allow		#N/A	$0,00	$0		$0	$0
Labour:fuel management, comissioning/decom		$/h		#N/A	$0,00	$0		$0	$0
Chemical addition, _____ kg/m3 of water		tonne		#N/A	$0,00	$0		$0	$0
Chemicals, purchase and shipping		tonne		#N/A	$0,00	$0		$0	$0
Passive/biological additives		$/ha		#N/A	$0,00	$0		$0	$0
Passive additives purchase and shipping		tonne		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
				Annual pumping costs		$0			
Number of years of pump flooding		years							
				Total pumping costs		$0		$0	$0
					Total	$1 080		$540	$540
					% of Total			50%	50%

Open Pit Name: **Vault** **Pit # 3**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
CONTROL ACCESS									
Fence		m		#N/A	$0,00	$0		$0	$0
Signs		each		#N/A	$0,00	$0		$0	$0
Berm at crest and Rock barricade at ramp		m3	450	DRH	$2,40	$1 080	50%	$540	$540
Block roads		m3							
Other				#N/A	$0,00	$0		$0	$0
STABILITY STUDY									
Conduct stability and setback study		allow		#N/A	$0,00	$0		$0	$0
STABILIZE SLOPES									
Off-load crest, soil A		m3		#N/A	$0,00	$0		$0	$0
Off-load crest, soil B		m3		#N/A	$0,00	$0		$0	$0
Doze/trim overburden at crest		m3		#N/A	$0,00	$0		$0	$0
Drill & blast pit crest		m3		#N/A	$0,00	$0		$0	$0
Buttress slope		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER/CONTOUR SLOPES									
Place fill, soil A		m3		#N/A	$0,00	$0		$0	$0
Place fill, soil B		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Vegetate slopes		ha		#N/A	$0,00	$0		$0	$0
Vegetate pit floor		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0,00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0,00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0,00	$0		$0	$0
CONSTRUCT SPILLWAY									
Excavate channel		m3		#N/A	$0,00	$0		$0	$0
Concrete		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
RECLAIM QUARRIES									
Contour slopes		m3		#N/A	$0,00	$0		$0	$0
Place overburden		m3		#N/A	$0,00	$0		$0	$0
Vegetate		m3		#N/A	$0,00	$0		$0	$0
FLOOD PIT-Captital									
Remove stationary equipment (sump pumps)		each		#N/A	$0,00	$0		$0	$0
Remove dewatering pipeline		m		#N/A	$0,00	$0		$0	$0
Remove power lines		each		#N/A	$0,00	$0		$0	$0
Construct diversion ditches		m3		#N/A	$0,00	$0		$0	$0
-Ditch, mat'l A		m3		#N/A	$0,00	$0		$0	$0
-Ditch, mat'l B		m3		#N/A	$0,00	$0		$0	$0
Construct embankment/dam		m3		#N/A	$0,00	$0		$0	$0
Supply/install pump station		each		#N/A	$0,00	$0		$0	$0
Supply/install piping system		m		#N/A	$0,00	$0		$0	$0
Remove pump post-closure		each		#N/A	$0,00	$0		$0	$0
Remove pipeline post-closure		m		#N/A	$0,00	$0		$0	$0
FLOOD PIT-Annual Cost									
Operate pumps (power)		m3		#N/A	$0,00	$0		$0	$0
Maintain pump/pipeline		allow		#N/A	$0,00	$0		$0	$0
Labour:fuel management, comissioning/decom		$/h		#N/A	$0,00	$0		$0	$0
Chemical addition, _____ kg/m3 of water		tonne		#N/A	$0,00	$0		$0	$0
Chemicals, purchase and shipping		tonne		#N/A	$0,00	$0		$0	$0
Passive/biological additives		$/ha		#N/A	$0,00	$0		$0	$0
Passive additives purchase and shipping		tonne		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
				Annual pumping costs		$0			
Number of years of pump flooding		years							
				Total pumping costs		$0		$0	$0
					Total	$1 080		$540	$540
					% of Total			50%	50%

Open Pit Name: **Phaser** **Pit # 4**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
CONTROL ACCESS									
Fence		m		#N/A	$0,00	$0		$0	$0
Signs		each		#N/A	$0,00	$0		$0	$0
Berm at crest and rock barricade at ramp		m3	450	DRH	$2,40	$1 080	50%	$540	$540
Block roads		m3							
Other				#N/A	$0,00	$0		$0	$0
STABILITY STUDY									
Conduct stability and setback study		allow		#N/A	$0,00	$0		$0	$0
STABILIZE SLOPES									
Off-load crest, soil A		m3		#N/A	$0,00	$0		$0	$0
Off-load crest, soil B		m3		#N/A	$0,00	$0		$0	$0
Doze/trim overburden at crest		m3		#N/A	$0,00	$0		$0	$0
Drill & blast pit crest		m3		#N/A	$0,00	$0		$0	$0
Buttress slope		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER/CONTOUR SLOPES									
Place fill, soil A		m3		#N/A	$0,00	$0		$0	$0
Place fill, soil B		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Vegetate slopes		ha		#N/A	$0,00	$0		$0	$0
Vegetate pit floor		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0,00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0,00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0,00	$0		$0	$0
CONSTRUCT SPILLWAY									
Excavate channel		m3		#N/A	$0,00	$0		$0	$0
Concrete		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
RECLAIM QUARRIES									
Contour slopes		m3		#N/A	$0,00	$0		$0	$0
Place overburden		m3		#N/A	$0,00	$0		$0	$0
Vegetate		m3		#N/A	$0,00	$0		$0	$0
FLOOD PIT-Captital									
Remove stationary equipment (sump pumps)		each		#N/A	$0,00	$0		$0	$0
Remove dewatering pipeline		m		#N/A	$0,00	$0		$0	$0
Remove power lines		each		#N/A	$0,00	$0		$0	$0
Construct diversion ditches		m3		#N/A	$0,00	$0		$0	$0
-Ditch, mat'l A		m3		#N/A	$0,00	$0		$0	$0
-Ditch, mat'l B		m3		#N/A	$0,00	$0		$0	$0
Construct embankment/dam		m3		#N/A	$0,00	$0		$0	$0
Supply/install pump station		each		#N/A	$0,00	$0		$0	$0
Supply/install piping system		m		#N/A	$0,00	$0		$0	$0
Remove pump post-closure		each		#N/A	$0,00	$0		$0	$0
Remove pipeline post-closure		m		#N/A	$0,00	$0		$0	$0
FLOOD PIT-Annual Cost									
Operate pumps (power)		m3		#N/A	$0,00	$0		$0	$0
Maintain pump/pipeline		allow		#N/A	$0,00	$0		$0	$0
Labour:fuel management, comissioning/decom		$/h		#N/A	$0,00	$0		$0	$0
Chemical addition, _____ kg/m3 of water		tonne		#N/A	$0,00	$0		$0	$0
Chemicals, purchase and shipping		tonne		#N/A	$0,00	$0		$0	$0
Passive/biological additives		$/ha		#N/A	$0,00	$0		$0	$0
Passive additives purchase and shipping		tonne		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
				Annual pumping costs		$0			
Number of years of pump flooding		years							
				Total pumping costs		$0		$0	$0
					Total	$1 080		$540	$540
					% of Total			50%	50%

1 **Tailings Impoundment Name:** **Pond # 1**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
CONTROL ACCESS									
Fence		m		#N/A	$0,00	$0		$0	$0
Signs		each		#N/A	$0,00	$0		$0	$0
Berm		m3		#N/A	$0,00	$0		$0	$0
Block roads		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
STABILIZE EMBANKMENT(S)									
Toe buttress, drainage layer		m3		#N/A	$0,00	$0		$0	$0
Toe buttress, bulk fill		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Raise crest		m3		#N/A	$0,00	$0		$0	$0
Flatten slopes		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER TAILINGS - North Cell									
NPAG UM waste rock cover (4 m thick)		m3	3227722	SB3L	$5,10	$16 461 382	50%	$8 230 691	$8 230 691
Grade/shape tailings surface		m3		#N/A	$0,00	$0		$0	$0
Liner bedding		m3		#N/A	$0,00	$0		$0	$0
Subgrade preparation - compact		m2		#N/A	$0,00	$0		$0	$0
Supply geotextile/geosynthetic		m2		#N/A	$0,00	$0		$0	$0
Install geotextile/geosynthetic		m2		#N/A	$0,00	$0		$0	$0
Soil cover		m3		#N/A	$0,00	$0		$0	$0
Rock cover		m3		#N/A	$0,00	$0		$0	$0
Vegetate		m2		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
DITCHES - North Cell									
DITCHES excavate soil		m3	6428	SB2L	$4,60	$29 569	50%	$14 784	$14 784
DITCHES excavate rock		m3	23512	RB2L	$12,05	$283 320	50%	$141 660	$141 660
NPAG waste rockfill		m3	9935	SB4L	$5,50	$54 643	50%	$27 321	$27 321
SEDIMENTATION POND - North Cell									
POND excavate soil		m3	17428	SB2L	$4,60	$80 169	50%	$40 084	$40 084
POND excavate rock		m3	32472	RB2L	$12,05	$391 288	50%	$195 644	$195 644
NPAG waste rockfill		m3	3510	SB4L	$5,50	$19 305	50%	$9 653	$9 653
COVER TAILINGS - South Cell									
NPAG UM waste rock cover (4 m thick)		m3	2783838	SB4L	$5,50	$15 311 109	50%	$7 655 555	$7 655 555
Grade/shape tailings surface		m3		#N/A	$0,00	$0		$0	$0
Liner bedding		m3		#N/A	$0,00	$0		$0	$0
Subgrade preparation - compact		m2		#N/A	$0,00	$0		$0	$0
Supply geotextile/geosynthetic		m2		#N/A	$0,00	$0		$0	$0
Install geotextile/geosynthetic		m2		#N/A	$0,00	$0		$0	$0
Soil cover		m3		#N/A	$0,00	$0		$0	$0
Rock cover		m3		#N/A	$0,00	$0		$0	$0
Vegetate		m2		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
DITCHES - South Cell									
DITCHES excavate soil		m3	20764	SB2L	$4,60	$95 513	50%	$47 756	$47 756
DITCHES excavate rock		m3	31745	RB2L	$12,05	$382 531	50%	$191 265	$191 265
NPAG waste rockfill		m3	25527	SB4L	$5,50	$140 399	50%	$70 199	$70 199
SEDIMENTATION POND - South Cell									
POND excavate soil		m3	36176	SB2L	$4,60	$166 410	50%	$83 205	$83 205
POND excavate rock		m3	74308	RB2L	$12,05	$895 406	50%	$447 703	$447 703
NPAG waste rockfill		m3	5394	SB4L	$5,50	$29 667	50%	$14 833	$14 833
BREACH SADDLE DAM 3									
Excavate Breach Saddle Dam		m3	25000	SB2L	$4,60	$115 000	50%	$57 500	$57 500
Rock placement		m3	9000	SB4H	$11,00	$99 000	50%	$49 500	$49 500
REMOVE TAILINGS DISCHARGE									
Removing Piping		m	11500	PLRL	$22,00	$253 000	50%	$126 500	$126 500
Dismantle Booster Pump		allow	1	OPS	$15 630,00	$15 630	50%	$7 815	$7 815
BURY PAG ROCK									
Relocate PAG rock		m3		#N/A	$0,00	$0		$0	$0
Place cover over PAG rock		m3		#N/A	$0,00	$0		$0	$0
Raise crest of dam		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
STABILIZE DECANT SYSTEM									
Excavate and replace		m3		#N/A	$0,00	$0		$0	$0
Plug/backfill with concrete or clay		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
REMOVE TAILINGS DISCHARGE									
Cyclones		m3		#N/A	$0,00	$0		$0	$0
Pipe		m3		#N/A	$0,00	$0		$0	$0
Remove reclaim barge		allow		#N/A	$0,00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0,00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0,00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0,00	$0		$0	$0
FLOOD TAILINGS									
Doze tailings to final contour		m3		#N/A	$0,00	$0		$0	$0
Raise crest of dam		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
UPGRADE SPILLWAY									
Excavate channel, rock		m3		#N/A	$0,00	$0		$0	$0
Excavate channel, soil		m3		#N/A	$0,00	$0		$0	$0
Concrete		m3		#N/A	$0,00	$0		$0	$0
Rip rap		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
CONSTRUCT SEEPAGE COLLECTION POND									
Excavate seepage collection pond		m3		#N/A	$0,00	$0		$0	$0
Doze & spread excavated material		m3		#N/A	$0,00	$0		$0	$0
Vegetate spread material		ha		#N/A	$0,00	$0		$0	$0
Bedding layer		m3		#N/A	$0,00	$0		$0	$0
Supply geomembrane		m2		#N/A	$0,00	$0		$0	$0
Install geomembrane		m2		#N/A	$0,00	$0		$0	$0
Erosion protection layer		m3		#N/A	$0,00	$0		$0	$0
INSTALL GROUNDWATER COLLECTION SYSTEM									
Excavate/install sumps		m3		#N/A	$0,00	$0		$0	$0
Install pumping wells		m3		#N/A	$0,00	$0		$0	$0
Install pumps/pipelines/power supply		LS		#N/A	$0,00	$0		$0	$0
SPECIALIZED ITEMS									
Install permanent instrumentation, supply & technican		each		#N/A	$0,00	$0		$0	$0
Install permanent instrumentation and drilling		each	5	OPS	$10 000,00	$50 000	50%	$25 000	$25 000
TREAT SEEPAGE - see "Water Management" and "Water Treatment"									
TREAT SUPERNATANT									
Pump water (to pit, U/G)		m3		#N/A	$0,00	$0		$0	$0
Equipment maintenance and parts		allow		#N/A	$0,00	$0		$0	$0
Supply reagents		tonne		#N/A	$0,00	$0		$0	$0
					Annual treatment costs	$0			
Number of years of treatment		years							
					Total treatment costs	$0			$0
					Total	$34 873 338		$17 436 669	$17 436 669
					% of Total			50%	50%

* for construction of passive treatment system refer to "Water Management"

2 **Rock Pile Name:** **Portage**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
STABILIZE SLOPES									
Flatten slopes with dozer		m3		#N/A	$0,00	$0		$0	$0
Flatten "bubble dump" areas		m3		#N/A	$0,00	$0		$0	$0
Divert runon, ditch mat'l A		m3		#N/A	$0,00	$0		$0	$0
Divert runon, ditch mat'l B		m3		#N/A	$0,00	$0		$0	$0
Toe buttress, drain mat'l		m3		#N/A	$0,00	$0		$0	$0
Toe buttress, fill mat'l A		m3		#N/A	$0,00	$0		$0	$0
Toe buttress, fill mat'l B		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER ROCK PILE									
NPAG UM waste rock cover (4 m thick)		m3	514285	SB3L	$5,10	$2 622 854	50%	$1 311 427	$1 311 427
Subgrade preparation - doze surface		m3		#N/A	$0,00	$0		$0	$0
Soil cover - excavate,haul,spread&compact		m3		#N/A	$0,00	$0		$0	$0
Rock cover - excavate,haul & spread		m3		#N/A	$0,00	$0		$0	$0
Excavate downslope drainage channel & chute		m3		#N/A	$0,00	$0		$0	$0
Rip rap drainage channel and chute		m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER SUMPS									
NPAG UM waste rock cover (4 m thick)		m3	6800	SB3L	$5,10	$34 680	50%	$17 340	$17 340
Other				#N/A	$0,00	$0		$0	$0
VERY LOW PERMEABILITY COVER (in addition to above)									
Liner subgrade preparation - compact		m2		#N/A	$0,00	$0		$0	$0
Supply geomembrame		m2		#N/A	$0,00	$0		$0	$0
Install geomembrane		m2		#N/A	$0,00	$0		$0	$0
Protective cover - excavate,haul,spread&compact		m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Install infiltration/seepage instrumentation		allow		#N/A	$0,00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0,00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0,00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0,00	$0		$0	$0
CONSTRUCT SEEPAGE COLLECTION POND									
Excavate seepage collection pond		m3		#N/A	$0,00	$0		$0	$0
Doze & spread excavated material		m3		#N/A	$0,00	$0		$0	$0
Vegetate spread material		ha		#N/A	$0,00	$0		$0	$0
Bedding layer		m3		#N/A	$0,00	$0		$0	$0
Supply geomembrane		m2		#N/A	$0,00	$0		$0	$0
Install geomembrane		m2		#N/A	$0,00	$0		$0	$0
Erosion protection layer		m3							
INSTALL GROUNDWATER COLLECTION SYSTEM									
Excavate/install sumps		m3		#N/A	$0,00	$0		$0	$0
Install pumping wells		m3		#N/A	$0,00	$0		$0	$0
Install pumps/pipelines/power supply		allow		#N/A	$0,00	$0		$0	$0
RELOCATE DUMPS									
Load, haul, dump or doze		m3		#N/A	$0,00	$0		$0	$0
Add lime		tonne		#N/A	$0,00	$0		$0	$0
Contour reclaimed area		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
SPECIALIZED ITEMS									
Install permanent instrumentation		each	5	OPS	$10 000,00	$50 000	50%	$25 000	$25 000
Install permanent instrumentation, drilling		each		#N/A	$0,00	$0		$0	$0
TREAT ROCK PILE SEEPAGE - see "Water Treatment"									
HEAP LEACH SEEPAGE TREATMENT - Cyanide Detox									
Cyanide destruction water treatment pumping		m3		#N/A	$0,00	$0		$0	$0
Reagents		tonnes		#N/A	$0,00	$0		$0	$0
Electrician/mechanic to maintain treatment plant		allow		#N/A	$0,00	$0		$0	$0
Equipment maintenance and parts		allow		#N/A	$0,00	$0		$0	$0
					Annual treatment costs	$0			
Number of years of treatment		years							
					Total treatment costs	$0			$0
HEAP LEACH SEEPAGE TREATMENT - ARD/ML**									
Upgrade/modify pumping system - report to WTP		allow		#N/A	$0,00	$0			$0
					Total	$2 707 534		$1 353 767	$1 353 767
					% of Total			50%	50%

* For construction of passive treatment system refer to "Water Management". ARD/ML seepage treatment becomes post-closure water treatment cost

**Heap leach ARD/ML seepage treatment becomes post-closure water treatment cost

Rock Pile Name: **Vault** ***1***

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
COVER ROCK PILE									
Flatten slopes with dozer		m3		#N/A	$0,00	$0		$0	$0
Flatten "bubble dump" areas		m3		#N/A	$0,00	$0		$0	$0
Divert runon, ditch mat'l A		m3		#N/A	$0,00	$0		$0	$0
Divert runon, ditch mat'l B		m3		#N/A	$0,00	$0		$0	$0
Toe buttress, drain mat'l		m3		#N/A	$0,00	$0		$0	$0
Toe buttress, fill mat'l A		m3		#N/A	$0,00	$0		$0	$0
Toe buttress, fill mat'l B		m3		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER ROCK PILE									
NPAG UM waste rock cover (4 m thick)		m3	0	SB3L	$5,10	$0		$0	$0
Subgrade preparation - doze surface		m3		#N/A	$0,00	$0		$0	$0
Soil cover - excavate,haul,spread&compact		m3		#N/A	$0,00	$0		$0	$0
Rock cover - excavate,haul & spread		m3		#N/A	$0,00	$0		$0	$0
Excavate downslope drainage channel & chute		m3		#N/A	$0,00	$0		$0	$0
Rip rap drainage channel and chute		m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
COVER SUMPS									
NPAG UM waste rock cover (4 m thick)		m3	0	#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
VERY LOW PERMEABILITY COVER (in addition to above)									
Liner subgrade preparation - compact		m2		#N/A	$0,00	$0		$0	$0
Supply geomembrame		m2		#N/A	$0,00	$0		$0	$0
Install geomembrane		m2		#N/A	$0,00	$0		$0	$0
Protective cover - excavate,haul,spread&compact		m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Install infiltration/seepage instrumentation		allow		#N/A	$0,00	$0		$0	$0
CONSTRUCT DIVERSION DITCHES									
Excavate ditches -soil		m3		#N/A	$0,00	$0		$0	$0
Excavate ditches -rock		m3		#N/A	$0,00	$0		$0	$0
Rip rap in channel base		m3		#N/A	$0,00	$0		$0	$0
CONSTRUCT SEEPAGE COLLECTION POND									
Excavate seepage collection pond		m3		#N/A	$0,00	$0		$0	$0
Doze & spread excavated material		m3		#N/A	$0,00	$0		$0	$0
Vegetate spread material		ha		#N/A	$0,00	$0		$0	$0
Bedding layer		m3		#N/A	$0,00	$0		$0	$0
Supply geomembrane		m2		#N/A	$0,00	$0		$0	$0
Install geomembrane		m2		#N/A	$0,00	$0		$0	$0
Erosion protection layer		m3							
INSTALL GROUNDWATER COLLECTION SYSTEM									
Excavate/install sumps		m3		#N/A	$0,00	$0		$0	$0
Install pumping wells		m3		#N/A	$0,00	$0		$0	$0
Install pumps/pipelines/power supply		allow		#N/A	$0,00	$0		$0	$0
RELOCATE DUMPS									
Load, haul, dump or doze		m3		#N/A	$0,00	$0		$0	$0
Add lime		tonne		#N/A	$0,00	$0		$0	$0
Contour reclaimed area		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
SPECIALIZED ITEMS									
Install permanent instrumentation		each	3	OPS	$10 000,00	$30 000	50%	$15 000	$15 000
Install permanent instrumentation, drilling		each		#N/A	$0,00	$0		$0	$0
TREAT ROCK PILE SEEPAGE - see "Water Treatment"									
HEAP LEACH SEEPAGE TREATMENT - Cyanide Detox									
Cyanide destruction water treatment pumping		m3		#N/A	$0,00	$0		$0	$0
Reagents		tonnes		#N/A	$0,00	$0		$0	$0
Electrician/mechanic to maintain treatment plant		allow		#N/A	$0,00	$0		$0	$0
Equipment maintenance and parts		allow		#N/A	$0,00	$0		$0	$0
				Annual treatment costs		$0			
Number of years of treatment		years							
				Total treatment costs		$0			$0
HEAP LEACH SEEPAGE TREATMENT - ARD/ML**									
Upgrade/modify pumping system - report to WTP		allow		#N/A	$0,00	$0			$0
					Total	$30 000		$15 000	$15 000
					% of Total			50%	50%

* For construction of passive treatment system refer to "Water Management". ARD/ML seepage treatment becomes post-closure water treatment cost

**Heap leach ARD/ML seepage treatment becomes post-closure water treatment cost

3 **Building / Equip Name:** **Meadowbank** **Bldg / Equip #:** **1**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
DISPOSE MOBILE EQUIPMENT									
Decontaminate and ship off-site		allow		#N/A	$0,00	$0		$0	$0
Decontaminate and dispose on-site		manhours	1088	MECHL	$49,00	$53 312	50%	$26 656	$26 656
Other				#N/A	$0,00	$0		$0	$0
REMOVE BUILDINGS - see note below									
Mill Complex:									
Mill		m2	37800	BRS1H	$65,00	$2 457 000	50%	$1 228 500	$1 228 500
Leech Tanks		m2	12500	BRS1H	$65,00	$812 500	50%	$406 250	$406 250
Primary and Secondary Crusher		m2	740	BRS1H	$65,00	$48 100	50%	$24 050	$24 050
Pebble Crusher		m2	650	BRS1H	$65,00	$42 250	50%	$21 125	$21 125
Conveyors		m2	1950	BRS1H	$65,00	$126 750	50%	$63 375	$63 375
Assay Lab		m2	440	BRS1L	$45,00	$19 800	50%	$9 900	$9 900
Accomodation Complex (Inc. Nova Camp)		m2	17005	BRS1L	$45,00	$765 225	50%	$382 613	$382 613
Services Building		m2	13080	BRS1L	$45,00	$588 600	50%	$294 300	$294 300
Site Services Building		m2	500	BRS1L	$45,00	$22 500	50%	$11 250	$11 250
Dome Warehouse		m2	2854	BRS1L	$45,00	$128 430	50%	$64 215	$64 215
Ore Dome		m2	21000	BRS1L	$45,00	$945 000	50%	$472 500	$472 500
Power Plant		m2	7455	BRS1H	$65,00	$484 575	50%	$242 288	$242 288
Cat Warehouse		m2	2690	BRS1L	$45,00	$121 050	50%	$60 525	$60 525
Toromont Facilities		m2	925	BRS1L	$45,00	$41 625	50%	$20 813	$20 813
Fountain Tire		m2	330	BRS1L	$45,00	$14 850	50%	$7 425	$7 425
White Coverall		m2	2790	BRS1L	$45,00	$125 550	50%	$62 775	$62 775
Batch Plant		m2	2100	BRS1L	$45,00	$94 500	50%	$47 250	$47 250
Environmental Office		m2	140	BRS1L	$45,00	$6 300	50%	$3 150	$3 150
Dike Dewatering Shop		m2	755	BRS1L	$45,00	$33 975	50%	$16 988	$16 988
Incinerator		m2	280	BRS1L	$45,00	$12 600	50%	$6 300	$6 300
Talbon Shop		m2	235	BRS1L	$45,00	$10 575	50%	$5 288	$5 288
Blue Coverall		m2	710	BRS1L	$45,00	$31 950	50%	$15 975	$15 975
Gate House		m2	100	BRS1L	$45,00	$4 500	50%	$2 250	$2 250
Fuel Dispensing Station		m2	165	BRS1H	$65,00	$10 725	50%	$5 363	$5 363
Emulsion Plant		m2	2000	BRS1H	$65,00	$130 000	50%	$65 000	$65 000
Bulk Fuel Tank		m2	1910	BRS1H	$65,00	$124 150	50%	$62 075	$62 075
Containers to Landfill		mt	3500	OPS	$20,00	$70 000	50%	$35 000	$35 000
Other				#N/A	$0,00	$0		$0	$0
BREAK BASEMENT SLABS									
Puncture Concrete Foundations		m2	25211	BRCS	$6,00	$151 266	50%	$75 633	$75 633
LANDFILL FOR DEMOLITION WASTE									
Place rock cover	Blast rock fill	m3		#N/A	$0,00	$0		$0	$0
Place soil cover	Soil Cap - Landfill and Septic Field	m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
GRADE AND CONTOUR PADS									
Accomodation Complex		ha		#N/A	$0,00	$0		$0	$0
Process Facilities		ha		#N/A	$0,00	$0		$0	$0
Offices, Repair, Lab, Warehouse		ha		#N/A	$0,00	$0		$0	$0
Storage Facilites		ha		#N/A	$0,00	$0		$0	$0
Water and Wastewater Treatment Facilities		ha		#N/A	$0,00	$0		$0	$0
U/G Heating Plant		ha		#N/A	$0,00	$0		$0	$0
Emulsion Plant		ha		#N/A	$0,00	$0		$0	$0
Warehouse, Shops and Other		ha		#N/A	$0,00	$0		$0	$0
Place rock cover		m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
PUNCTURE LINED SUMPS									
Puncture liner and place soil cover		m3		#N/A	$0,00	$0		$0	$0
RECLAIM ROADS, LAYDOWN AREA & AIRSTRIP									
Remove culverts		each	15	OPS	$4 000,00	$60 000	50%	$30 000	$30 000
Install Water Breaks		allow	1	OPS	$40 000,00	$40 000	50%	$20 000	$20 000
Scarify airstriip		ha	4,1	SCFYL	$4 300,00	$17 630	50%	$8 815	$8 815
Scarify laydown areas		ha		#N/A	$0,00	$0	50%	$0	$0
Scarify access roads (~10 m x 12 km)		ha	12	SCFYL	$4 300,00	$51 600	50%	$25 800	$25 800
Scarify haul roads (~25 m x 14.5 km)		ha	36,3	SCFYL	$4 300,00	$156 090	50%	$78 045	$78 045
Scarify Portage/Mill Disturbed Area		ha	40,6	SCFYL	$4 300,00	$174 580	50%	$87 290	$87 290
Scarify Vault Disturbed Area		ha	6,5	SCFYL	$4 300,00	$27 950	50%	$13 975	$13 975
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
SPECIALIZED ITEMS									
Dispose of misc. debris and laydown area refuse				#N/A	$0,00	$0		$0	$0
					Total	$8 005 508		$4 002 754	$4 002 754
					% of Total			50%	50%

Note: Unit costs are based on 3m high, single storey building. Scale larger building areas accordingly. E.g. 10m high building multiply area by 3.3 (10/3)

Building / Equip Name: **Baker Lake** **Bldg / Equip #:** 2

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
DISPOSE MOBILE EQUIPMENT									
Decontaminate and ship off-site		allow		#N/A	$0,00	$0		$0	$0
Decontaminate and dispose on-site		allow		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
REMOVE BUILDINGS - see note below									
Mill Complex:									
Mill		m2		#N/A	$0,00	$0	50%	$0	$0
Leech Tanks		m2		#N/A	$0,00	$0	50%	$0	$0
Primary and Secondary Crusher		m2		#N/A	$0,00	$0	50%	$0	$0
Pebble Crusher		m2		#N/A	$0,00	$0	50%	$0	$0
Conveyors		m2		#N/A	$0,00	$0	50%	$0	$0
Assay Lab		m2		#N/A	$0,00	$0	50%	$0	$0
Accomodation Complex (Inc. Nova Camp)		m2		#N/A	$0,00	$0	50%	$0	$0
Services Building		m2		#N/A	$0,00	$0	50%	$0	$0
Site Services Building		m2		#N/A	$0,00	$0	50%	$0	$0
Dome Warehouse		m2		#N/A	$0,00	$0	50%	$0	$0
Ore Dome		m2		#N/A	$0,00	$0	50%	$0	$0
Power Plant		m2		#N/A	$0,00	$0	50%	$0	$0
Cat Warehouse		m2		#N/A	$0,00	$0	50%	$0	$0
Toromont Facilities		m2		#N/A	$0,00	$0	50%	$0	$0
Fountain Tire		m2		#N/A	$0,00	$0	50%	$0	$0
White Coverall		m2		#N/A	$0,00	$0	50%	$0	$0
Batch Plant		m2		#N/A	$0,00	$0	50%	$0	$0
Environmental Office		m2		#N/A	$0,00	$0	50%	$0	$0
Dike Dewatering Shop		m2		#N/A	$0,00	$0	50%	$0	$0
Incinerator		m2		#N/A	$0,00	$0	50%	$0	$0
Talbon Shop		m2		#N/A	$0,00	$0	50%	$0	$0
Blue Coverall		m2		#N/A	$0,00	$0	50%	$0	$0
Gate House		m2		#N/A	$0,00	$0	50%	$0	$0
Fuel Dispensing Station		m2		#N/A	$0,00	$0	50%	$0	$0
Emulsion Plant		m2		#N/A	$0,00	$0	50%	$0	$0
Bulk Fuel Tank		m2		#N/A	$0,00	$0	50%	$0	$0
Containers to Landfill		each		#N/A	$0,00	$0	50%	$0	$0
10,000,000L Diesel Fuel Tanks		m2	21180	BRS1H	$65,00	$1 376 700	50%	$688 350	$688 350
100,000L Jet Fuel Tanks		m2	720	BRS1L	$45,00	$32 400	50%	$16 200	$16 200
Other				#N/A	$0,00	$0		$0	$0
BREAK BASEMENT SLABS									
Puncture Concrete Foundations		m2	6095	BRCS	$6,00	$36 570	50%	$18 285	$18 285
LANDFILL FOR DEMOLITION WASTE									
Place rock cover	Blast rock fill	m3		#N/A	$0,00	$0		$0	$0
Place soil cover	Soil Cap - Landfill and Septic Field	m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
GRADE AND CONTOUR PADS									
Accomodation Complex		ha		#N/A	$0,00	$0		$0	$0
Process Facilities		ha		#N/A	$0,00	$0		$0	$0
Offices, Repair, Lab, Warehouse		ha		#N/A	$0,00	$0		$0	$0
Storage Facilites		ha		#N/A	$0,00	$0		$0	$0
Water and Wastewater Treatment Facilities		ha		#N/A	$0,00	$0		$0	$0
U/G Heating Plant		ha		#N/A	$0,00	$0		$0	$0
Emulsion Plant		ha		#N/A	$0,00	$0		$0	$0
Warehouse, Shops and Other		ha		#N/A	$0,00	$0		$0	$0
Place rock cover		m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
PUNCTURE LINED SUMPS									
Puncture liner and place soil cover		m3		#N/A	$0,00	$0		$0	$0
RECLAIM ROADS, LAYDOWN AREA & AIRSTRIP									
Remove culverts		each		#N/A	$0,00	$0	50%	$0	$0
Scarify and install water breaks		ha		#N/A	$0,00	$0	50%	$0	$0
Scarify airstriip		ha		#N/A	$0,00	$0	50%	$0	$0
Scarify laydown areas		ha	50	SCFYL	$4 300,00	$215 000	50%	$107 500	$107 500
Scarify access roads (~10 m x 10 km)		ha		#N/A	$0,00	$0	50%	$0	$0
Scarify haul roads (~25 m x 14.5 km)		ha		#N/A	$0,00	$0	50%	$0	$0
Scarify Portage/Mill Disturbed Area		ha		#N/A	$0,00	$0	50%	$0	$0
Scarify Vault Disturbed Area		ha		#N/A	$0,00	$0	50%	$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
SPECIALIZED ITEMS									
Dispose of misc. debris and laydown area refuse				#N/A	$0,00	$0		$0	$0
					Total	$1 660 670		$830 335	$830 335
					% of Total			50%	50%

Note: Unit costs are based on 3m high, single storey building. Scale larger building areas accordingly. E.g. 10m high building multiply area by 3.3 (10/3)

Building / Equip Name: **AWAR** **Bldg / Equip #: 3**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
DISPOSE MOBILE EQUIPMENT									
Decontaminate and ship off-site		allow		#N/A	$0,00	$0		$0	$0
Decontaminate and dispose on-site		allow		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
REMOVE BUILDINGS - see note below									
Mill Complex:									
Mill		m2		#N/A	$0,00	$0	50%	$0	$0
Leech Tanks		m2		#N/A	$0,00	$0	50%	$0	$0
Primary and Secondary Crusher		m2		#N/A	$0,00	$0	50%	$0	$0
Pebble Crusher		m2		#N/A	$0,00	$0	50%	$0	$0
Conveyors		m2		#N/A	$0,00	$0	50%	$0	$0
Assay Lab		m2		#N/A	$0,00	$0	50%	$0	$0
Accomodation Complex (Inc. Nova Camp)		m2		#N/A	$0,00	$0	50%	$0	$0
Services Building		m2		#N/A	$0,00	$0	50%	$0	$0
Site Services Building		m2		#N/A	$0,00	$0	50%	$0	$0
Dome Warehouse		m2		#N/A	$0,00	$0	50%	$0	$0
Ore Dome		m2		#N/A	$0,00	$0	50%	$0	$0
Power Plant		m2		#N/A	$0,00	$0	50%	$0	$0
Cat Warehouse		m2		#N/A	$0,00	$0	50%	$0	$0
Toromont Facilities		m2		#N/A	$0,00	$0	50%	$0	$0
Fountain Tire		m2		#N/A	$0,00	$0	50%	$0	$0
White Coverall		m2		#N/A	$0,00	$0	50%	$0	$0
Batch Plant		m2		#N/A	$0,00	$0	50%	$0	$0
Environmental Office		m2		#N/A	$0,00	$0	50%	$0	$0
Dike Dewatering Shop		m2		#N/A	$0,00	$0	50%	$0	$0
Incinerator		m2		#N/A	$0,00	$0	50%	$0	$0
Talbon Shop		m2		#N/A	$0,00	$0	50%	$0	$0
Blue Coverall		m2		#N/A	$0,00	$0	50%	$0	$0
Gate House		m2		#N/A	$0,00	$0	50%	$0	$0
Fuel Dispensing Station		m2		#N/A	$0,00	$0	50%	$0	$0
Emulsion Plant		m2		#N/A	$0,00	$0	50%	$0	$0
Bulk Fuel Tank		m2		#N/A	$0,00	$0	50%	$0	$0
Containers to Landfill		each		#N/A	$0,00	$0	50%	$0	$0
Other				#N/A	$0,00	$0		$0	$0
BREAK BASEMENT SLABS									
Puncture Concrete Foundations		m2		#N/A	$0,00	$0	50%	$0	$0
LANDFILL FOR DEMOLITION WASTE									
Place rock cover	Blast rock fill	m3		#N/A	$0,00	$0		$0	$0
Place soil cover	Soil Cap - Landfill and Septic Field	m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
GRADE AND CONTOUR PADS									
Accomodation Complex		ha		#N/A	$0,00	$0		$0	$0
Process Facilities		ha		#N/A	$0,00	$0		$0	$0
Offices, Repair, Lab, Warehouse		ha		#N/A	$0,00	$0		$0	$0
Storage Facilites		ha		#N/A	$0,00	$0		$0	$0
Water and Wastewater Treatment Facilities		ha		#N/A	$0,00	$0		$0	$0
U/G Heating Plant		ha		#N/A	$0,00	$0		$0	$0
Emulsion Plant		ha		#N/A	$0,00	$0		$0	$0
Warehouse, Shops and Other		ha		#N/A	$0,00	$0		$0	$0
Place rock cover		m3		#N/A	$0,00	$0		$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
PUNCTURE LINED SUMPS									
Puncture liner and place soil cover		m3		#N/A	$0,00	$0		$0	$0
RECLAIM QUARRIEST									
Drill and blast slopes to 1:1		m3	14319	RB3H	$17,80	$254 878	50%	$127 439	$127 439
RECLAIM ROADS									
Remove culverts		each	38	OPS	$4 000,00	$152 000	50%	$76 000	$76 000
Remove bridges (clear Span bridges and HADD bridges)		each	9	OPS	$25 000,00	$225 000	50%	$112 500	$112 500
Scarify and install water breaks		ha	84	SCFYL	$4 300,00	$361 200	50%	$180 600	$180 600
Scarify airstriip		ha		#N/A	$0,00	$0	50%	$0	$0
Scarify laydown areas		ha		#N/A	$0,00	$0	50%	$0	$0
Vegetate		ha		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
SPECIALIZED ITEMS									
Dispose of misc. debris and laydown area refuse				#N/A	$0,00	$0		$0	$0
					Total	$993 078		$496 539	$496 539
					% of Total			50%	50%

Note: Unit costs are based on 3m high, single storey building. Scale larger building areas accordingly. E.g. 10m high building multiply area by 3.3 (10/3)

1 **Chemicals/Soil Area Name:**

Note: The procedures, equipment and packaging for clean up and removal of chemicals or contaminated soils are highly dependent on the nature of the chemicals and their existing state of containment. Government guidelines should be consulted on an individual chemical basis. Any estimate made here should be considered very rough unless specific evaluations have been conducted.

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost	% Land	Land Cost	Water Cost
HAZARDOUS MATERIALS AUDIT									
Hazardous materials audit		mandays	1	#N/A	$0,00	$0		$0	$0
BUILDING DECONTAMINATION & CONSOLIDATION OF HAZARDOUS MATERIALS									
Environmental technician/coordinator		mandays		#N/A	$0,00	$0		$0	$0
Decontaminate: oil, fuel		mandays		#N/A	$0,00	$0		$0	$0
Decontaminate maintenance shop		mandays	10	OPS	$1 000,00	$10 000	50%	$5 000	$5 000
Decontaminate power plant		mandays	10	OPS	$1 000,00	$10 000	50%	$5 000	$5 000
Decontaminate bulk fuel storage		mandays	10	OPS	$1 000,00	$10 000	50%	$5 000	$5 000
Decontaminate ANFO plant		mandays	3	OPS	$1 000,00	$3 000	50%	$1 500	$1 500
Decontaminate offices/warehouse/accom		mandays		#N/A	$0,00	$0		$0	$0
Removal of asbestos siding on buildings		m2		#N/A	$0,00	$0		$0	$0
Removal of friable asbestos on equipment		m2		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
HAZARDOUS MATERIALS REMOVAL									
Waste oils		litre	0	#N/A	$0,00	$0		$0	$0
Waste fuel		litre	309000	ORL	$0,43	$132 870	50%	$66 435	$66 435
Oily/Glycol contaminated water		litre	58456	ORL	$0,43	$25 136	50%	$12 568	$12 568
Waste batteries		each	1	OPS	$3 000,00	$3 000	50%	$1 500	$1 500
Assay & environmental lab reagents		kg	10000	PCRH	$2,50	$25 000	50%	$12 500	$12 500
Mill and Water Treatment Reagents		kg	285614	PCRH	$2,50	$714 035	50%	$357 018	$357 018
Machine shop paints, solvents, filters etc		each	1	OPS	$20 000,00	$20 000	50%	$10 000	$10 000
Glycol		kg	16170	PCRH	$2,50	$40 425	50%	$20 213	$20 213
Process reagents		kg		#N/A	$0,00	$0		$0	$0
Nuclear sources		allow		#N/A	$0,00	$0		$0	$0
Other hazardous materials		allow		#N/A	$0,00	$0		$0	$0
HAZARDOUS MATERIALS									
Transportation to disposal facility		allow		#N/A	$0,00	$0		$0	$0
Disposal fees		allow		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
CONTAMINATED SOILS									
Contam. soil investigation - Phase 1		each	1	CS1L	$7 500,00	$7 500	50%	$3 750	$3 750
Contam. soil investigation - Phase 2		each	1	CS2L	$50 000,00	$50 000	50%	$25 000	$25 000
CONTAMINATED SOIL REMOVAL									
Excavate and transport to onsite facility		m3	0	#N/A	$0,00	$0		$0	$0
Manage hydrocarbon remediation at facility		m3	2745	CSRL	$47,00	$129 015	50%	$64 508	$64 508
Reagents/stabilizing agent		m2		#N/A	$0,00	$0	50%	$0	$0
Excavate and transport to offsite facility		m3	137	OPS	$1 000,00	$137 000	50%	$68 500	$68 500
Contour decontaminated area		m3		#N/A	$0,00	$0		$0	$0
CONTAMINATED SOIL VERY LOW PERMEABILITY COVER									
Supply geomembrame, HDPE, ES3, GCL		m2		#N/A	$0,00	$0		$0	$0
Upper and lower bedding layers		m3		#N/A	$0,00	$0		$0	$0
Install geomembrane, HDPE, ES3, GCL		m2		#N/A	$0,00	$0		$0	$0
Erosion protection layer		m3		#N/A	$0,00	$0		$0	$0
Vegetate		m2		#N/A	$0,00	$0		$0	$0
Install infiltration/seepage instrumentation		allow		#N/A	$0,00	$0		$0	$0
Other				#N/A	$0,00	$0		$0	$0
OTHER									
				#N/A	$0,00	$0		$0	$0
					Total	$1 316 981		$658 491	$658 491
					% of Total			50%	50%

1 **Capital Expenditures and Short Term Water Treatment identified in 'Instructions' worksheet**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost
FLOOD PITS						
Repurpose/Install dewatering pumps and piping for pit flooding		Allow	1	OPS	$100 000,00	$100 000
Pumped pit flooding water (Third portage Lake and Reclaim Pond) - Portage Pit		m3	31179343	OPS	$0,02	$623 587
Pumped pit flooding water (Third portage Lake) - Goose Pit		m3	3182704	OPS	$0,02	$63 654
Pumped pit flooding water (Wally Lake) - Vault Pit		m3	28051096	OPS	$0,02	$561 022
Pump maintenance and operation (7 yrs)						
Maintain pumps (2 skilled labourer x 12hr days, 4months/yr, 7yrs)		manhours	20832	LAB-SH	$49,60	$1 033 267
Annual Pump Servicing (2 x Manufacturer Consultant x 7days/year x 7 years)		manhours	1176	OPS	$120,00	$141 120
Pump Servicing Travel Allowance (Round Trip Flight/person)		visits	14	OPS	$4 000,00	$56 000
Camp Accomodations		days	1834	ACCML	$100,00	$183 400
DYKE RECONNECTION						
Bay-Goose Dike Reconnection (1-2-3)		m3	94000	SB2L	$4,60	$432 400
Rock placement Bay-Goose (1-2-3)		m3	27900	SB2H	$7,30	$203 670
South Camp Dike Reconnection		m3	24000	SB2L	$4,60	$110 400
Rock placement South Camp Dike		m3	9500	SB2H	$7,30	$69 350
Channel Vault Pit to North Phaser		m3	7000	SB2L	$4,60	$32 200
Rock placement Channel Vault Pit		m3	2300	SB2H	$7,30	$16 790
Vault Pit to Wally Lake Reconnection		m3	27000	SB2L	$4,60	$124 200
Rock Placement Vault Pit Reconnection		m3	10800	SB2H	$7,30	$78 840
Remove fill		m3		#N/A	$0,00	$0
Contour water intake area		m3		#N/A	$0,00	$0
STABILIZE SEDIMENT PONDS/WATER MANAGEMENT PONDS						
Place soil cover		m3		#N/A	$0,00	$0
Doze & spread excavated material		m3		#N/A	$0,00	$0
Vegetate spread material		ha		#N/A	$0,00	$0
Rip rap in channel base		each		#N/A	$0,00	$0
REDIRECT RUNOFF/CONSTRUCT DIVERSION DITCHES						
Excavate ditches -soil		m3		#N/A	$0,00	$0
Excavate ditches -rock		m3		#N/A	$0,00	$0
Stabilize side slopes		m3		#N/A	$0,00	$0
Rip rap in channel base		m3		#N/A	$0,00	$0
BREACH DITCHES (Diversion ditch)						
Excavate breaches		m3		#N/A	$0,00	$0
Backfill/recontour (consider work on 1000m of diversion ditch: 1000m x 4m²)		m3	4000	SB2L	$4,60	$18 400
Install flow dissipation		m3		#N/A	$0,00	$0
Vegetate remainder of ditch		m2		#N/A	$0,00	$0
DECOMISSION FRESH WATER SUPPLY						
Breach embankment		m		#N/A	$0,00	$0
Remove pump/barge		Allow	1	OPS	$3 000,00	$3 000
Remove pipeline		m	1000	PLRL	$22,00	$22 000
WATER CONTROL IN RECLAMATION QUARRY						
Install pumping system		LS		#N/A	$0,00	$0
Remove pumping system		LS		#N/A	$0,00	$0
REMOVE PIPELINES						
Remove pipes		m	2000	PLRL	$22,00	$44 000
Concrete plug deep pipes		m3		#N/A	$0,00	$0
Other - diffuser		each	2	OPS	$3 000,00	$6 000
GROUNDWATER COLLECTION SYSTEM						
Excavate/install sumps		m3		#N/A	$0,00	$0
Install pumping wells		m3		#N/A	$0,00	$0
Install pumps/pipelines/power supply		LS		#N/A	$0,00	$0
CONSTRUCT CONTAMINATED WATER STORAGE POND						
Excavate pond		m3		#N/A	$0,00	$0
Doze & spread excavated material		m3		#N/A	$0,00	$0
Vegetate spread material		ha		#N/A	$0,00	$0
Bedding layer		m3		#N/A	$0,00	$0
Supply geomembrane		m2		#N/A	$0,00	$0
Install geomembrane		m2		#N/A	$0,00	$0
Erosion protection layer		m3		#N/A	$0,00	$0
CONSTRUCT PASSIVE TREATMENT SYSTEM (e.g. Constructed Wetland)						
Construct access roads		km		#N/A	$0,00	$0
Install HDPE piping system from collection pond		m		#N/A	$0,00	$0
Inter-cell flow structures		allow		#N/A	$0,00	$0
Install liners		m2		#N/A	$0,00	$0
Install growth media		m3		#N/A	$0,00	$0
Wetland vegetation		ha		#N/A	$0,00	$0
CONSTRUCT TEMPORARY WATER TREATMENT PLANT (If Necessary)						
Build treatment plant		LS		#N/A	$0,00	$0
Build sludge containment facility		LS		#N/A	$0,00	$0
Storage, Prep and Reactor Tanks/Silos		Allow	1	OPS	$855 000,00	$855 000
Mech. Equip. (Metering Pumps and Air)		Allow	1	OPS	$385 000,00	$385 000
Piping		%	30		$372 000,00	$372 000
Electrical		%	15		$186 000,00	$186 000
Instrumentation and Controls		%	15		$186 000,00	$186 000
Equipment Installation Costs		%	35		$434 000,00	$434 000
DECOMMISION TEMPORARY WATER TREATMENT PLANT (If Necessary)						
Decontaminate and dispose equipment on site		manhours	540	LAB-USL	$31,00	$16 740
Camp Accomodations		days	45	ACCML	$100,00	$4 500
Demolish Structure		m2	1500	BRS1L	$45,00	$67 500
Scarify Footprint		ha	0,15	SCFYH	$6 030,00	$905
SHORT TERM WATER TREATMENT*						
Annual water treatment cost, from "Water Treatment"						$0
					Total	$6 430 945

For cost of long-term/post-closure water treatment see "WATER TREATMENT" Worksheet"

1 **Water Treatment**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost
OPERATE TEMPORARY WATER TREATMENT PLANT **(3 YEARS CONSIDERED)**						
Reagent Allowance		allow	1	OPS	$150 000,00	$150 000
Direct Pumping cost		m3	177089	OPS	$0,07	$11 511
Skilled Labourer (1 skilled labourers X 12hr/day, 6 Months/year)		manhours	2160	OPER-WTH	$59,86	$129 298
Annual Treatment Plant Servicing (2 Consultants x 7days/year)		manhours	168	OPS	$120,00	$20 160
Treatment Plant Servicing Travel Allowance (Round Trip Flight/person)		visits	2	OPS	$4 000,00	$8 000
Camp Accomodations		days	180	ACCML	$100,00	$18 000
ADDITION OF REAGENTS						
H2O2		kg		#N/A	$0,00	$0
lime		kg		#N/A	$0,00	$0
ferric sulphate		kg		#N/A	$0,00	$0
ferrous sulphate		kg		#N/A	$0,00	$0
flocculents		kg		#N/A	$0,00	$0
Other				#N/A	$0,00	$0
LABOUR AND SUPPLIES						
Annual fuel		litres		#N/A	$0,00	$0
Annual power		kW-h		#N/A	$0,00	$0
Electrician/mechanic to maintain treatment plant		allow		#N/A	$0,00	$0
Equipment maintenance and parts		allow		#N/A	$0,00	$0
Misc. supplies, hoses, tools		allow		#N/A	$0,00	$0
Communications		allow		#N/A	$0,00	$0
Other				#N/A	$0,00	$0
WATER SAMPLING AND ANALYSES						
Sampling equipment		allow		#N/A	$0,00	$0
Analyses		allow		#N/A	$0,00	$0
Shipping to laboratory		allow		#N/A	$0,00	$0
Reporting		allow		#N/A	$0,00	$0
Other				#N/A	$0,00	$0
SITE ACCESS						
Road maintenance (incl. snow removal)		allow		#N/A	$0,00	$0
Winter road tariff		allow		#N/A	$0,00	$0
Truck rental		allow		#N/A	$0,00	$0
Air support		allow		#N/A	$0,00	$0
					Annual water treatment costs	$336 968
Number of years of water treatment		years	3			
					Total	$1 010 905

Assume 3 years of treatment for reclaim water

1 **Interim Care and Maintenance**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost
INTERIM CARE & MAINTENANCE						
on-site caretaker		manmonths		#N/A	0	$0
extra personnel		manmonths		#N/A	0	$0
-electrician		manmonths		#N/A	0	$0
-mechanic		manmonths		#N/A	0	$0
annual fuel		litre		#N/A	0	$0
misc. supplies		allow		#N/A	0	$0
pick-up truck		each		#N/A	0	$0
small dozer		allow		#N/A	0	$0
small excavator		allow		#N/A	0	$0
snow machine		allow		#N/A	0	$0
communications		allow		#N/A	0	$0
SNP/AEMP water sampling & reporting		each		#N/A	0	$0
geotechnical assessment		each		#N/A	0	$0
interim water treatment				#N/A		$336 968
Maintenance, Surveillance, Monitoring and inspection - Active Closure				#N/A		$282 600
other		each		#N/A	0	$0
			Annual	Interim C&M Cost		$619 568
Number of years of ICM		years	3		**Total**	$1 858 705

m **Post-Closure Monitoring & Maintenance:**

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost
MONITORING & INSPECTIONS - **ACTIVE CLOSURE (2022 to 2030)**						
Monitoring programs (Meadowbank and AWAR)		each		#N/A	$0,00	$0
- Active closure		each	1	OPS	$100 000,00	$100 000
- Post-closure		each		#N/A	$0,00	$0
Annual geotechnical inspection		each		#N/A	$0,00	$0
- Active closure (1 eng, 7 days, 150$/h, + report at 5000$, 2500$ of transport, 700$ of accommodation)		each	1	OPS	$20 800,00	$20 800
- Post-closure		each		#N/A	$0,00	$0
Groundwater monitoring		each	1	OPS	$10 000,00	$10 000
Survey inspection		each		#N/A	$0,00	$0
Regulatory costs*		each	1	OPS	$15 500,00	$15 500
Site water monitoring		each		#N/A	$0,00	$0
- Active closure		each	1	OPS	$73 100,00	$73 100
- Post-closure		each		#N/A	$0,00	$0
Air Quality Monitoring Program (AQMP)		each		#N/A	$0,00	$0
Wildlife Effects Monitoring Program (WEMP)		each		#N/A	$0,00	$0
Vegetation Monitoring		each		#N/A	$0,00	$0
Other				#N/A	$0,00	$0
COVER MAINTENANCE - **ACTIVE CLOSURE (2022 to 2030)**						
Repair erosion - infill gullies		allow		#N/A	$0,00	$0
Repair erosion - upgrade diversion ditches		allow		#N/A	$0,00	$0
Remove problem vegetation		allow		#N/A	$0,00	$0
Repair animal damage		allow		#N/A	$0,00	$0
Repair/upgrade access controls		allow		#N/A	$0,00	$0
Other				#N/A	$0,00	$0
SPILLWAY MAINTENANCE - **ACTIVE CLOSURE (2022 to 2030)**						
Repair erosion		m3		#N/A	$0,00	$0
Clear spillway		each		#N/A	$0,00	$0
CWTS MAINTENANCE - **ACTIVE CLOSURE (2022 to 2030)**						
Maintain flow, restore vegetation		allow		#N/A	$0,00	$0
MAINTENANCE AND SURVEILLANCE - **ACTIVE CLOSURE (2022 to 2030)**						
Site care-taker		manhours	480	OPERH	$65,00	$31 200
Site Vehicle and equipment		allow	1	OPS	$20 000,00	$20 000
Accommodations		mandays	20	ACCML	$100,00	$2 000
Site Maintenance		allow	1	OPS	$10 000,00	$10 000
Subtotal, Annual active-closure costs						$282 600
Discount rate for calculation of net present value of active-closure cost, %				3,00%		
Number of years of active-closure activity				9	years	
Present Value of payment stream (at Year 2022) - Active closure (2022 to 2030)						$2 200 354
MONITORING & INSPECTIONS - **POST CLOSURE (2031 to 2041)**						
Monitoring programs (Meadowbank and AWAR)		each		#N/A	$0,00	$0
- Active closure		each		#N/A	$0,00	$0
- Post-closure		each	0,5	OPS	$100 000,00	$50 000
Annual geotechnical inspection		each		#N/A	$0,00	$0
- Active closure		each		#N/A	$0,00	$0
- Post-closure (1 eng, 7 days, 150$/h, + report at 5000$, 2500$ of transport, 700$ of accommodation)		each	1	OPS	$20 800,00	$20 800
Groundwater monitoring		each	1	OPS	$10 000,00	$10 000
Survey inspection		each		#N/A	$0,00	$0
Regulatory costs*		each	1	OPS	$15 500,00	$15 500
Site water monitoring		each		#N/A	$0,00	$0
- Active closure		each		#N/A	$0,00	$0
- Post-closure		each	1	OPS	$49 432,00	$49 432
Air Quality Monitoring Program (AQMP)		each		#N/A	$0,00	$0
Wildlife Effects Monitoring Program (WEMP)		each		#N/A	$0,00	$0
Vegetation Monitoring		each		#N/A	$0,00	$0
Other				#N/A	$0,00	$0
COVER MAINTENANCE - **POST CLOSURE (2031 to 2041)**						
Repair erosion - infill gullies		allow		#N/A	$0,00	$0
Repair erosion - upgrade diversion ditches		allow		#N/A	$0,00	$0
Remove problem vegetation		allow		#N/A	$0,00	$0
Repair animal damage		allow		#N/A	$0,00	$0
Repair/upgrade access controls		allow		#N/A	$0,00	$0
Other				#N/A	$0,00	$0
SPILLWAY MAINTENANCE - **POST CLOSURE (2031 to 2041)**						
Repair erosion		m3		#N/A	$0,00	$0
Clear spillway		each		#N/A	$0,00	$0
CWTS MAINTENANCE - **POST CLOSURE (2031 to 2041)**						
Maintain flow, restore vegetation		allow		#N/A	$0,00	$0
MAINTENANCE AND SURVEILLANCE - **POST CLOSURE (2031 to 2041)**						
Site care-taker		manhours	480	OPERH	$65,00	$31 200
Site Vehicle and equipment		allow	1	OPS	$20 000,00	$20 000
Accommodations		mandays	20	ACCML	$100,00	$2 000
Site Maintenance		allow	1	OPS	$10 000,00	$10 000
Subtotal, Annual post-closure costs						$208 932
Discount rate for calculation of net present value of post-closure cost, %				3,00%		
Number of years of post-closure activity				11	years	
Present Value of payment stream (at Year 2022) - Post closure (2031 to 2041)						$1 933 169
POST-CLOSURE WATER TREATMENT**						
Annual water treatment cost, from "Water Treatment"						$336 968
Subtotal, Annual post-closure costs						$336 968
Discount rate for calculation of net present value of post-closure cost, %				3,00%		
Number of years of post-closure activity (included in ICM, 3 YEARS)				0	years	
Present Value of payment stream (at Year 2022)						$0
Present Value of payment stream - TOTAL at Year 2022						$4 133 524

*Regulatory costs - annual reporting, management plans, progress reports etc.

1 Mobilization/Demobilization:

ACTIVITY/MATERIAL	Notes	Units	Quantity	Cost Code	Unit Cost	Cost
MOBILIZE HEAVY EQUIPMENT						
Barge to/from Baker Lake		each	2	OPS	500000	$1 000 000
Excavators	5	km	550	mherh	10,25	$5 638
Dump trucks	3	km	330	mherh	10,25	$3 383
Dozers	3	km	330	mherh	10,25	$3 383
Demolition shears	3	km	330	mherh	10,25	$3 383
Crane	1	km	110	mherh	10,25	$1 128
Loader	2	km	220	mherh	10,25	$2 255
Compactor	1	km	110	mherh	10,25	$1 128
Elavator equipements	3	km	330	mherh	10,25	$3 383
other	4	km	440	mherh	10,25	$4 510
Light duty vehicles	4	km	440	mherh	10,25	$4 510
MOBILIZE MISC. EQUIPMENT						
Pump shipping		each		#N/A	0	$0
Pipe shipping		m		#N/A	0	$0
Minor tools and equipment		allow		#N/A	0	$0
Truck tires		allow		#N/A	0	$0
Other	1 lot	each	1	OPS	50000	$50 000
MOBILIZE CAMP						
Reclamation activities		allow		#N/A	0	$0
Long term reclamation activities (eg pump flooding)		allow		#N/A	0	$0
MOBILIZE AND HOUSE WORKERS						
Maintain Camp Accomodations (50 workers, 180 per year, 3 years)		days	27000	accml	100	$2 700 000
Reclamation activities - travel time (50 workers, 4 trips per year, 6h per trip)		hour	1200	lab-usl	31	$37 200
Reclamation activities - transport cost (50 workers, 4 trips per year, 3 years)		each	600	#N/A	2500	$1 500 000
Long term reclamation activities (eg pump flooding) - transport		each		#N/A	0	$0
Long term reclamation activities (eg pump flooding) - travel time		each		#N/A	0	$0
Monitoring Airfare		each		#N/A	0	$0
WORKER ACCOMODATIONS						
Reclamation activities		manmonths		#N/A	0	$0
Long term reclamation activities (eg pump flooding)		each	0		0	$0
Long term reclamation activities (eg pump flooding)		manhours	0	#N/A	0	$0
MOBILIZE FUEL						
Fuel freight - reclamation activities		litre		#N/A	0	$0
Fuel freight - long term reclamation activities		litre		#N/A	0	$0
Fuel freight accomodations		litre		#N/A	0	$0
WINTER ROAD						
Construction and operation		km		#N/A	0	$0
Limited winter use		km		#N/A	0	$0
Winter road tarriff		km		#N/A	0	$0
DEMOBILIZE HEAVY EQUIPMENT						
Excavators	4	km	440	MHERH	10,25	$4 510
Dump trucks	6	km	660	MHERH	10,25	$6 765
Dozers	3	km	330	MHERH	10,25	$3 383
Demolition shears	2	km	220	MHERH	10,25	$2 255
Crane	1	km	110	MHERH	10,25	$1 128
Loader	2	km	220	MHERH	10,25	$2 255
Compactor	1	km	110	MHERH	10,25	$1 128
Light duty vehicles	4	km	440	MHERH	10,25	$4 510
Other						$0
DEMOBILIZE CAMP						
		allow		#N/A	0	$0
DEMOBILIZE WORKERS						
crew travel time		mandays		#N/A	0	$0
crew transportation		each		#N/A	0	$0
WINTER ROAD						
Construction and operation		km		#N/A	0	$0
Limited winter use		km		#N/A	0	$0
Winter road tarriff		km		#N/A	0	$0
					Total	$5 345 830

Unit Cost Table (for refining unit costs see "Estimator" worksheet)

Filter by unit

ITEM	Detail	COST CODE	UNITS	LOW $	HIGH $	SPECIFIED $	COMMENTS
Accomodation							
		ACCM	manday	100,00	175,00		
Buildings - Decontaminate							
	Asbestos	BDA	m2	25,60	51,20		Low: removal of asbestos siding & flooring; High: removal of insulated pipes, friable asbestos
Buildings - Remove							Unit costs are based on 3m high, single storey building. Scale areas accordingly.
	Wood	BRW	m2	27,50	41,00		
	Concrete	BRC	m2	40,00	65,00	6,00	Specified: puncture concrete foundation slabs
	Steel - teardown	BRS1	m2	45,00	65,00		
	Steel - for salvage	BRS2	m2	67,00	100,00		
Concrete work							
	Small pour	CSF	m3	426,50	639,75		Low: YK; High=1.5xLow
	Large pour	CLF	m3	353,50	530,25	2 130,00	Specified: concrete crown pillar
Contaminated Soils							
	ESA Phase 1	CS1	each	7500,00			Low: small, "clean" site
	ESA Phase 1	CS2	each	50000,00			Low: small, "clean" site
	Remediate on site	CSR	m3	47,00	146,00		
Dozing							
	doze rock piles	DR	m3	1,05	2,40		Low cost: doze crest off dump
	doze overburden/soil piles	DS	m3	0,95	3,80		High cost: push up to 300 m
Excavate Rock; Low Spec's and QA/QC							
	drill/blast/load/short haul	RB1	m3	11,40	17,05		Low:quarry operations for bulk fill
	drill/blast/load/long haul	RB2	m3	12,05	17,80		
	RB1 + spread and compact	RB3	m3	12,05	17,80		
	RB2 + spread and compact	RB4	m3	12,50	30,75		
	Specified activity	RBS	m3				
Excavate Rock; High Spec's and QA/QC							(e.g. ditch/spillway excavation)
	drill/blast/load/short haul	RC1	m3	12,05	17,80		Low:foundation excavation;High:spillway excavation
	drill/blast/load/long haul	RC2	m3	12,70	18,40		
	RC1 + spread and compact	RC3	m3	12,70	18,40		e,g, cover construction
	RC2 + spread and compact	RC4	m3	13,50	19,20		e,g, cover construction
	Specified activity	RCS	m3			175,00	Specified-drift excavation
Excavate Rip Rap							
	drill/blast/load/short haul/place	RR1	m3	13,50	17,75		High: quarry & place rip rap in channel
	drill/blast/load/long haul/place	RR2	m3	14,20	20,65		
	source is waste dump/short haul	RR3	m3	7,00			cost includes sorting
	source is waste dump/long haul	RR4	m3	7,60			
	Specified activity	RRS	m3				
Excavate Soil; Low Spec's and QA/QC							
	clear & grub	SBC	m2	3,40	5,00		
	excavate/load/short haul	SB1	m3	4,30	5,90		
	excavate/load/long haul	SB2	m3	4,60	7,30		
	SB1 + spread and compact	SB3	m3	5,10	8,90		Low: non-engineered; High:engineered
	SB2 + spread and compact	SB4	m3	5,50	11,00		Low: non-engineered; High:engineered
	Specified activity	SBS	m3	3,20	6,30		Low: rehandle waste rock dump by dozing; High:rehandle waste rock by hauling
	Tailings	SBT	m3	1,35	3,70	15,50	High:contour surface - wet or frozen; Specified:haul/place wet infill
Excavate Soil, High Spec's and QA/QC							
	excavate/load/short haul	SC1	m3	6,80	9,30		
	excavate/load/long haul	SC2	m3	7,10	11,75		
	SC1 + spread and compact	SC3	m3	8,90	14,20		Low: non-engineered; High:engineered
	SC2 + spread and compact	SC4	m3	9,30	23,20		Low: non-engineered; High:engineered (e.g. complex covers, low volume dam construction)
	Specified activity	SCS	m3			18,80	Backfill adit with waste rock
Fence							
		FNC	m	13,55	203,00		
Fuel and Electricity							
	Fuel cost - gas	FCG	litre	1,05	1,40		
	Fuel cost - diesel	FCD	litre	0,99	1,39		
	Fuel mobilization	FCM	litre	0,22	0,42		High: winter road usage
	Electricity	FCE	kW-h	0,17	0,19	0,49	Low and High:Yellowknife; Specified:diesel generator
Geo-Synthetics							
	geotextile	GST	m2	3,44			Supply and install
	geogrid	GSG	m2	5,75			
	liner, HDPE	GSHDPE	m2	7,95			Supply and install; large quantity
	liner, ES3	GSES3	m2	20,20			FOB Yellowknife
	geosynthetic installation	GSI	m2	3,16	14,00		Low:geotextile; High:ES3 or HDPE
	bentonite soil ammendment	GSBA	tonne	308,30	348,50		FOB Edmonton, add shipping & mixing
Grouting (/m3 of rock grouted)							
		grout	m3	236,55	286,75		High: cement, FOB Yellowknife
Labour & Equipment Rates							
	Site manager	sman	$/hr	125,00	152,00		
	Supervisor	super	$/hr	52,00	91,84		
	Registered engineer	eng	$/hr	95,00	220,00		
	Environmental coordinator	envco	$/hr	74,16	130,00		
	Evironmental technologist	envtech	$/hr	36,00			

Electrician	elec	$/hr	74,00	95,00		
Journeyman - various	journey	$/hr	44,00	71,79		
Labour - skilled	lab-s	$/hr	41,00	49,60		
Labour - unskilled	lab-us	$/hr	31,00	43,98		
Equipment operator	oper	$/hr	41,00	65,00		
Heavy duty mechanic	mech	$/hr	49,00	72,85		
Water treatment plant operator	oper-wt	$/hr	41,00	59,86		
Security / first aid	safety	$/hr	36,00	66,97		
Administative staff	admin	$/hr	38,00	57,89		
Equipment rates include operator and fuel						
Loader - 4 cu.yd (3.06m3)	load-s	$/hr	175,00			
Loader - 7 cu.yd (5.35m3)	load-l	$/hr	315,00			
Excavator - 26.76-30.84 tonnes	exc-s	$/hr	190,00			
Excavator - 68.95+tonnes	exc-l	$/hr	420,00			
Grader	grad	$/hr	190,00			
Dump truck off hwy 30-50 tonnes	truck-s	$/hr	225,00			
Dump truck off hwy 55-75 tonnes	truck-l	$/hr	300,00			
dozer, small	dozers	$/hr	205,00	260,00		
dozer, large	dozerl	$/hr	490,00	565,00		
smooth drum compactor	comp	$/hr	155,00			
scooptram, 6 yd3 bucket	scoop	$/hr	170,00			
flat bed truck with hiab	hiab	$/hr	155,00			
fuel truck	ftruck	$/hr	150,00			
water truck	wtruck	$/hr	58,00	150,00		
Mobilize Heavy Equipment						
Road access	MHER	kmtonne	3,40	10,25		
Air access	MHEA	kmtonne	12,00			cargo rate>500lb
Mobilize Camp						
Road access	MCR	each	50000,00			refurbish existing camp
Mobilize Workers						
flight	MW	each	4500,00	9100,00		Low:e.g. 8 passenger; High: Dash 7
Oil Removal						
oil removal	OR	litre	0,43	1,20		Low:waste oil heater; High: ship offsite
PCB Removal						
Remove from site	PCBR	litre	40,20	46,90		Low: shipping, handling & disposal from Yellowknife
Pipes, small (<6in dia.)						
remove/dispose on site	PSR	m	1,00	24,00		Low: remove/dispose on site; High: remove/re-use
supply	PSS	m	6,10	11,10		Low:supply; High:supply and ship
install	PSI	m	25,00			
Pipes, large (>6in dia.)						
remove/dispose on site	PLR	m	22,00	72,00		Low: remove/dispose on site; High: remove/re-use
supply	PLS	m	129,00	143,00		Low:supply; High:supply and ship
install	PLI	m	50,00			
Power Lines						
remove/dispose on site	POWR	m	25,50			
Process Chemicals						
Remove from site	PCR	kg	0,45	2,50		Low: shipping, handling & disposal from Yellowknife
Pumps						
Pump capital cost	PC	each	195000,00			
Pump shipping	PS	each	2500,00			
Pump operating cost	POC	m3	0,12			pump operating costs should be calculated based on pump capacity, fuel costs, etc.
Pump maintenance	PM	allow	25000,00			
Pump sand BackFill						
	PBF	m3	85,00	300,00		
Scarify - road/mine site						
	SCFY	ha	4300	6030	2150	
Shaft, Raise & Portal Closures						
Shaft & Raises	SR	m2	645,00	2132,00		Low:pre-cast concrete slabs, little site prep. Area=shaft+>1m all around
Portals	POR	m3	18,80	250,00	1200,00	Low:unit cost code SCS;High:excavate & backfill collapsed portal;Spec: installed pressure plug
Site Inspection Report						
	RPT	each	10000,00	20000,00		
SpillWay - Clear						
	SW	each	3000,00	7000,00		
Survey/Instrumentation						
	SI	each	1800,00	3600,00		2 person crew
Treatment Plant - Construct						
Small (< 1000 m3/d)	TPS	lump sum	9000000	15000000		
Large (> 1000 m3/d)	TPL	lump sum	15000000	46000000		
Constructed Wetland	CWTS	ha	200000	300000		
Treatment Plant - Operate						
	TPO	m3	0,35	2,00		
Treatment Chemicals						
ferric sulphate	ferric	kg	1,19			
ferrous sulphate	ferrous	kg	1,32			
lime	lime	kg	0,56			
hydrogen peroxide, 35%	hperox	kg	1,50			
Sodium Metabisulfate	Nametab	kg	1,18			
Caustic soda, 50%	caustic	kg	0,74			
Sulfuric acid, 93%	sulfuric	kg	0,31			

flocculant	flocc	kg	6,00			
copper sulphate	copper	kg				
shipping	shipping	kg	0,20			
Vegetation						
Hydroseed, Flat	VHF	ha	4000,00			
Hydroseed, Sloped	VHS	ha	4500,00			
Veg. blanket/erosion mat	VB	ha	13000,00			
Tree planting	VT	ha	2600,00	6000,00		
Wetland species	VW	ha			47,72	Specified= /m3, Wetland Growth Media Substrate mixed and installed (sand, biochar and fertilizer, woodchips)
Water Sampling/Analysis/Reporting						
	WS	each	7000,00	10000,00		
Winter Road						
Construction	WRC	km	2000,00	11500,00		
Usage	WRU	kmtonne	0,29			



SNC·LAVALIN
5400, boul. des Galeries
Ville de Québec, Québec, Canada

Tailings Storage Facility - Operation, Maintenance and Surveillance Manual, Version 9

MEADOWBANK GOLD PROJECT

TAILINGS STORAGE FACILITY

Operation, Maintenance and Surveillance Manual

Prepared by:
Agnico Eagle Mines Limited – Meadowbank Division

Version 9
March 2019

TAILINGS STORAGE FACILITY

OPERATION, MAINTENANCE AND

SURVEILLANCE MANUAL

MEADOWBANK GOLD PROJECT

AGNICO EAGLE MINES LIMITED

This Operation, Maintenance and Surveillance Manual has been prepared by Agnico Eagle Mines Limited and is to be used for the operation, maintenance and surveillance of the Tailings Storage Facility at the Meadowbank Gold Project. All Registered Manual Holders are responsible for ensuring that they are using the most recent revision of this document. This Operation, Maintenance and Surveillance Manual, may not be copied in whole or in part without the written consent of Agnico Eagle Mines Limited.

IMPLEMENTATION SCHEDULE

This Plan is immediately implemented.

DISTRIBUTION LIST

AEM - General Mine Manager

AEM – General Superintendent

AEM- Environment Superintendent

AEM- Mine Operations Superintendent

AEM- Engineering Superintendent

AEM- Energy & Infrastructure Superintendent

AEM- Maintenance Superintendent

AEM- Process Plant Superintendent

AEM- Nunavut Division Engineer of Record

DOCUMENT CONTROL

Version	Date (YMD)	Section	Page	Revision
(first revision)	February 2012	All	All	
V2	August 27, 2013	All	All	
V3	September 15, 2013	All	All	Updated items mentioned by MDRB and the Mine Inspector in the Annual Geotechnical Inspection in September 2013
V4	January 2015	All	All	
V5	October 2015	All	All	
V6	February 2016	All	All	
V7	March 2017	All	All	
V8	February 2018	All	All	Integration of the updated Central Dike TARP and Emergency Action Plan
V9	February 2019	All	All	

Approved by :

_____
Luc Chouinard
Mine Manager

_____
Pierre McMullen
Enngineering Superintendent

TABLE OF CONTENTS

DOCUMENT CONTROL ..... **III**

LIST OF TABLES ..... **V**

LIST OF FIGURES ..... **VI**

LIST OF APPENDICES ..... **VI**

SECTION 1 • INTRODUCTION **1**

1.1 objective of the oms manual 1
1.2 Registered Manual Holders and Revisions 1
1.3 management of change 2
1.4 Required Levels of Knowledge 3
1.5 LINKAGE with Emergency Response plan 3

SECTION 2 • ROLES AND RESPONSIBILITIES **4**

SECTION 3 • TAILINGS MANAGEMENT INFRASTRUCTURES DESCRIPTION **10**

3.1 Background 10
3.2 Facility Components 13
3.2.1 Saddle Dam 1 – North Cell 13
3.2.2 Saddle Dam 2 – North Cell 13
3.2.3 RF 1 and RF2 – North Cell 13
3.2.4 North Cell Internal Structure – North Cell 14
3.2.5 Saddle Dam 3, Saddle Dam 4 and Saddle Dam 5 – South Cell 14
3.2.6 Internal Structure for Reclaim – South Cell 15
3.2.7 Central Dike 15
3.2.8 Stormwater Dike – Divider Dike 16
3.2.9 Water Control Structures 17
3.3 Water & Tailings Pumping infrastructure 18
3.4 Instrumentation 21
3.5 Reference Documents and Drawings 23

SECTION 4 • OPERATIONS **27**

4.1 REFERENCES 27
4.2 summary of performance objectives and operation controls 27
4.3 Deposition Planning 28
4.4 Freeboard 32
4.5 Tailings Management 32
4.6 Water Management 33
4.7 Performance indicator during tailings management 34
4.8 Communication and decision making 39

SECTION 5 • MAINTENANCE **40**

5.1 preventative, predictive and corrective maintenance 40
5.2 references 40
5.3 component of the tailings management infrastructure requiring maintenance 41
5.3.1 Maintenance component that are outside the scope of this OMS manual 42
5.4 description of maintenance activity 42

SECTION 6 • SURVEILLANCE 45

6.1 Site observations and inspections 45
6.1.1 Site observation 46
6.1.2 Inspection program 47
6.1.2.1 Routine Visual Inspection 47
6.1.2.1 Special Visual Inspection 50
6.1.2.2 Dike Safety Inspection (annual geotechnical inspection) 50
6.1.2.3 Independent Dam Safety Review 51
6.2 Instrument monitoring program – data acquistion 52
6.3 Adding instrument to the monitoring program 54
6.4 Analysis of surveillance Results 54
6.4.1 Procedure in case of data exceeding expected range of observation 56
6.4.1.1 Blast Monitor 56
6.4.2 Anomalous Instrumentation Data 56
6.5 surveillance documentation & reporting 58
6.6 Data Management 60

SECTION 7 • REFERENCES 61

LIST OF TABLES

Table 1-1: OMS Manual Distribution List 2
Table 1-2 Emergency Response Reference Documents 3
Table 2-1: Responsibilities related to Tailings Management 6
Table 2-2: OMS Manual Contact for each position 8
Table 3-1: Description of the tailings management infrastructures 10
Table 3-2: Tailing Management Earthwork Design Criteria 12
Table 3-3 : Instrumentation Summary within the TSF 21
Table 3-4: Tailings Storage Facility Design Report and Specifications 23
Table 3-5 Tailings Storage Facility Construction Summary Report 23
Table 3-6 List of Construction Drawings for Embankment Structures 24
Table 3-7 List of Construction Drawings for Infrastructure and Piping 25
Table 4-1 : Reference Documents for Operation of Tailing Storage Facility 27
Table 4-2 : Performance Objectives and Operational Criteria for Tailings Management 27
Table 4-3 : Input parameter into a deposition plan 30
Table 4-4 : Output of a deposition plan 31
Table 4-5 : Freeboard Criteria During Operation 32
Table 4-6 Threshold Criteria and pre-defined action during operation of tailings retention structures (Excluding Central Dike) 35
Table 4-7 Threshold Criteria and pre-defined action during operation of Central Dike (Part 1/3) 36
Table 4-8 : Threshold Criteria and pre-defined action during operation of Central Dike (Part 2/3) 37
Table 4-9Threshold Criteria and pre-defined action during operation of Central Dike (Part 3/3) 38

Table 5-1: Reference documents for Maintenance of Whale Tail water management infrastructure 41
Table 5-2: Component of the water management infrastructure requiring maintenance 42
Table 5-3 :Description of maintenance activity for component of tailings management infrastructure 43
Table 6-1: Changes that may be observed through site observation and inspection of tailings management infrastructure 46
Table 6-2: Summary of routine inspection requirements 49
Table 6-3: Information collected using instrument monitoring 52
Table 6-4: Summaries of data acquisition program related to instrument monitoring of Whale Tail water management infrastructure 53
Table 6-5 : Requirement for Review, Analyses and Reporting of Instrument Data 55
Table 6-6: Example of anomalous data and some common cause 57
Table 6-7 : How data should be presented in report for instrumentation monitoring 59

LIST OF FIGURES

Figure 2-1 : Organizational Structure 5
Figure 3-1 - Tailings Storage Facilities Infrastructures 11
Figure 3-2 Deposition Point Locations in the North Cell 19
Figure 3-3 : Deposition Point Locations in the South Cell 20
Figure 3-4 : Instruments Location Within the TSF 22
Figure 4-1 : Water Management Strategy for 2019 34
Figure 4-2 : Communication and Decision Process for Tailings Management TARP 39

LIST OF APPENDICES

Appendix A Tailings Storage Facility - Inspection Form
Appendix B TSF Instruments list
Appendix C Potential Mitigation for Upset Condition

SECTION 1 • INTRODUCTION

1.1 OBJECTIVE OF THE OMS MANUAL

The objective of this manual is to define the technical aspect related to the operation, maintenance and surveillance (OMS) of the tailings storage facility at the Meadowbank Mine operated by Agnico Eagle Mines Limited (AEM).

This manual is intended as a practical document used by the personnel involved in with the Tailings Storage Facility. It incorporates operating, maintenance and surveillance procedures recommended by the Canadian Dam Association (CDA) “Dam Safety Guidelines” (CDA 2013 & 2014) and the Mining Association of Canada (MAC) “Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities” (MAC, 2018). It also incorporate principle found in ‘A Guide to the Management of Tailings Facilities” (MAC 2017). This manual was written by the Meadowbank Engineering team and the Nunavut Engineer of Record.

The objectives of this OMS manual are to define and describes:

- Roles, responsibilities, and level of authority of personnel who perform activities related to the water management infrastructure
- The tailings management infrastructure covered in the scope of this OMS manual
- Plans, procedures and processes for :
    - The operation, maintenance and surveillance of the tailings storage facility infrastructures to ensure that it functions in accordance with their design, meets performance objectives and link to emergency response planning
    - Evaluating performance of the structures, and report performance results
    - Managing change

This manual contains protocols and information that will assist AEM to operate, maintain, and monitor the tailings management infrastructure in a safe manner and identify early signs of malfunction.

Element related to design, construction and closure of tailings management infrastructures, are out of scope of this manual.

1.2 REGISTERED MANUAL HOLDERS AND REVISIONS

This OMS manual is a controlled document. The latest version of this document is available in Intelex.

The person responsible for the preparation, update and distribution of this manual is the Engineering Superintendent. Any change to this OMS manual must be submitted to and approved by the Engineering Superintendent who will be responsible to update the OMS manual in Intelex.

It is each user responsibility to ensure that they are using the latest version of this document. In case of issue with retrieving the electronic version of this document, the most up to date paper version of this document will always be kept in the Engineering Superintendent Office.

The Engineering Superintendent is responsible to communicate any change to this manual by e-mail to the distribution list in Table 1-1. The Engineering Superintendent is responsible for maintaining an up-to-date distribution list of this manual.

Table 1-1: OMS Manual Distribution List

Position	**Name**
General Mine Manager	Luc Chouinard
General Superintendant	Eric Côté / Jacques Proulx
Environment Superintendent	Nancy Duquet-Harvey
Mine Operations Superintendent	Yan Côté, Nicolas P. Deschamps (asst.)
Engineering Superintendent	Pierre McMullen, Miles Legault (asst.)
Maintenance Superintendant	Christian Quirion
Energy & Infrastructures Superintendent	Guillaume Gemme
Process Plant Superintendent	Michel Fortin
Engineer of Record, Meadowbank Division	Thomas Lepine

1.3 MANAGEMENT OF CHANGE

This manual will be reviewed on an annual basis at the beginning of Q3 and revised as necessary to accommodate changes in the condition and operation of the facilities. The Engineering Superintendent will be responsible to coordinate this review process.

In conducting the review and update of the OMS manual the following must be taken into account:

- Performance of the facility
- Current life cycle of the facility
- Change since the last review (site condition, critical control, risk profile, personnel, methodology and technology for OMS activities)

In addition to the annually scheduled review, a review may be triggered by a significant event or may need to be updated in response to:

- Planned changes, such as change in surveillance instrumentation or methodologies, or introduction of new instrumentation methodology
- Changes in personnel or roles referred to in the OMS manual
- Other changes that may occur that need to be addressed prior to the next scheduled review of the OMS manual

The update need to be completed in a timely manner following the document control criteria specified in Section 1.2.

As a good practice the Engineering Superintendent should organise on a yearly basis a session to present the change in the OMS manual to the person in its distribution list.

1.4 REQUIRED LEVELS OF KNOWLEDGE

To preserve the integrity of the operation of these structures, the personnel must have a good comprehension of the factor that can impact the performance of the water management infrastructures. It must also be know that any deviation can signify the emergence of a problem and the role that each person must have in the operation, maintenance and surveillance of these infrastructures.

It is the responsibility of each person in the distribution list of this manual to be familiar with it and understand its whole content. They also need to ensure that everyone under their supervision who's duty involve task related to the operation, maintenance or surveillance of any component of the water management infrastructures have the appropriate level of knowledge and the resources to comply with the protocol presented in this document.

1.5 LINKAGE WITH EMERGENCY RESPONSE PLAN

An emergency is a situation that poses an impending or immediate risk to health, life, property, or the environment and which requires urgent intervention to prevent or limit the expected outcome.

This OMS manual address conditions related to operation under normal or upset conditions, as opposed to emergency situation. An Emergency Response Plan (ERP) describes measures the Owner and, in some cases, external parties will take to prepare for an emergency, and to respond if an emergency occurs.

An OMS and ERP manual must be aligned, as a results this OMS manual contain the following information (refer to Section 4):

- Performance, occurrences, or observation that would results in an emergency being declared
- Roles and responsaibilities of key personnel in transition from normal or upset conditions to an emergency
- Actions to be taken to transition from normal or upset confitions to an emergency situation

Once an emergency has been declared reference must be made to the Emergency Response Plan (Reference included in Table 1-2). The most recent version of the ERP can be found on Intelex and in the Engineering Superintendant Office

Table 1-2 Emergency Response Reference Documents

Document	Current Revision
Emergency Response Plan	Updated by AEM. Version 12, January 2018. (Intelex)

SECTION 2 • ROLES AND RESPONSIBILITIES

A functional chart for the water management infrastructure at the Whale Tail project is shown in Figure 2-1.

The roles and responsibilities of the key personnel involved in the water management infrastructure of the Whale Tail Project are shown in Table 2-1. Contact information for each position is indicated in Table 2-2.

Personnel who have task directly related to the water management infrastructure need to receive a training when they start in the position to ensure they understand their roles and responsibility related to this OMS manual.

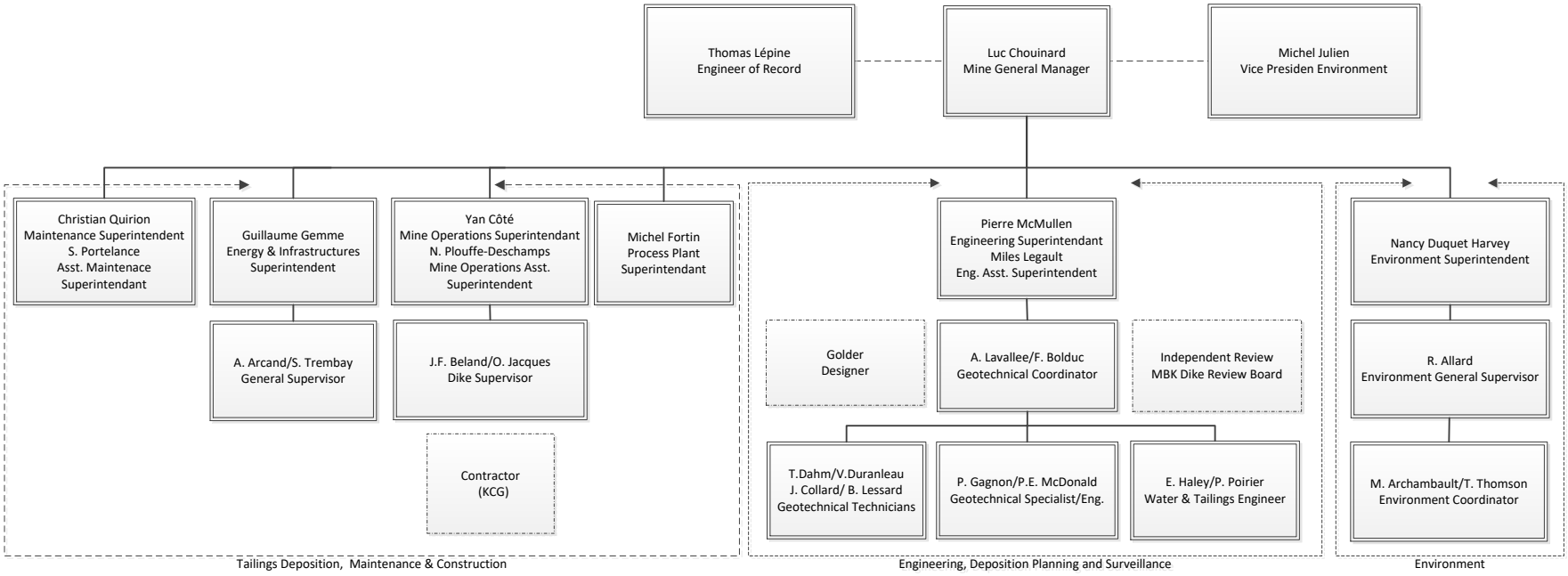


Figure 2-1 : Organizational Structure

Table 2-1: Responsibilities related to Tailings Management

Role	Responsibilities
Vice-President Environment	• Be aware of key outcome of water & tailings management risk assessment and how these risks are being managed • Has accountability and responsibility for putting in place appropriate management structure • Assign responsibility and appropriate budgetary authority for water & tailings management and defines the personnel duties, responsibility and reporting relationships, supported by job description and organisational charts to implements the water management system though all stages in the facility life cycles • Provide assurance to AEM and its Community of Interest that the water & tailings management infrastructure are managed responsibly
General Mine Manager	• Identifies the scope of work and budget requirement for all aspect of water & tailings management • Approve budget for OMS related activity • Establish an organisational structure with Roles and Responsibility that meets the operational needs • Delegate specific tasks and responsibilities for water management to qualified personnel • Liaise with independent reviewer (MDRB) as required
Engineer of Record (EoR)	• Input into the OMS activities in accordance with the design • Receive and review the OMS manual on a regular basis • Receive and review performance data at a frequency determined based on the risks • Either confirm operation is compliant or identify deviations from performance objectives and advise the Owner with recommendations • Advise on contemplated change on the facility operation • Maintain records relating to design construction and operation • Participate in inspection and independent review
Independent Reviewer – Meadowbank Dike Review Board (MDRB)	• Provide independent, objective, expert commentary, advice and recommendations, to assist in identifying, understanding, and managing risk associated with tailings management facilities
Engineering Superintendent	• Revise and update the OMS Manual to reflect as-built conditions and any other changes. • Review and update OMS manual into Intelex • Maintain up to date distribution list of the OMS Manual. • Establish a formal relationship with the EOR to ensure operation is compliant with design intent • Identify when/where contemplated operational changes are a potential deviation from the design intent and engage the EoR and Designer as part of processes to manage change • Coordinate work force as required for monitoring and maintenance.

Role	Responsibilities
Mine Operations Superintendent / Dike Supervisor	• Maintain access to the structure and seepage collection systems, including making road repairs, controlling dust and removing snow. • Carry out field maintenance related to earthwork as required, • Supervise Mine Contractor for aspect related to earthwork construction and maintenance
Geotechnical Coordinator	• Supervise the work of the geotechnical engineer, geotechnical technician and water and tailings engineer • Approve tailings deposition plan
Geotechnical Engineer	• Carry out inspections of the facility as required in the OMS Manual. • Carry out instrument monitoring as required in the OMS Manual. • Review and distribute surveillance reporting as required in the OMS Manual •
Geotechnical Technician	• Carry out inspections of the facility as required in the OMS Manual. • Monitor instrumentation as required in the OMS Manual. • Maintain instrumentation, readout units, data acquisition system and cabins • Responsible for data acquisition as required in the OMS manual • Prepare reports on instrumentation readings, dike performance, visual observations, etc. as required in the OMS Manual.
Water & Tailings Engineer	• Carry out inspections of the facility as required in the OMS Manual. • Carry out instrument monitoring as required in the OMS Manual. • Review and analyse surveillance data to evaluate dike performance with respect to design parameters. • Analyse geotechnical instrumentation monitoring data to evaluate performance with respect to design parameters • Coordinate equipment, labour, materials and maintenance activities required for pumps and pipelines associated with dewatering, seepage collection systems and any runoff diversions. • Prepare tailings deposition plan and water management plan
Environment Department Superintendent / General Supervisor / Coordinator / Technician	• Ensure monitoring of water quality and total suspended solids from the tailings storage facility as required in the water management plan • Review environmental monitoring data for compliance with Water License and regulations and to determine tailings management performance with respect to design parameters. • Liaise with external stakeholders including NIRB, Nunavut Water Board, NGO's, government agencies.

Role	Responsibilities
Energy & Infrastructures Superintendent / General Supervisor / Pump crew supervisor / electrical supervisor	• Installation and operation of pumps and pipeline (electrical, mechanical) • Maintain and service pumps and pipelines • Coordinate equipment, labour and materials for maintenance of electrical and mechanical equipment • Carry out field operations including tailings deposition move, pipe cleaning (pig) and reclaim move • Carry out field maintenance on pumps and pipeline including electrical and mechanical repairs.
Process Plant Superintendant / General Supervisor	• Ensure tailings distribution from the mill to the tailings storage facility • Operation, maintenance and surveillance of mill pump and booster pump
Mine Contractor	• Rent equipment and manpower for construction and maintenance of water management infrastructure
Design Engineer	• Advise on contemplated change to the facility design • Advisor on structure performance as required • Participate in inspection and independent review as required
Maintenance Superintendent/ Pump mechanics	• Ensure preventive maintenance is carried out regularly on each pumping equipment • Repair pumping equipment as required • Update and maintain a list of operational pumping equipment • Keep records of maintenance on pumping equipment

Table 2-2: OMS Manual Contact for each position

Role	Name	Work Contact Info
Vice-President Environment	Michel Julien	416-947-1212 x3738 514-244-5876
General Mine Manager	Luc Chouinard	819-759-3555 x4606896
Engineer of Record (EoR)	Thomas Lepine	416-947-1212 x3722 418-473-8077
Engineering Superintendent / Assistant	Pierre McMullen Miles Legault	819-759-3555 x4606721
Mine Operations Superintendent / Assistant	Yan Côté Nicolas Plouffe-Deschamps	819-759-3555 x4606832
Dike Supervisor	Jean-François Béland Olivier jacques	819-759-3555 x4606807
Geotechnical Coordinator	Frédérick L.Bolduc Alexandre Lavallée	819-759-3555 x4606837
Geotechnical Engineer	Patrice Gagnon Pier-Eric McDonald	819-759-3555 x4606726
Geotechnical Technician	Vincent Duranleau	819-759-3555 x4606818

Role	Name	Work Contact Info
	Thomas Dahm Bruno Lessard Jerome Collard.	819-759-3555 x4606851
Water & Tailings Engineer	Eric Haley Pascal Poirier	819-759-3555 x4606752
Environment Superintendent	Nancy Duquette	819-759-3555 x4606980 x3175
Environment General Supervisor	Robin Allard	819-759-3555 x4606838
Environment Coordinator	Martin Archambault Tom Thomson	819-759-3555 x4606744
Process Plant Superintendent	Michel Fortin	819-759-3555 x4606814
Energy & Infrastructures Superintendent	Guillaume Gemme	819-759-3555 x4606632
Maintenance Superintendent	Pierre Laberge Sylvain Portelance	819-759-3555 x4606722
Energy & Infrastructure General Supervisor	Alexandre Arcand Steven Tremblay	819-759-3555 x4606822
Pump crew supervisor	Shawn Valiquette	819-759-3555 x4606616
Electrical Supervisor	Alain Villeneuve	819-759-3555 x4606762
Mine Contractor	KCG	819-759-3555 x4606963 418-615-0559
Designer – Golder	Yves Boulianne	514 383 6196 x7434 514 207-0264
Independent Reviewer – Meadowbank Dike Review Board (MDRB)	Anthony Rattue Don Hayley	anthony.rattue@bell.net don.hayley@icloud.com

SECTION 3 • TAILINGS MANAGEMENT INFRASTRUCTURES DESCRIPTION

3.1 BACKGROUND

The tailings storage facility (TSF) is the permanent storage facility for tailings produced during the operation of the mine. It is located north of the Process Plant Site within the dewatered portion of the northwestern arm of Second Portage Lake.

The tailings management include the operation of a series of water & tailings management infrastructures as shown in . Table 3-1 indicate the water management infrastructure of the Whale Tail Project.

The design criteria of the earthwork infrastructure are presented in Table 3-2. Reference to design and construction document are presented in Section 3.7

Table 3-1: Description of the tailings management infrastructures

Infrastructure	Function
North Cell Peripheral Structure : Saddle Dam 1, Saddle Dam 2, RF1, RF 2	Peripheral tailings retention structure for tailings containment within the North Cell
North Cell Internal Structure and associated ditches and sump	Upstream raise built on the tailings to increase capacity of the North Cell
South Cell Peripheral Structure : Saddle Dam 3, Saddle Dam 4, Saddle Dam 5, Central Dike	Peripheral tailings retention structure for tailings containment within the South Cell
Stormwater Dike	Internal structure that divide the TSF into the North and the South Cell
Diversion Ditches	Non-contact water diversion structure. Prevents runoff from the watershed to reach the TSF
Deposition and reclaim infrastructure	Infrastructure required for tailings deposition and to reclaim water within the TSF

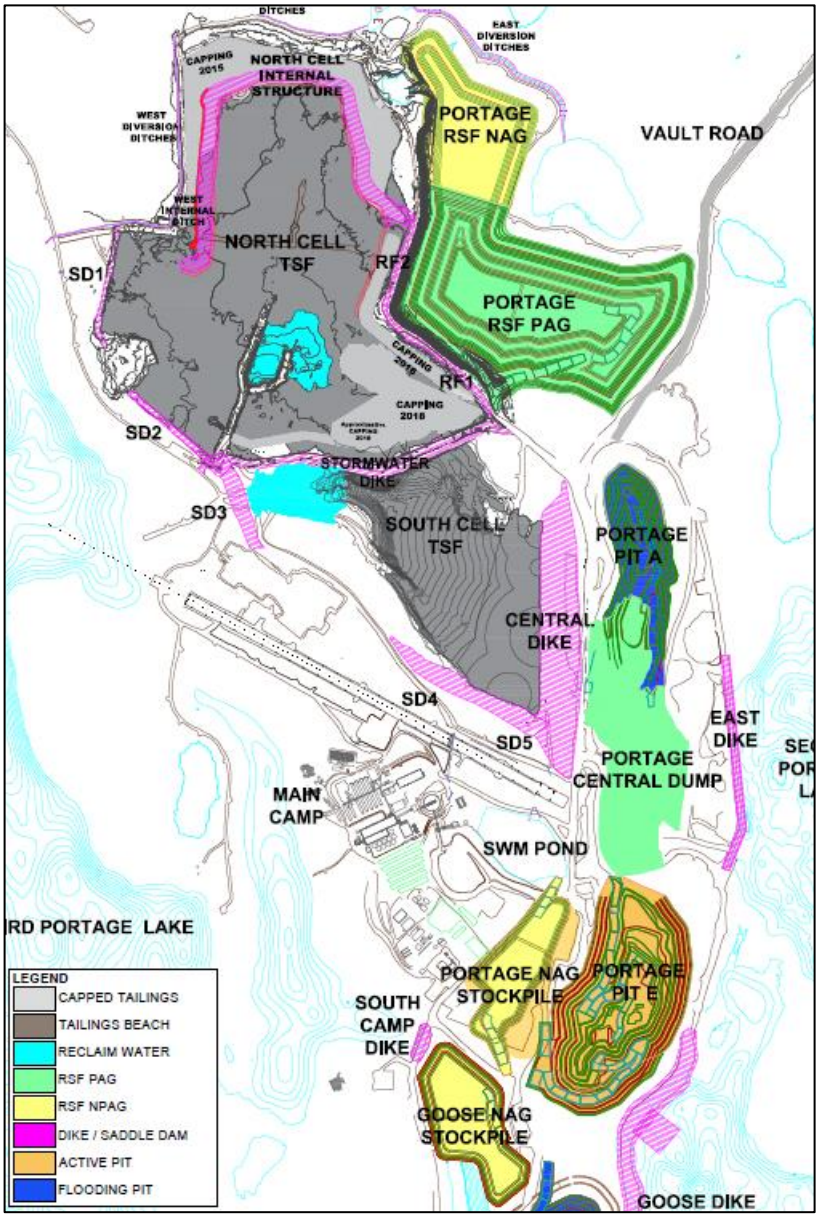


Figure 3-1 - Tailings Storage Facilities Infrastructures

Table 3-2: Tailing Management Earthwork Design Criteria

Structures	Classification (CDA 2007/2013)	Side slope	Crest elevation (m)	Length (m)	Construction period
Saddle Dam 1	High	US 3H:1V DS 1.3H:1V	150	~ 400	2009 (El. 141 m) 2010 (El. 150 m)
Saddle Dam 2	High	US 3H:1V DS 1.5H:1V	150	~460	2011 (El.150 m)
Saddle Dam 3	High	US 3H:1V DS 1.5H:1V	150	~245	2015 (El.140 m) 2016 (El.143 m) 2017-2018 (El.145 m)
Saddle Dam 4	High	US 3H:1V DS 1.5H:1V	143	~365	2015 (El.140 m) 2016 (El.143 m) 2017 (El.145 m)
Saddle Dam 5	High	US 3H:1V DS 1.5H:1V	143	~255	2016 (El.143 m) 2017 (El.145 m)
RF1	-	US 1.5H:1V DS 1.5H:1V	150	~400	2009 2013 (Till Plug)
RF2	-	US 1.5H:1V US 1.5H:1V	150	~281	2009
Central Dike	High	US 2 H:1V El.130 US 3H:1V El. 130 DS 1.5H:1V	150	~900	2012 (El.110 m) 2013 (El. 115 m) 2014 (El.132 m) 2016 (El.143 m) 2017-2018(El.145 m)
Strormwater Dike	High	US 3H:1V DS 1.3H:1V	150	~1000	2009 (El.140 m) 2010 (El.148 m) 2013 (El.150 m)
North Cell Internal Structure	Significant	US 3H:1V DS 1.5H:1V	Variable El.152-154	~2160	2018 (Variable El.152-154)
South Cell Internal Structure (reclaim)	-	US 1.3H:1V DS 1.3H:1V	El 142.5	-	2017 (El. 137.2) 2019 (El. 142.5)

3.2 FACILITY COMPONENTS

3.2.1 Saddle Dam 1 – North Cell

Saddle Dam 1 is located in the northwestern corner of the TSF and forms one of the perimeter structures of the North Cell intended to retain tailings and supernatant fluid during the operation and the closure of the TSF. Saddle Dam 1 crosses a depression between the northwestern arm of Second Portage Lake and Third Portage Lake.

Saddle Dam 1 is a rockfill embankment with an 3H:1V upstream slope and a 1.3H:1V downstream slope. This structure has inverted base filters, upstream graded filters, and a linear low density polyethylene (LLDPE) geomembrane liner on the upstream dike face. The geomembrane liner is placed between an upper and lower non-woven geotextile layer for protection, and is covered by approximately 0.3 m of granular material up to El. 140 m. No granular layer was placed above El. 140 m and the liner is exposed above that elevation. According to the design, a tailings beach has to be maintained on the face of the structure to reduce the potential for ice damage to the liner. The abutments are founded on bedrock, while the central portion of the dike is founded on ice-poor soil. Till and/or crushed aggregate mixed with dry bentonite powder have been placed above the toe of the liner.

Stage 1 of Saddle Dam 1 was constructed in the fall of 2009 to a height of 10 m (crest elevation of 141 m) and a length of 250 m. Stage 2 was constructed in 2010 to an overall height of 20 m (final crest elevation of 150 m) and length of about 400 m.

3.2.2 Saddle Dam 2 – North Cell

Saddle Dam 2 is located along the western side of the TSF and connects to the western corner of Stormwater Dike. Along with Saddle Dam 1, it forms one of the perimeter structures of the TSF's North Cell which retain tailings and supernatant fluid during the operation and closure of the TSF. Saddle Dam 2 crosses a depression between the northwestern arm of Second Portage Lake and Third Portage Lake. Its construction and design is similar to Saddle Dam 1. Saddle Dam 2 has a maximum height of about 10 m and a crest length of 460 m. Saddle Dam 2 was constructed in one stage to El. 150 m in 2011.

The upstream foundation of the dike and abutments are primarily founded on bedrock; however, some portions of the structure, underneath the inverted filter, are founded on ice-poor soil. During construction, a thin layer of low permeability till was placed and compacted along the toe liner tie-in connection with bedrock. A thin layer of crushed aggregate (0-22 mm) mixed with dry bentonite powder was also placed under the thin layer of low permeability till in areas where open factures were observed within the bedrock. The toe liner tie-in was then covered with till.

3.2.3 RF 1 and RF2 – North Cell

RF1 and RF2 are two rockfill access roads located between the eastern side of the North Cell and the Portage Waste Rock Storage Facility. These access roads were not designed as a containment structure and do not include a low permeability element due to the topography of the sector.

In 2013 a till plug was installed on RF1 when seepage was observed reporting into Lake NP2 from this location. The till plug was constructed in the summer of 2013. Its construction consisted in profiling the upstream slope and placing a 0.5-m-thick layer of compacted crusher reject, and then installing a geotextile membrane covered by 0.5 m of fine ultramafic rockfill and material reject from till sieving. Both granular layers were compacted with an excavator bucket.

3.2.4 North Cell Internal Structure – North Cell

The North Cell Internal Structure is designed and constructed as a permeable zoned rockfill dam with filter zones built on the top surface of dried tailings and on an existing rockfill cover. Placement of the rockfill cover on the tailings was carried out in winter when the tailings foundation was frozen. The maximum elevation of the North Cell Internal Structure is designed to be El. 154 m and an offset is keep from the perimeter of the North Cell and the peripheral structure.

The typical section of the structure is a rockfill shell with a 3H:1V upstream slope and a 1.5H:1V downstream slope. The upstream face of the structure is comprised of two granular filter zones. The filter zones are designed to prevent tailings migration and internal erosion while allowing water to flow through the embankment. Fine ultramafic rockfill was used during the construction of the structure. Temporary ditches and sumps system were constructed on the downstream side of the internal structure within the existing tailings to collect seepage and runoffs during operation.

In 2018 the North Cell internal structure was built from Station 1+100 to 3+260 for a total of 2160 m. Section 1+100 to 1+660 and 2+750 to 3+260 were built to El. 152 with a width of 39 m and the part from Sta 1+660 to 2+750 was built to El. 154 m with a crest width of 30 m.

3.2.5 Saddle Dam 3, Saddle Dam 4 and Saddle Dam 5 – South Cell

Saddle Dam 3 is located in the northwestern corner of the South Cell and merges into Saddle Dam 2 to El. 145 m. Saddle Dam 4 is located in the southwestern corner of the South Cell and merges into Saddle Dam 5, which merges with the southern end of Central Dike, to El. 145 m.

Saddle Dams 3, 4, and 5 are designed and constructed as zoned rockfill dams with filter zones, low permeability upstream liners, and upstream toe liner tie-in key trenches. The Saddle Dams 3, 4 and 5 cross-sections consist of a rockfill embankment, constructed from run-of-mine waste rock, placed in lifts and compacted. The upstream faces are designed at a 3H:1V slope and the downstream faces are designed at a 1.5H:1V slope. The upstream faces of Saddle Dams 3, 4 and 5 are comprised of two granular filter zones and a polyethylene liner (LLDPE) extending along the upstream foundation. The filter zones mean to keep the tailings inside the facility in a case of liner puncture but mainly act as appropriate bedding for the liner. An upstream liner tie-in key trench excavated to bedrock and filled with compacted till is located along the upstream area of the structures. The bulk part of Saddle Dams 3, 4 and 5 consists of coarse rockfill material.

The design of Saddle Dam 3 include an additional protection cover over the liner made of till and rockfill. This protection was added to the design as this structure will not be protected with a tailings beach during operation as water need to be maintained in that area for reclaim.

Stage 1 of Saddle Dam 3, 4 and 5 was constructed in 2015. During Stage 1, Saddle Dam 3 and 4 were constructed to El. 140 m and Saddle Dam 5 to El. 137 m. Stage 2 of Saddle Dam 3, 4 and 5 was constructed to El. 143 m in 2016. Stage 3 of Saddle Dam 3, 4 and 5 was constructed to El. 145 m in 2017. The filter and liner installation at Saddle Dam 3 was finalized in 2018. These

structures are designed to be able to be raised to El. 150 m and the final crest elevation of these structures is subject to review by AEM. The completed crest length is approximately 245 m for Saddle Dam 3, 365 m for Saddle Dam 4, and 255 m for Saddle Dam 5.

3.2.6 Internal Structure for Reclaim – South Cell

An internal structure was built into the South Cell in 2017 in front of the reclaim area. The objective of this structure was to prevent tailings from filling the reclaim area near SD3 and to limit the turbidity of the reclaim water for mill usage. This structure was built by pushing rockfill in the South Cell with a dozer. In the winter of 2019 this structure was raised to El 142.5 m.

3.2.7 Central Dike

Central Dike is located along the eastern side of the TSF and crosses a depression within Second Portage Lake. It forms one of the perimeter structures of the South Cell.

Central Dike design includes a compacted rockfill embankment with an upstream seepage barrier, granular filters and a key trench along the centreline of the dike transitioning on the upstream toe near both abutments. The foundation soils include lakebed sediments and till overlying bedrock. Soft and ice-rich soils were removed from the Central Dike footprint during construction.

Construction of Central Dike started in 2012. Central Dike was built to El. 143 m during the 2016 construction season (Stage 5), and its north abutment raised to El. 145 m during the 2017 and 2018 construction season (Sta. 0+090 to 0+174 m). Central Dike is designed to be able to be raised to El. 150 m and the final crest elevation is subject to review by AEM. The completed crest length is approximately 900 m.

Seepage into the basin at the downstream toe of Central Dike was observed when tailings deposition was transferred from the North Cell of the TSF to the South Cell in 2014. The rate of seepage started to increase proportionally to the rise of the pond level of the South Cell and reach a peak of 900 m^3/h in 2015. Desktop studies were undertaken by Golder in 2015 to estimate the seepage flows and pore water pressures, verify the dike stability, and attempt to predict the eventual flow volume that would report to the downstream toe for higher pond elevation. The seepage pathway used in the Golder 2015 model was through a layer of fine material in the till layer of the foundation as it was deemed the most critical scenario for the structure stability. The main recommendation from this desktop study was to maintain beaches adjacent to Central Dike and to maintain a ‘back pressure’ on the downstream side of Central Dike in order to reduce the hydraulic gradient by holding the downstream pond at El. 115 m.

Willowstick was also hired to carry out geophysical soundings (electromagnetic survey) to detect seepage paths. The geophysical campaign led to additional recommendations and identified possible seepage path locations. Following the geophysical investigation, an investigation was conducted by SNC Lavallin (SNC) and AEM in December 2015 at station CD-595, and between CD-810 and CD-850. Highly altered and fractured bedrock was encountered and high hydraulic conductivity was measured from Packer testing. Instrumentation of the four boreholes with piezometers and thermistors was done at the same time. In 2016, the MDRB recommended that the seepage model and stability analyses be updated.

A study has been completed in 2017 to update the seepage modelling and stability assessment with a seepage flow through the bedrock. In the summer of 2017 an investigation and instrumentation campaign was performed by Golder to confirm the results of the seepage modelling. The results from this investigation support the hypothesis that the seepage pathway occur in the bedrock. During this investigation a potential void in the till layer was encountered during drilling. A complementary investigation was thus performed and was not able to confirm the presence of the void.

The Central Dike seepage is normally back into the South Cell. From September to October 2017 the seepage was transferred to Goose Pit as a mitigation measure. This measure, combined with an adapted tailings deposition plan was effective in reducing the seepage flow rate. As a results the average seepage rate at Central Dike decreased from 540 m^3/h in 2017 to 263 m^3/hr at the end of 2018 and is following the trend from the 2017 seepage modelling done by Golder.

In the summer of 2017 the water in the downstream pond became orange and this was associated with rapid temperature variation. This event was investigated by chemical analysis and was found to be caused by the precipitation of iron oxide from bacterial process. As predicted this event re-occurred in the summer of 2018.

3.2.8 Stormwater Dike – Divider Dike

Stormwater Dike is an internal structure that subdivides the TSF into the North Cell and the South Cell within the dewatered northwestern arm of Second Portage Lake. In this document, the North Cell side is taken as upstream and the South Cell side as downstream.

Stormwater Dike is a rockfill embankment structure founded on lakebed soils. The upstream slope is approximately 3H:1V and the downstream slope is about 1.3H:1V. A bituminous geomembrane liner has been installed above the graded filters on the upstream face of the dike. Low permeability till was placed and compacted along the upstream toe of the dike, above the liner.

Stormwater Dike was progressively constructed. Stage 1 was constructed in 2009 to a height of 10 m (crest elevation of 140 m) and a length of 860 m. Stage 2 was primarily constructed in 2010 to an overall height of 18 m (crest elevation of 148 m) and length of about 1,060 m. A horizontal bench is present along the upstream face of the structure due to the connection of the 2009 and 2010 portions of the structure. The junction between the bituminous liner of Stormwater Dike and the LLDPE liner of Saddle Dam 2 was completed in 2011. The crest of Stormwater Dike was raised to 150 m in 2013.

The majority of the dike is seated on dense till from the former lakebed within the talik while the abutments are generally founded on bedrock. The foundation preparation of Stage 2 was completed in winter conditions. It was generally done above water except in an area where water ponding was present (between Sta.10+500 and 10+750 approximately). This pond was located where the topography suggests that the soft lakebed sediment thickness may be greater than at other locations along the dike. Due to the presence of water, the ice crust was cracked with the excavator and only minimal foundation preparation was possible. As a result, most of the lakebed sediment probably remained in place in this area.

At the end of August 2016, during a routine inspection, AEM noticed tension cracks and signs of settlements on the crest of Stormwater Dike between Sta. 10+500 to 10+750 approximatively.

The crack system that suddenly developed in this area had a lateral and vertical component according to the monitoring equipment. To mitigate against a possible foundation failure, a rockfill buttress support was constructed at the downstream toe of Stormwater Dike in the South Cell (from Sta. 10+300 to Sta. 10+700 approximatively). After the completion of this buttress the displacement at Stormwater Dike stabilized and then stopped. Cracks have since been filled with bentonite.

In July 2017, during a routine inspection, AEM noticed new tension cracks and signs of settlements on the crest of Stormwater Dike around Sta. 10+425, between Sta. 10+550 and Sta. 10+650, between Sta. 10+800 and Sta. 10+950, and around Sta. 11+050 approximatively. Settling of about 300 mm was observed between Sta. 10+800 and Sta. 10+950, approximately. Cracks appear to be oblique tension fractures, extending over the entire width of the dike crest. Some cracks were up to 5 cm wide but most of them did not progress after they were first observed. The area affected by these cracks is consistent with the limits of the South Cell water ponding against Stormwater Dike, which probably thawed the frozen soft soil foundation.

In April 2018, new cracks were observed by AEM in between Sta. 10+950 and Sta. 11+010. The widest crack was about 4 cm wide but the cracks did not progress significantly after they were first noted. New crack were observed later in July in between S114 and S115 but no elongation was noted after.

The current understanding of the situation is that the soft sediment foundation was frozen in the winter of 2010 while additional rockfill material continued to be placed over it until July 2010. The foundation freezing explains why no adverse settlement or soil failure was observed until the South Cell water level started reaching the toe of the structure in July 2016, which probably thawed the frozen soft soil foundation. The mechanism that caused the observed movement could be due to a foundation soil failure, the thawing of ice lenses or a combination of both.

3.2.9 Water Control Structures

The diversion ditches (East and West), located around the perimeter of the North Cell TSF and the Portage RSF, are designed to collect the non-contact water runoff from the surrounding watershed. The ditches are divided in two sections – the west and east sections, to divert non-contact water respectively to Third Portage Lake and to NP1 Lake. On the west end of the diversion ditches, an Interception Sump was constructed in 2014-2015. The objective of the interception sump is to collect runoff water from the west section of the diversion ditches and to retain it until the total suspended solids in the water have reached the criteria allowing discharge to the environment. When the TSS level in the interception sump is considered too high water from that sump is pumped back into the North Cell of the TSF.

The perimeter water control structures will be used throughout the operating life of the TSF. These will continue to be used into the post-closure of the project until both the TSF and adjacent ground returns to pre-development permafrost conditions or the surface runoff and seepage waters are of acceptable quality to be discharged directly to the environment.

Following the construction of the North Cell Internal Structure, internal ditches and sump were constructed over the existing tailings surface. A ditch connecting to a sump was built on the western side of the North Cell internal structure and two sumps were built on the eastern side. The objective of these structures is to collect water that would seep through the internal structure during operation. Water collected in these structures is pumped back into the TSF. These structures will be operational only during deposition from the internal structure of the North Cell.

3.3 WATER & TAILINGS PUMPING INFRASTRUCTURE

Tailings is distributed from the mill to the TSF by pumping it as a slurry (details on tailings property are presented in Section 4). The infrastructure located inside the mill is out of scope of this OMS manual.

The pipe used for tailings distribution is insulated 14'' and 16'' HDPE pipe. The tailings pipe is heat traced form the mill to the pig launcher. The tailings pipe from the mill first reach the pig launcher station. The pig launcher station is the location where the tailings deposition can be switch to the by-pass point. This station is used for maintenance of the tailings pipe (passing the pig).

Tailings deposition at Meadowbank is done using the end of pipe technique with only one active tailings deposition point at a given time. From the pig launcher the tailings pipe is then positioned to reach the current deposition points. The location of the tailings deposition point is determined during the tailings deposition plan exercise and are constructed as they become required. Location of the tailings discharge point are shown on Figure 3-2 and Figure 3-3. Each deposition point switch requires physical manipulation of the pipe (extension / shortening) as there is no valve system.

When tailings deposition occurs from a dike, the tailings deposition point is constructed in a way to prevent damaging the structure (also call deposition finger). The protection usually includes placement of aggregate over the structure as well as the placement of geomembrane or used conveyor belt

A booster pump station is required to be able to pump the tailings into the North Cell due to the pumping distance and difference in elevation. The booster pump station includes two electrical pumps that are controlled by the mill.

A reclaim station is located in the South Cell near SD3. This infrastructure is used to send back water from the TSF to be used as part of the milling process. The reclaim station is a pumphouse on skid that can be moved as the water level change in the South Cell. The suction line is placed at the bottom of the pond and is extended as needed. The pump of the reclaim station is electrical and is controlled remotely by the mill. The line that bring the reclaim water to the mill is a heat traced insulated 14'' HDPE DR 17

Water ponding in the North Cell is transferred into the South Cell pond using a HL250 pump.

Water seeping out of the dike TSF is captured in sump and pumped back as required on the upstream side of the dike. Most sumps do not have a permanent pumping system and water is pump out as required during freshet using mobile pump. These sumps are located at SD1, SD3 and SD4, and around North Cell Internal Structure.

At freshet water from the interception sump of the western ditches is pumped back in the North Cell as well as water from ST-16. These setup are considered to be temporary and are used and installed as required.

Central Dike has a permanent pumping system comprised of an electrical pump and a diesel pump. Pumping of the downstream pond is required on a year-round basis as to maintain a target EL. At 115 m. Water from Central Dike seepage is sent back into the South Cell.

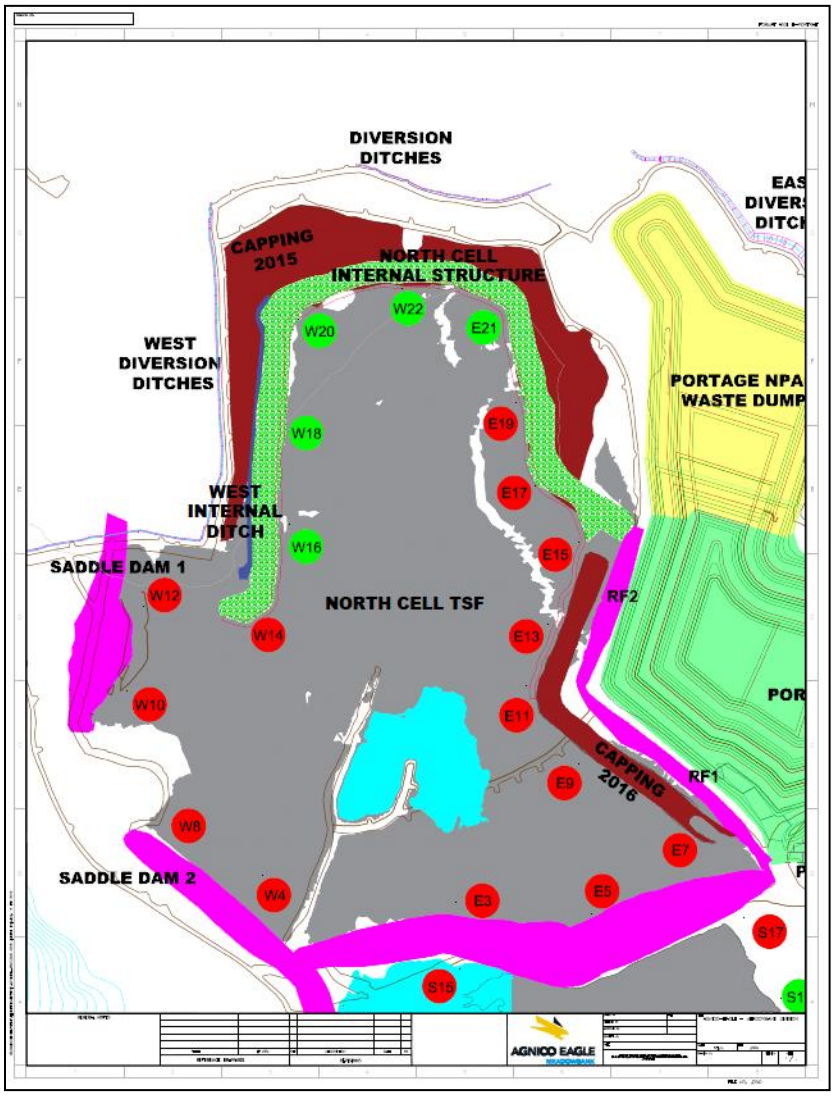


Figure 3-2 Deposition Point Locations in the North Cell

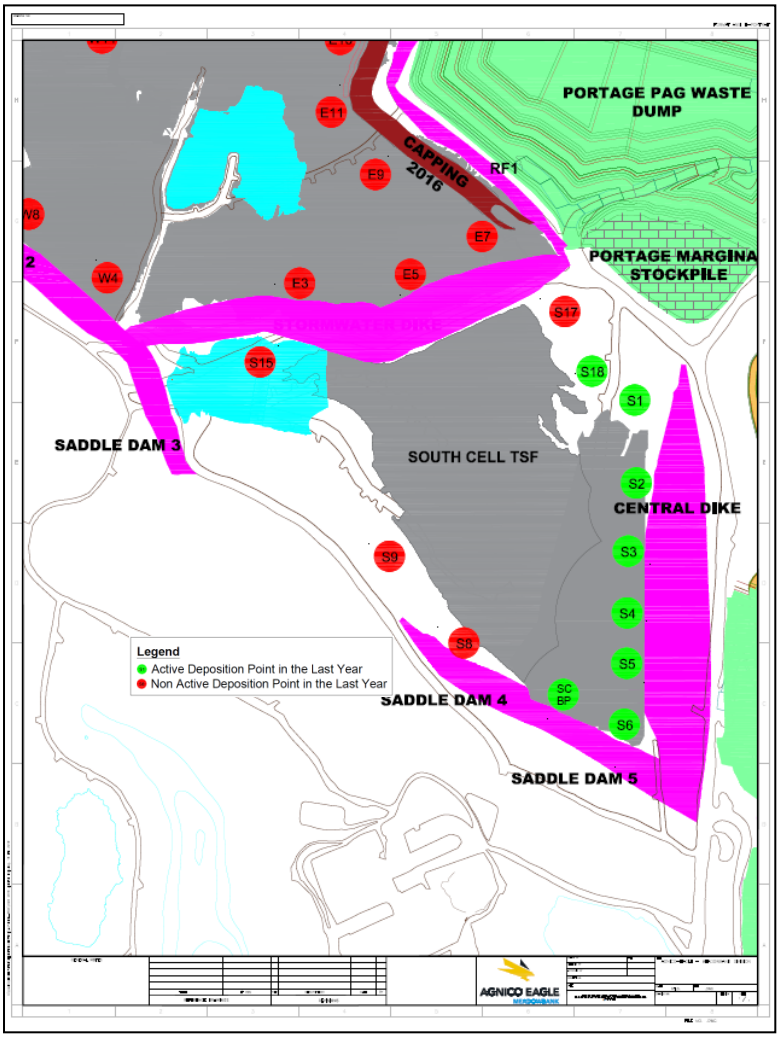


Figure 3-3 : Deposition Point Locations in the South Cell

3.4 INSTRUMENTATION

The TSF is instrumented with geotechnical instrumentation to monitor performance of the containment structure and the freeze back of the tailings. The instruments are installed within the structure and inside the tailings and includes piezometers, thermistors and survey monuments (prisms).

Reference document for the instrumentation installed within the TSF and their status are presented in Appendix 2. The summary of instrument installed is summarised in Table 3-3. Figure 3-4 show the instruments installed within the TSF.

Table 3-3 : Instrumentation Summary within the TSF

Structure	Piezometers	Thermistors	Survey Monument	Crackmeters	Staff Gauge
Central Dike	69	26	-	-	-
Stormwater Dike	3	3	19	3	-
Saddle Dam 1	-	4	-	-	-
Saddle Dam 2	-	4	-	-	-
Saddle Dam 3	-	5	-	-	-
Saddle Dam 4	-	4	-	-	-
Saddle Dam 5	-	3	-	-	-
RF1-RF2	-	4	-	-	-
North Cell Internal Structure	-	4	16	-	-
North Cell Tailings	-	9	-	-	1

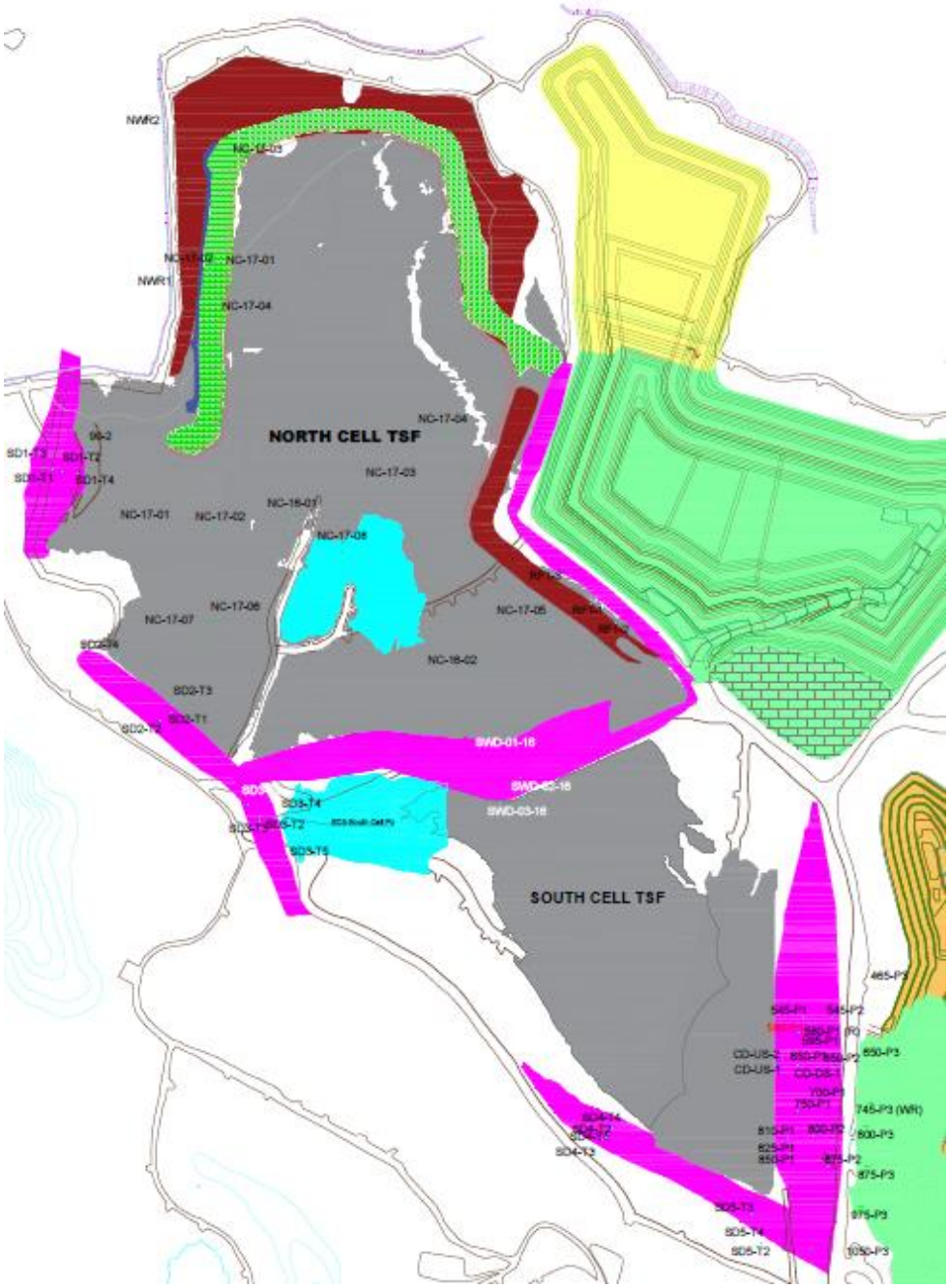


Figure 3-4 : Instruments Location Within the TSF

3.5 REFERENCE DOCUMENTS AND DRAWINGS

Reference to key document for the design and construction of the TSF infrastructures is presented in Table 3-4 to Table 3-6.

Table 3-4: Tailings Storage Facility Design Report and Specifications

Item	Description	Reference
Tailings Storage Facility Dike Design	Design Report	Doc. No. 784 Ver. 0, Golder 2008
TSF Dike Construction Technical Specifications	Technical Specifications	Doc. No. 796 Rev. 0, Golder 2009
Detailed Design Report for Central Dike	Design Report	Doc. No. 1349 Ver. 0 Rev. 1, Golder 2012
Central Dike Construction Technical Specifications	Technical Specifications	Doc. No. 1327 Rev. 0, Golder 2012
North Cell Diversion Ditches	Design Memorandum	Doc. No. 1370 Rev. 0, Golder 2012
Detailed Design Report for Saddle Dams 3, 4 and 5	Design Report, Technical Specifications and Drawings	Doc. No. 1504 Rev. 1, Golder 2015
Detailed Engineering Design of Internal Structure (TSF North Cell)	Design Report, Specifications and Drawings	Doc. No. 1784383 Rev. 0, Golder 2018

Table 3-5 Tailings Storage Facility Construction Summary Report

Item	Description	Reference
RF1, RF2 Stormwater Dike : Stage 1-2 SD1 : Stage 1-2 SD2 : Stage 1-2	2009-2011 Construction Season as-built report	AEM (June 2013)
North Cell Diversion Ditches	2012 construction summary report	AEM 2012
Central Dike Stage 1	Construction Summary Report Stage 1 – Central Dike 2012	AEM 2018
Central Dike Stage 3	Construction Summary Report Stage 3 – Central Dike 2014	AEM 2015
Central Dike Stage 4 SD3, SD4, SD5 Stage 1	2015 Construction Season as-built report	AEM 2015
Central Dike Stage 5 SD 3, SD4, SD5 Stage 2	2016 Construction Season as-built report	Doc. No. 1552 1656047 Rev. 0, Golder 2017

Central Dike North Abutment Raise SD3, SD4, SD5 Stage 3	2017 Construction Season as-built report	Doc. No. 1777687 1572 Rev. 0, Golder 2017
Central Dike Stage 6 Finalization SD3 Stage 3 North Cell Internal Structure	2018 Construction Season as-built report	Doc. No. 1897439 1578 Rev.0, Golder 2018

Table 3-6 List of Construction Drawings for Embankment Structures

Drawing No. (Prepared by)	Title	Revision No.	Date of Revision
4100-30 to 4100-39 (Golder)	Tailings Storage Facility – Stormwater Dike	0	July 10, 2009
4100-50 to 4100-60 (Golder)	Tailings Storage Facility – Saddle Dam 1	0	July 10, 2009
SD2-SD3-01 to SD2-SD3-13 (Golder)	Tailings Storage Facility –Saddle Dam 2 and Saddle Dam 3	A	August 25, 2010
SD6-01 to SD6-11 (Golder)	Tailings Storage Facility – Saddle Dam 6	A	September 13, 2010
Figure 1—Supersedes Drawing Nos. 4100-30, 4100-31, and 4100-32 (Golder)	Agnico-Eagle Mines Limited, Meadowbank Gold Project Nunavut, Stormwater Dike Staged Layout Plan	N/A	August 5, 2009
Figure 2—Supersedes Drawing Nos. 4100-33, Detail 3 on 4100-34 (Golder)	Tailings Storage Facility Typical Cross-Section and Details	N/A	August 5, 2009
Figure 1—Supersedes Drawing Nos. 4100-51, 4100-52, 4100-53, and 4100-58 (Golder)	Tailings Storage Facility Saddle Dam 1 Rockfill Plan and Liner Details	N/A	August 17, 2009
All drawings in the Construction Report TSF (AEM)	Construction Report Tailings Storage Facility	N/A	June 15, 2013
All drawings in the Detailed Design Report for Saddle Dams 3, 4 and 5 Doc 1504 1416081 SD3,4 & 5 Design Rev1	Detailed Design Report for Saddle Dams 3, 4 and 5	0	May 12, 2015
All drawings in the Detailed Design Report for North Cell Internal Structure Doc 1784383 Rev0	Detailed Engineering Design of Internal Structure	0	April 19, 2018
Update as Required			

Table 3-7 List of Construction Drawings for Infrastructure and Piping

Drawing No. (Prepared by)	Title	Revision No. and Title	Date of Revision
All Booster Pump Design Drawings	Booster Pump Design Drawings, MEAD-360	N/A	June 26, 2012
All drawings in the Construction Summary Report North Cell Diversion Ditches (AEM)	Construction Summary Report North Cell Diversion Ditches	N/A	July 27, 2013
All South Cell Infrastructures Drawings (AEM)	Reclaim pump drawings 61-430 Pig launcher drawings 61-360 Central Dike Seepage drawings P1607151-1000-00	N/A	2016
Update as Required			

SECTION 4 • OPERATIONS

The following section outlines the key operational procedure that need to be observed and followed during operation of the tailings management facility in accordance with the performance objectives.

4.1 REFERENCES

Reference to key documents for the operation of the tailings facility are presented in Table 4-1.

Table 4-1 : Reference Documents for Operation of Tailing Storage Facility

Type of information	Reference	Link to Retrieve Document
Tailings Deposition Plan	2019_V1B	..\..\..\..\06-TailingsManagement\4 - DEPOSITION PLAN\2019\1- Current Deposition Plan
Meadowbank Annual Water Balance	2019	..\..\..\..\05-WaterManagement\2019\Water Balance
Meadowbank Water Management Plan	V7 AEM 2018	..\..\..\..\..\12- Annual Report\2019\Water management plan
Meadowbank Waste Management Plan	V8 AEM 2018	..\..\..\..\..\12- Annual Report\2019\Waste rock and tailings management plan

4.2 SUMMARY OF PERFORMANCE OBJECTIVES AND OPERATION CONTROLS

The performance objectives and the operational criteria for tailings management are summarised in Table 4-2.

Table 4-2 : Performance Objectives and Operational Criteria for Tailings Management

Tailings Transportation and Placement
• Tailings must deposited within accepted compliance to the tailings deposition plan (respect of deposition duration and location). Tailings deposition plan has to have some flexibility to take into account variable tailings property and milling schedule. • Tailings transportation and placement must happen continuously while the mill is operating • Limit switching between tailings deposition point so to ease operation (maximize duration at a given deposition point)

• The tailings delivery system (pumps, pipe) must be operated and maintained as per the defined operating procedure • Tailings deposition need to limit ice-entrapment by limiting sub-aerial deposition in the winter over long distance
Tailings Containment
• All tailings must be stored within the TSF. Presence of tailings outside the TSF is considered a spill. • The tailings freeboard must be respected at all time (refer to section 4.4) • Tailings beaches need to be promoted along the peripheral structure (except SD3) • The construction schedule for the raise of the tailings containment structure must be aligned with the deposition plan.
Water Management
• A sufficient water volume must be maintained in the TSF ponds to allow recirculation to the mill (reclaim). The volume of water to be kept in the TSF should not exceed that value • The freshwater limit of the Water License must be respected. • The location of the water pond must comply with the deposition plan and a minimum water head should pond against the peripheral structure (except SD3) • A sufficient water depth must be maintained within the reclaim area • Ice is not allowed to pond against the liner of the tailings retention structure. A 20 m tailings beach need to be maintained in winter • Operational freeboard of each tailings retention structure must be respected during operation (refer to section 4.4) • Water movement must be tracked and recorded on a monthly basis (volume, origin, destination) • The water management system (pump, pipes, WTP) must be operated and maintained as per the defined operating procedure • Any seepage must be captured by sump and pumped back to allowed location (or naturally report to an approved location)
Water Quality
• Water quality and quantity of seepage water is monitored
Surveillance
• Proper surveillance (inspection and data review) of the tailings facility occur and is documented (refer to section 6) • The performance of the tailings management facility is reviewed against the threshold for performance criteria and trigger pre-defined actions (refer to Table 4-6 to 4-9)

4.3 DEPOSITION PLANNING

Deposition of tailings in the TSF (location & duration) must be done according to an approved deposition plan. The process of preparing or updating a deposition includes defining the parameter analysis and the deposition strategy, preparing the deposition plan, having the deposition plan approved and distribution of the deposition plan. Also at the end of each month the actual deposition

performed will be simulated to obtain end of month theoretical surface to verify if the deposition is on track with the plan.

Deposition plan are schedule to be updated twice a year following update to the LOM and Budget. The deposition planning is done by the Engineering Department (water & tailings engineer) using the software Muck 3D. Unplanned update to the deposition plan might be required if compliance to the deposition plan can no longer be reconciled (i.e change in deposition strategy, change in deposition parameter).

While defining the deposition strategy it is important to refer to Table 4-2 to ensure that the strategy of the deposition plan met the performance objective and operational criteria. Any proposed deviation to the performance objective must be submitted for approval to the Engineering Superintendent and Engineer of Record.

Twice a year a bathymetry and scan of the TSF will be completed (one in June and one in September). The latest information is to be used to calculate some of the parameters used in the deposition planning. As much as possible the update of the tailings deposition plan will start from an existing bathymetry.

Table 4-3 presents the information required prior updating a deposition plan and how to obtain it. Input parameter need to be approved prior to beginning working on the deposition plan.

The deposition plan usually presents the deposition strategy for each month for the coming year, on a quarterly basis for the second year and on a yearly basis after that.

Table 4-4 present what are the output of a deposition plan for each timestep modeled.Table 4-3

Once the deposition plan has been reviewed by the Engineering Coordinator and Superintendent it is ready to be approved. An approved deposition plan is an essential tool to be used to plan water management strategy, raise of tailings dike, reclaim vs freshwater ratio and deposition points constructions.

Table 4-3 : Input parameter into a deposition plan

Information obtained from the approved mining schedule (approved LOM or Budget)
• Tonnage profile to be stored until the end of life of the mining operation • Nominal processing rate at the mill on a monthly basis
Information obtained using a bathymetric analysis
• Tailings dry density in t/m^3 (historically varied from 1.2 to 1.4 t/m^3) • Deposition slope angle (sub-aerial and sub-aqueous) for each tailings storage location • Ice entrapment by volume
Information obtained from the water balance
• Volume of water in the pond • Need for water transfer • Quantity of reclaim vs freshwater • Ice entrapment by volume •
Tailings property from the mill
• Tailings discharge solids content (usually around 52 %) • Specific gravity of tailings solid

Table 4-4 : Output of a deposition plan

Active deposition point
• List of the active deposition point and the order of deposition • Duration (days) and tonnage (tons) of deposition at each point • Tailings elevation at each point at the end of deposition (ensure that freeboard is respected) • Total tonnages deposited (ensure compliance with milling schedulle)
Pond Property
• Total water volume (ensure compliance with water balance) • Free water volume (ensure compliance with reclaim objective) • Pond elevation (ensure that freeboard is respected) • Ice volume, ice thickness, ice ratio (%)
Figure of deposition area at the end of deposition
• Pond location is shown (ensure that the pond is at desired location) • Tailings location is shown (ensure that tailings beach requirements are met)
Recommendations
• Verify if a change in water management strategy is required (i.e water transfer, change in reclaim volume vs freshwater)

- Verify if tailings dike raise is required for capacity and what is the timeline
- Verify if new deposition point creation are required
- Verify if action are required to maintain reclaim capability (i.e construction of internal structure to prevent tailings from reaching reclaim area)

4.4 FREEBOARD

The minimum freeboard to be respected for tailings and water is presented within the design report of the TSF and is summarised in Table 4-5.

Table 4-5 : Freeboard Criteria During Operation

Location	Type of freeboard	Value
North Cell / South Cell	Tailings freeboard with containment structure	0.5 m below crest of structure
North Cell	Water freeboard	El. 148 m (2m below El. Of peripheral structure)
South Cell	Water freeboard	El. 143 m (2m below El. Of peripheral structure)

4.5 TAILINGS MANAGEMENT

The TSF was commissioned in conjunction with the mill start-up in February 2010, with tailings being deposited within the North Cell of the facility. Tailings deposition was transferred from the North Cell to the South Cell at the end of 2014. Tailings deposition occurred during the summer of 2015 within the North Cell and resumed in the South Cell in October 2015. Progressive closure of the North Cell started in the winter of 2015 with the construction of a non-acid generating rockfill capping over the tailings and continued in the winter of 2016. In the summer of 2018 the North Cell internal structure were built and deposition was resumed in the North Cell.

Deposition is done using end of pipe tailings deposition with one active point at a time. The deposition point location and duration is planned by the tailings deposition plan. Changing between deposition points on a given line consist of stopping the flow of tailings in the line, redirecting it through the pig launcher bypass, flushing the line, relocating the deposition point pipe and then switching tailings from the by-pass to the newly installed deposition line.

The tailings deposition strategy in the South Cell is to push the pond of water against SD3 and Stormwater Dike while maintaining tailings beach against the other peripheral structure (SD4, SD5, Central Dike). The objective is to keep the pond as far as possible from these structures with a minimum beach length target of 20 m.

The tailings deposition strategy in the North Cell is to promote closure landform as much as possible. This is done by depositing tailings from the North Cell Internal Structure located in the northern section of the North Cell. Due to the length of the beach in the North Cell the deposition strategy is to only perform deposition form May to October to limit aerial deposition in the winter which is typically associated with high ice entrapment.

4.6 WATER MANAGEMENT

The water management strategy for the TSF can be found in the water balance and in the water management plan. A schematic version of the water movement strategy for the TSF is summarised in Figure 4-1.

The strategy to deal with seepage is to capture it within sump at the downstream of the structure and to pump it back in the TSF. The quantity and quality of each seepage out of the TSF is monitored. Historically seepage mixed with runoff water has been pumped back into the TSF at freshet from SD1, SD3, SD4, SD5, RSF (ST 16). Seepage from Central Dike is pump back on a continuous basis into the South Cell. The location of the Central Dike seepage discharge was moved in the winter of 2019 from upstream of Central Dike to upstream of Saddle Dam 4. This decision was made when rapid ice buildup was observed against SD5 due to the seepage water getting entrapped in that sector.

All water accumulation from the North Cell (from tailings deposition, NCIS sumps, seepage and transfer from the Western Ditch interception sump) is transferred into the South Cell to maintain a minimum water level in the North Cell.

The water management strategy in the South Cell is to reclaim as much water as possible while avoiding excess storage of water due to the Central Dike situation. When the pond volume is too low for reclaim, additional freshwater is used at the mill. When the deposition plan predict that water will reach the reclaim pump area, action are taken to maintain the reclaim location. In 2017 and 2019 an internal structure was built into the South Cell to prevent tailings from reaching the reclaim area. The construction of such a structure in the North Cell is currently planned as part of the current tailings deposition plan.

As part of the water management strategy of the South Cell it is possible to send excess water into Goose Pit. This strategy was used in 2015 and 2017 and will be required in 2019 as part of the latest deposition plan update.

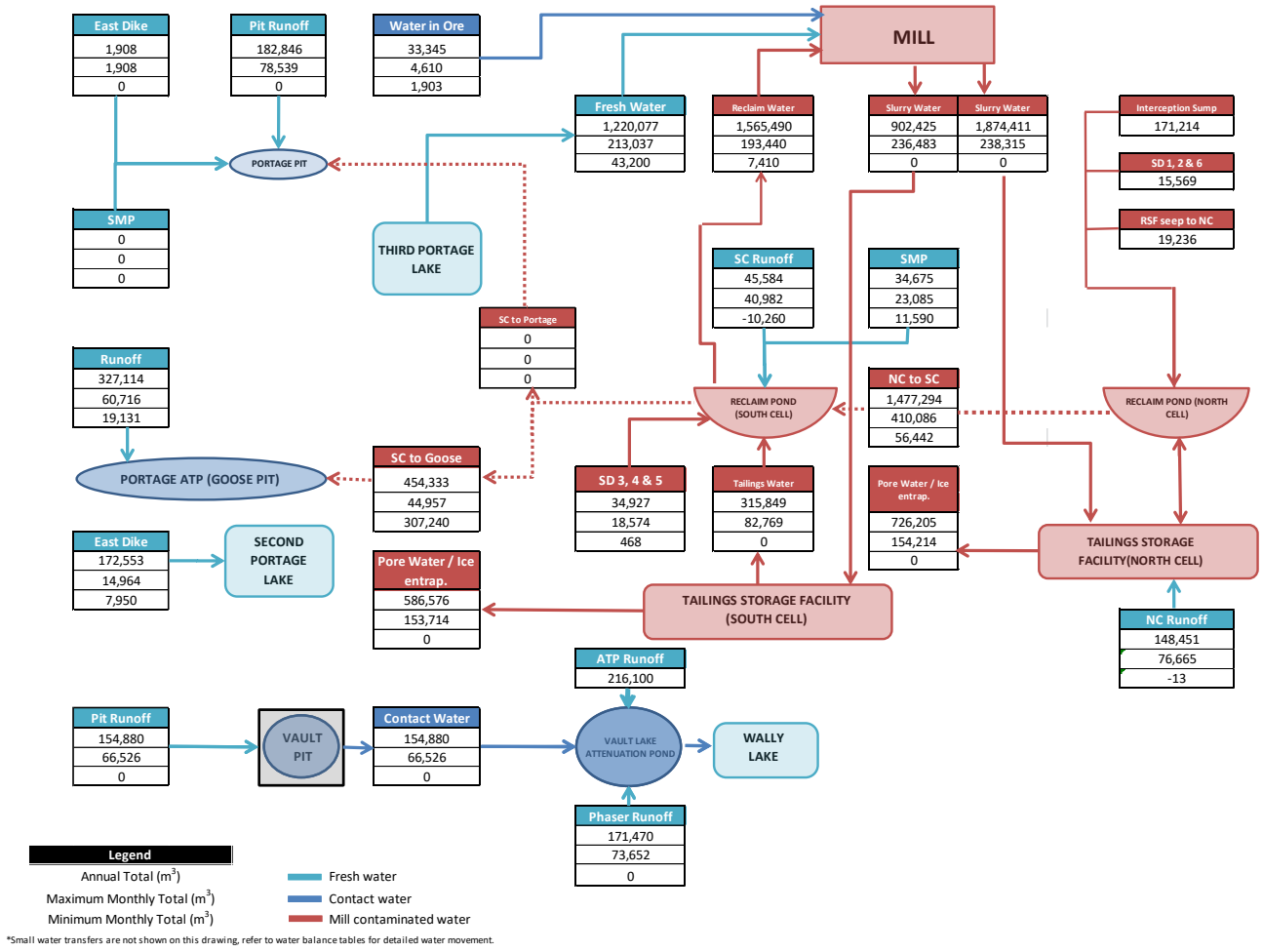


Figure 4-1 : Water Management Strategy for 2019

4.7 PERFORMANCE INDICATOR DURING TAILINGS MANAGEMENT

Table 4-6 to Table 4-9 below present performance indicator for each component of the tailings management system and the Trigger Action Response Plan (TARP) if the associated performance criteria deviate from defined range.

Table 4-6 Threshold Criteria and pre-defined action during operation of tailings retention structures (Excluding Central Dike)

		Threshold Criteria During Operation			
		Green Acceptable Situation	**Yellow Areas of Concern**	**Orange High Risk Situation**	**Red Emergency Situation**
Criteria	Cumulative crest settlement from operations start up	No settlement observed	< 0.2 m	> 0.2 m and < 1.0 m Increasing rate of settlement	> 1.0 m Increasing rate of settlement
	Downstream toe displacement	No displacement observed	Affecting seepage collection system	Loss of roadway	Loss of roadway
	Shear crack along rockfill embankment (differential settlement)	No shear crack observed	< 0.4 m deep	> 0.4 m and < 0.8 m deep	> 0.8 m deep
			< 5 m length along the dike	> 5 m and < 10 m length along the dike	> 10 m length along the dike
	Tension crack embankment alignment at crest	No tension crack observed	< 0.25 m deep	> 0.25 m and < 1 m deep	> 1 m deep
			< 0.10 m wide across the dike	> 0.10 m and < 0.20 m wide across the dike	> 0.20 m wide across the dike
			< 5 m length along the dike	> 5 m and < 10 m length along the dike	> 10 m length along the dike
	Sloughing along downstream rockfill embankment face	No sloughing observed	Observed	Observed and worsening from yellow situation	Observed and worsening from orange situation
	Embankment lateral cumulative deformation	No deformation observed	< 0.1 m	> 0.1 m and <0.25 m	> 0.25 m
	Seepage through embankment	No seepage observed	< 1/3 pumping rate capacity	> 1/3 and < 2/3 pumping rate capacity	> 2/3 pumping rate capacity
	Increase of seepage rate	No increase in seepage rate	< 5% per day over five consecutive days	> 5% < 10% per day over four consecutive days	> 10% per day over three consecutive days
	Turbidity of seepage water	No turbidity observed	Turbidity observed for first time	Turbidity observed and source of sediments matching cut-off wall or foundation till mineralogy	Turbidity observed and source of sediments matching cut-off wall or foundation till mineralogy
	Sinkhole on crest	No depressions or sinkholes on crest observed	Localized depression of embankment crest	Observed	Well developed
Action Required (general)			Monitor as normal All cracks filled or repaired If cracks re open implement engineering review Identify source of turbidity	Implement engineering review Suspend activities on embankment crest at chainage of concern Intensify monitoring at chainage of concern	Remove personnel and equipment from pit and suspend activities
		Take action and notify personel as per decision framework of Figure 4.2			

Table 4-7 Threshold Criteria and pre-defined action during operation of Central Dike (Part 1/3)

		Personnel notified	Seepage				
			Change in inferred Seepage Rate	***Total D/S pumped***	***Downstream Pond Elevation***	***Compliance to seepage model (1)***	
			Threshold	**Threshold**	**Threshold**	**Threshold**	**Possible actions**
Green	Normal	Take action and notify personel as per decision framework of Figure 4.2	Sudden or cumulative increase of < 25% over last 3 days	< 200 m3/h averaged on last 3 days (below capacity of one HL250 F.S ≥ 3)	Pond elevation stable at < 115.3 masl	Expected trend observed	General : Continue monitoring as per standard practices
Yellow	Monitor		Sudden or cumulative increase of > 25% over last 3 days	≥ 200 m3/h and < 1300 m3/h averaged on last 3 days (capacity of two HL250)	Pond elevation > 115.3 but < 115.8 masl	Stable seepage rate	Specific : Increase pumping capacity with back up HL250 pump in place General : Install additional instruments General : Implement engineering review
Orange	Proactive			≥ 1300 m3/h and < 1500 m3/h averaged on last 3 days (limit capacity of two HL250)	Pond elevation >115.8 but < 116 masl	Opposite trend observed	Specific : Evaluation and planning of parallel dewatering infrastructures Specific : Inspect West Road integrity General : Evaluation and planning of alternative deposition location General : Evaluation and planning of diminution of South Cell hydraulic head
Red	Reactive			≥ 1500 m3/h averaged on last 3 days (over capacity of two HL250)	Pond elevation > 116 masl		Specific : Install parallel dewatering infrastructures and consider installation of a 3rd HL250 pump Specific : Frequent inspection of Portage pit and West Road for flooding evidence Specific : Manage flood water in the pit General : Alter deposition sequence to increase tailings cover General : Execution of South Cell hydraulic head diminution strategy General : Grouting General : Initiate Emergency Response Plan

(1) Specific model: Doc1562 CD Seepage Modelling 16670255 Rev0 - must be interpreted by the designer and/or geotechnical coordinator

Table 4-8 : Threshold Criteria and pre-defined action during operation of Central Dike (Part 2/3)

		Personnel notified	Instrumentation monitoring (1)					
			Piezometers P1 installed in the till layer total head (2)	***Piezometers P2 installed in the till layer total head (3)***	***Change in Piezometric head***	***Thermistors***	***Downstream pond and TSS***	
			Threshold	**Threshold**	-	**Threshold**	**Threshold**	**Possible actions**
Green	Normal	Take action and notify personel as per decision framework of Figure 4.2	< 121.5 masl F.o.S > 1.5	< 115.5 F.o.S > 1.5	change less than 1 m in 3 day	Seasonal trend observed	Background TSS observed (4mg/L)	General : Continue monitoring as per standard practices Specific : Daily inspection of the structure by qualified personal and frequent instrumentation monitoring
Yellow	Monitor		121.6 - 126.2 masl 1.5 > F.o.S > 1.3	115.5 - 117.8 masl 1.5 > F.o.S > 1.3	change of 1 m in 3 days of piezometric head	Peak of temperature similar to South Cell TSF temperature observed in at least a single bead	Single TSS event of 30 mg/L	General : Evaluate needs to install additional instruments General : Implement engineering review
Orange	Proactive		126.3 - 127.4 masl 1.3 > F.o.S > 1.1 and based on interpretation by Geotechnical Coordinator or Designer	> 117.9 F.o.S < 1.3 and based on interpretation by Geotechnical Coordinator or Designer			Sustained high turbidity over 30 mg/L	Specific : Implement engineering review Specific : Increase in frequency of monitoring at station of concern Specific : Build buttress General : Evaluate needs to install additional instruments General : Evaluation and planning of alternative deposition location General : Evaluation and planning of diminution of South Cell hydraulic head
Red	Reactive							General : Alter deposition sequence to increase tailings cover General : Execution of South Cell hydraulic head diminution strategy (could include emptying the South Cell) General : Grouting General : Initiate Emergency Response Plan

(1) Instrumentation data must be interpreted by geotechnical coordinator or dike designer (Golder)
(2) Failure of till foundation: add report reference Specific model : Doc1562 CD Seepage Modelling 16670255 Rev0 - Section 6
(3) Backward erosion: add report reference. Specific model : Doc1562 CD Seepage Modelling 16670255 Rev0 - Section 7.3

Table 4-9Threshold Criteria and pre-defined action during operation of Central Dike (Part 3/3)

		Personnel notified	Visual Inspection							
			Loss of tailings	***Dike Vertical Movement - Cumulative crest settlement***	***Downstream toe displacement***	***Tension/shear crack at crest***	***Embankment lateral cumulative deformation (1)***	***Sloughing along downstream rockfill embankment face***	***Sinkhole on embankment***	
			Threshold	**Threshold**	**Threshold**	**Threshold**	**Threshold**	**Threshold**	**Threshold**	**Possible actions**
Green	Normal		Normal operating conditions	No settlement observed	No displacement observed	No tension crack observed	No deformation observed	No sloughing observed	No depressions on crest	General : Continue monitoring as per standard practices Specific : Daily inspection of the structure by qualified personal and frequent instrumentation monitoring
Yellow	Monitor	Take action and notify personel as per decision framework of Figure 4.2	Localized depression in tailings observed	<0.2m	Observed displacement at the toe	< 0.10 m wide across the dike & < 5 m length along the dike	< 0.1 m	Single event observed	Localized depression of embankment crest	Specific : Fill all cracks General : Install additional instruments General : Implement engineering review
Orange	Proactive		Presence of sustained localized depression in tailings and/or tailings observed inside the downstream pond	> 0.2 m and < 1.0 m Increasing rate of settlement	Displacement rate observed	> 0.10 m and < 0.20 m wide across the dike > 5 m and < 10 m length along the dike	> 0.1 m and <0.25 m	More than one events observed	Sinkhole identified	Specific : Implement engineering review Specific : Increase in frequency of monitoring at station of concern Specific : Build buttress General : Evaluation and planning of alternative deposition location General : Evaluation and planning of diminution of South Cell hydraulic head
Red	Reactive		Increase in depression hole dimension and/or tailings observed inside the Portage Pit	> 1.0 m Increasing rate of settlement	Acceleration of displacement rate	> 0.20 m wide across the dike > 10 m length along the dike	> 0.25 m	Continued event(s)	Development of sinkhole	General : Alter deposition sequence to increase tailings cover General : Execution of South Cell hydraulic head diminution strategy (could include emptying the South Cell) General : Grouting General : Initiate Emergency Response Plan

NOTE: *Specific action are triggered by specific risk (stability, seepage, environment)while general action are applied to all risk category*

If more than one criteria is triggered, a reevaluation of our global Alert level will be performed by the AEM team

4.8 COMMUNICATION AND DECISION MAKING

Figure 4-2 indicate the communication and decision process when the threshold criteria are met and when pre-defined action need to be implemented.

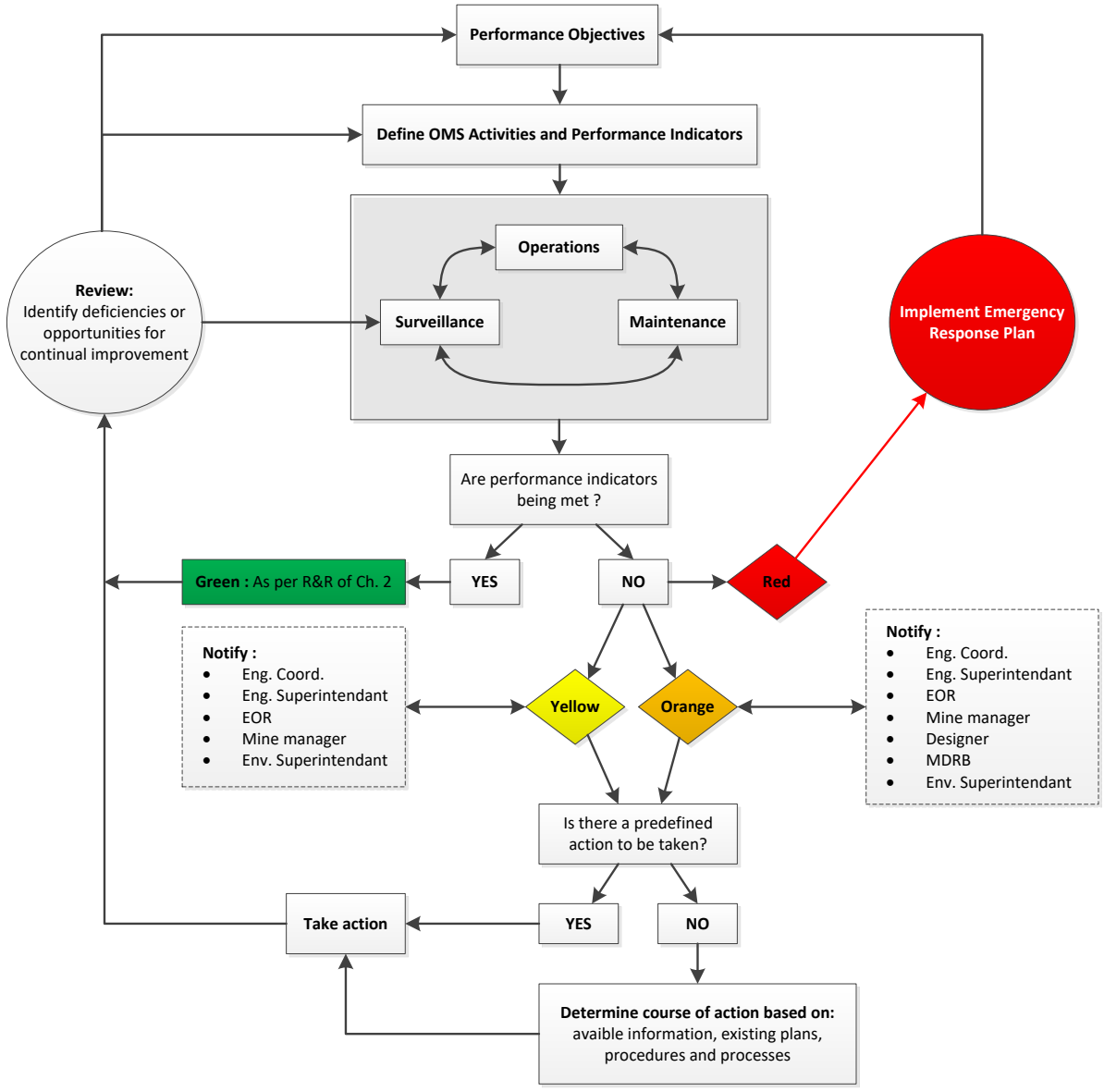


Figure 4-2 : Communication and Decision Process for Tailings Management TARP

SECTION 5 • MAINTENANCE

This section identifies all infrastructures within the scope of this manual that has maintenance requirements and identify all preventative, predictive and corrective maintenance activities.

The objectives of the maintenance program are to review and identify maintenance requirements, executing corrective measures and timely repairs of the containment structures, perimeter water control structures, facility access, and infrastructure.

5.1 PREVENTATIVE, PREDICTIVE AND CORRECTIVE MAINTENANCE

Maintenance is divided into preventative (planned), predictive and corrective.

Preventative maintenance are planned, recurring maintenance activities conducted at a fixed or approximate frequency and not typically arising from results of surveillance activities. Example of such maintenance include calibration and maintenance of surveillance equipment or regularly changing oil on a pump as per manufacturer's requirement.

Predictive maintenance are pre-defined maintenance conducted in response to results of surveillance activities that measure the condition of a specific component against performance criteria.

Corrective maintenance of a component of the tailings management system is to prevent further deterioration and ensure their performance in conformance with performance objectives. The need for corrective maintenance is based on surveillance activities, with surveillance results identifying the need and urgency of maintenance.

5.2 REFERENCES

Reference to key document for the maintenance of the Whale Tail water management infrastructure is presented in Table 5-1.

Table 5-1: Reference documents for Maintenance of Whale Tail water management infrastructure

Type of information	Link to Retrieve Information
Maintenance log of water management infrastructure (to come)	In progress
Maintenance log of pumping equipment	I:\MAINTENANCE\G dore\PWA-COM-LGT hrs reading.xlsx P:\EnergyInfra\08-PowerHouse\2 EQUIPMENT\2 GENERATORS
Maintenance log of geotechnical instrumentation (to come)	In progress
Pump allocation tool	..\..\..\04- Water Management\4- Water Management Infrastucture\3- 2019\1 - Planning\9- Procurement\Pump Allocation\AMQ Pump Allocation 2019-2020.pptx
Geotechnical instrument & Datalogger inventory	In progress

5.3 COMPONENT OF THE TAILINGS MANAGEMENT INFRASTRUCTURE REQUIRING MAINTENANCE

Table 5-2 indicate all the component of the Whale Tail water management infrastructure that require maintenance.

Table 5-2: Component of the water management infrastructure requiring maintenance

Water Management Infrastructure
• Dike embankment (i.e repair erosion, reprofile slope) • Dike crest (i.e fill inactive tension cracks) • Seepage collection sump (i.e, reprofile slope, increase sump volume) • Ditches and diversions (i.e snow removal, repair erosion, remove sediment accumulation)
Pumping infrastructure
• Pumps (mechanical and electrical maintenance) • Pipes (steaming, drain line, repair leak, avoid snow blockage) • Flush pipes of tailings and water prior to periods of non-use
Surveillance
• Geotechnical instruments (thermistors, piezometers, inclinometers, survey monument) • Data acquisition system • Flowmeter
Other
• Dike crest access road • Access to sump

5.3.1 Maintenance component that are outside the scope of this OMS manual

The following component maintenance activity are outside of the scope of this OMS manual. For more information the superintendent of the department responsible for these maintenance can be contacted

- Infrastructures located within the process plant – Process Plant
- Electrical systems and supply – E&I
- Maintenance of heavy equipment and light vehicles – Maintenance
- Communication infrastructures - IT
- Road used to access the infrastructures – Mine

5.4 DESCRIPTION OF MAINTENANCE ACTIVITY

Table 5-3 summarize the description of maintenance activities for each component of the tailings management infrastructure. Each component have activity as well as a trigger for that maintenance and a person responsible for this activity. It is the person responsible for the maintenance activity to ensure that the person doing the maintenance has the qualifications and competency required to conduct the maintenance and is following the proper safety procedure. The responsible person must also ensure that the proper documentation and reporting requirement are followed.

Table 5-3 :Description of maintenance activity for component of tailings management infrastructure

Component	Type of maintenance	Nature of the activity	Frequency of maintenance (preventative) OR Trigger of maintenance (predictive and corrective)	Responsible for the activity	Documentation Required	Reporting Requirement
Water Management Infrastructure						
Dike embankment - repair erosion	Corrective	Gullies and depression to be filled with rockfill and re-sloped	Following a demand from engineering superintendant following a visual inspection showing erosion	Mine Superintendent (can use a contractor alternatively)	Photo of remediation work	Engineering to update the maintenance log of the structure
Dike crest – fill inactive tension cracks	Corrective	Inactive tension cracks to be filled with bentonite to prevent widening due to water infiltration	Following a demand from engineering superintendant following a visual inspection showing inactive tension cracks	Geotechnical technician	Photo of remediation work	Engineering to update the maintenance log of the structure
Dike crest - compensate settlement	Corrective	Add rockfill to increase the height of the dike following observation of settlement	Following a demand from engineering superintendant following a visual inspection showing settlement that need to be compensated (i.e loss of freeboard)	Mine Superintendent (can use a contractor alternatively)	Photo of remediation work Surveying of remediation work	Engineering to update the maintenance log of the structure and provide surveying
Seepage collection sump– increase volume	Predictive	Excavate an additional sump or increase the capacity of an existing sump	Following a demand from engineering superintendant following a re-assessment of the sump capacity	Mine Superintendent (can use a contractor alternatively)	Photo of remediation work Surveying of remediation work	Engineering to update the maintenance log of the structure and provide surveying
Seepage collection sump – reprofile sump	Corrective	Excavate flatter slope for the sump or add material against the slope to reprofile them	Following a demand from engineering superintendant following a visual inspection showing instable sump slope	Mine Superintendent (can use a contractor alternatively)	Photo of remediation work	Engineering to update the maintenance log of the structure and provide surveying
Ditches – snow removal	Predictive	Use an excavator to remove snow in the ditch	Every year prior to freshet to ensure that ditch is clear of snow obstruction. Demand will be formulated by the Engineering Superintendent	Energy & Infrastructure Superintendant	Photo of remediation work	Engineering to update the maintenance log of the structure
Ditches – clean debris and sediment accumulation	Corrective	Remove any debris and accumulation of sediment that can hinder flow	Following a demand from engineering superintendant following a visual inspection showing accumulation of debris and sediment	Energy & Infrastructure Superintendant	Photo of remediation work	Engineering to update the maintenance log of the structure
Ditches – repair erosion of granular layer	Corrective	Add granular material to repair erosion of the ditches	Following a demand from engineering superintendant following a visual inspection showing erosion of the ditches	Energy & Infrastructure Superintendant	Photo of remediation work	Engineering to update the maintenance log of the structure
Ditches – release of TSS from the ditches	Corrective	Corrective action to mitigate release of TSS from ditches. Can include placement of sill curtain or temporary by-passing the ditches using pump	Following a demand from the environment superintendant following sampling of a high turbidity event from the diches	Environment Superintendant	Water sample results Photo of remediation work	Engineering to update the maintenance log of the structure
Pumping infrastructure						
Pumps and Genset – maintenance as per manufacturer specification	Preventative	Do PM on the pumping unit as per manufacturer recommendation	As per manufacturer specification	Pump mechanics	Equipment log Maintenance record	Maintenance to update the pump maintenance log or Genset maintenance log
Pumps and Genset – maintenance when defiency are observed (cavitation, breakdown, electrical trouble)	Corrective	Troubleshoot the pump problem so that it is once again oeprational	When the E&I Superintendant ask that a pump be fixed following a visual inspection of defiecny	Pump mechanics	Equipment log Maintenance record	Maintenance to update the pump maintenance log or Genset maintenance log
Pumps – winterization of unit used in winter	Preventative	Ensure that pumps used in witner have been winterised	Once new pump is received on site that will be used in winter	Maintenance superintendant	Maintenance record	Maintenance to update the pump maintenance log
Pipe – drain the line	Preventative	Ensure that the line is empty of water and tailings during tailings deposition switch or mill shutdown	Every time tailings deposition is interrupted or switch	Energy & Infrastructure Superintendant	-	-
Pipe – unfreezing a line	Corrective	Steaming the line to unfreeze it in winter	When the E&I Superintendant ask that a line be unfroze following visual inspection of a frozen line	Energy & Infrastructure Superintendant	-	-
Pipe – maintenance when defiency are observed (leak, pipe burst)	Corrective	Replacing a deficient part of a line with new pipe	When the E&I Superintendant ask that a line be repaired following visual inspection of pipe deficiency	Energy & Infrastructure Superintendant	-	-
Surveillance						

Component	Type of maintenance	Nature of the activity	Frequency of maintenance (preventative) OR Trigger of maintenance (predictive and corrective)	Responsible for the activity	Documentation Required	Reporting Requirement
Geotechnical Instrument – loss of reading	Corrective	Investigate the status of an instrument who no longer gave data	When an instrument no longer gave data for an unknown reason	Geotechnical technician	Update status in instrument database	Update of the geotechnical instrument database by the geotechnical technician
Geotechnical instrument – unusual reading	Corrective	Investigate the status of an instrument who gave unusual data	When an instrument gave an unusual data	Geotechnical technician	Update status in instrument database	Update of the geotechnical instrument database by the geotechnical technician
Geotechnical instrument – replacement	Corrective	Replace an instrument that no longer work	When the engineering superintendant as for a geotechnical instrument to be replaced	Geotechnical technician	Instrument installation as-built report Update spare inventory Calibration sheet Initial instrument rading	Update of the geotechnical instrument database by the geotechnical technician
Geotechnical instrument –calibration of total station	Preventative	Send the total station to be calibrated	yearly	Geotechnical technician	Calibration sheet	Update of the geotechnical instrument database by the geotechnical technician
Geotechnical instrument –calibration of inclinometer probe	Preventative	Send the inclinometer probe to be calibrated	yearly	Geotechnical technician	Calibration sheet	Update of the geotechnical instrument database by the geotechnical technician
Datalogger – maintenance	Preventative	Do maintenance of datalogger as per manufacturer specification	yearly	Geotechnical technician	Maintenance report	Update of the geotechnical instrument maintenance log by the geotechnical technician
Datalogger – battery change	Predictive	Change battery when the battery level alarm get triggered	When the battery alarm is trigered in VDV	Geotechnical technician	Maintenance report	Update of the geotechnical instrument maintenance log by the geotechnical technician
Datalogger – troubleshooting	Corrective	Repair of a dataloger deficiency	When a dataloger is suspected of being deficient	Geotechnical technician	Update status in instrument database	Update of the geotechnical instrument maintenance log by the geotechnical technician
Flowmeter – calibration	Preventative	Send the flowmeter to be calibrated	yearly	Energy & Infrastructure Superintendant	Calibration sheet	Update of the geotechnical instrument maintenance log by the geotechnical technician
Flowmeter – deficient reading	Corrective	Repair of a flowmeter deficiency	When the Engineering Superintendant ask that a flowmeter be troubleshoot based on irregular data	Energy & Infrastructure Superintendant	Update status in instrument database	Update of the geotechnical instrument database by the geotechnical technician
Other						
Dike crest access	Predictive	Snow clearing, maintaining roadway, grading access	As required to maintain access	Mine Superintendent	-	-
Access to sump	Predictive	Snow clearing, maintaining roadway, grading access	As required to maintain access	Mine Superintendent	-	-

SECTION 6 • SURVEILLANCE

Surveillance Involves the inspection and monitoring (i.e collection of qualitative and quantitative observation and data) of activities related to tailings management infrastructures. Surveillance also includes the timely documentation, analysis and communication of surveillance results, to inform decision making and verify whether performance objective including critical controls are being met.

There are two type of surveillances activities which are further discussed in this chapter :

- Site observation and inspection
- Instrument monitoring

6.1 SITE OBSERVATIONS AND INSPECTIONS

The purpose of site observation and inspection is to identify warning signs for the development of potentially adverse conditions that could lead to a failure or some other form of loss of control. Site observation and inspection include the direct observations by personel on or adjacent to the tailings management infrastructure and may also include observation from helicopter or photo taken from unmanned airborne vehicle (UAV, satellites).

Site observation and inspections are used to identify and track visible change in the condition of the water management infrastructure. Changes that may be observed throughout site observations and inspections are included in Table 6-1.

Table 6-1: Changes that may be observed through site observation and inspection of tailings management infrastructure

Changes related to physical risk of dike, road, ramp, ditches
• Change in freeboard • Deformation or change in condition at the crest, slopes and toes (i.e bulge, cracks, sinkhole, sloughing, settlement) • Newly form or expanding areas of erosion • Evidence of piping or unexpected water movement through water containment structures • Changes in the seepage quantity (pumping rate) and quality (turbidity) • Newly form of obstruction to flow in ditchs(i.e boulder, sediments, snow)
Changes related to chemical risks
• Evidence of newly formed seepage, or changes in seepage and evidence of any changes in seepage characteristics (i.e coloration, turbidity, TSS)
Changes related to tailings & water storage and transport
• Change in sump level • Verify using the staff gauge that the pond is operated within its normal operating condition • Changes in the seepage quantity (pumping rate) and quality (turbidity) • Condition of pipe for tailings or water transport • Sign of leaks from tailings or water line • Condition of pumps and water reclaim infrastructure
Change related to surveillance instrumentation
• Condition of surveillance instruments and associate protection around instruments (i.e cover, barriers to prevent vehicle damage) • Condition of power supplies for instruments (i.e solar panel) • Condition of communication infrastructure associated with instruments (i.e antenna, datalogger)

6.1.1 Site observation

Site observation is conducted by personnel working on or adjacent to tailings management infrastructure as part of their daily activities, maintaining awareness of the facility in the course of carrying their duties. Trained personnel such as geotechnical technician should be on the lookout for sign of changing condition as indicated in **Error! Reference source not found.** as adverse condition can develop rapidly between inspection. A simplified visual observation form can be used to document such observations but they do not need to be documented unless a new condition has been observed. Any new observation should be documented by photograph and reported to the geotechnical personel or Engineering Superintendant.

6.1.2 Inspection program

Inspection are conducted by the engineering department or other personel with appropriate training and competency and are more rigorous than site observations.

The inspection program consists of several types of inspections such as routine and special visual inspection, dike safety inspection and dam safety review. The following sub-section describe in more details the scope, frequency and responsible for each type of inspection.

The main types of inspections are as follows:

- Routine visual inspections – performed on a predetermined basis by AEM geotechnical team;
- Special visual inspections – performed during and afeter unusual events by AEM geotechnical team ;
- Dike Safety Inspection (annual geotechnical inspection) – performed annually by a Geotechnical Engineering Consultant familiar with the design and operation of the facility to verify that the facilities are functioning as intended
- Independent Dam Safety Review – carried out by the dike review board of independent engineers every year to review all aspects of the design, construction, operation, maintenance, processes and other systems affecting the dam's safety, including the dam safety management system. The review defines and encompasses all components of the "dam system" under evaluation including the dam, foundations, abutments and seepage collection works.

6.1.2.1 Routine Visual Inspection

Routine visual inspection are conducted on a pre-defined schedule and may target specific activities. Their objective is to identify any conditions that might indicate change in the tailings management infrastructure performance and therefore require follow-up. The inspection need to cover the aspect described in Table 6-1. Of particular significance are new occurrence or noted changed in seepage, erosion, sinkholes, boils, slope slumping, settlement, displacement, or cracking of structure components. These inspection are held during operation.

There are two approved inspection form for inspection ; a simplified one and a detailed one. The detailed form should be used for monthly inspection while the simplified one can be used when inspection are required at an increased frequency. All area of the form must be fill.

The person responsible for the inspection must :

- Do the inspection as per the required frequency
- Fill all information on the proper inspection form
- Take picture to supplement the inspection. As much as possible, these are to be taken from the same vantage points during each inspection so that changes in conditions can be readily identified. Photos should be annotated or captioned and should include a date stamp.
- Store electronically all photo and inspection form
- Update the surveillance log

- Ensure that the reviewer is aware that the document is ready to be reviewed

During the review process, the reviewer must:

- Ensure that all require information is present
- Ensure that the observation does not trigger a change in alert level
- Sign the inspection form as a reviewer
- Update the surveillance log
- Distribute the inspection results

The frequency for inspection of a structure will vary based on its TARP level and need to be updated in the surveillance log.

Table 6-2 summarise the Routine & Special visual inspection R&R, suggested frequency and scope in function of the alert level of the structure.

Table 6-2: Summary of routine inspection requirements

Structure	TARP Level	Inspection Responsible	Scope of inspection	Inspection Frequency	Reporting	Inspection Reviewer	Distribution List
SD1, SD2, SD3, SD4, SD5, RF1, RF2, Central Dike, Stormwater Dike, NCIS - Operation	Green	Geotechnical Technician	Physical risk and surveillance	Monthly	Detailled inspection form	Geotechnical Engineer	Engineering Geotechnical Team, EOR
				Weekly during period of flow (from May to October)	Simplified inspection form	-	
	Yellow	Geotechnical Technician	Physical risk and surveillance	Monthly	Detailled inspection form + presentation and analysis of instrumentation data	Geotechnical Engineer	Engineering Geotechnical Team, EOR
				Weekly	Simplified inspection form		
	Orange	Geotechnical Technician	All of Table 7-2	Weekly	Report on summary of surveillance activity + status of mitigation action	Geotechnical Engineer	Engineering Geotechnical Team, EOR, designer, Management
				Monthly	Detailled inspection form + presentation and analysis of instrumentation data	Geotechnical Engineer	Engineering Geotechnical Team, EOR
		Geotechnical Engineer		Daily	Simplified inspection form	Geotechnical Coordinator	Engineering Geotechnical Team, EOR
TSF Pond, Tailings distribution and Pumping Infrastructure – Operation	Green	Water & Tailings Engineer	Tailings & Water storage and transport	Monthly	Detailed Inspection	Geotechnical Coordinator	Engineering Geotechnical Team, E&I, EOR,
				Weekly (from May to October)	Simplified inspection form		
	Yellow	Water & Tailings Engineer or Geotechnical Engineer	Water storage and transport	Weekly in area of concern	Simplified inspection form	Geotechnical Coordinator	Engineering Geotechnical Team, E&I, EOR,
				Monthly	Detailled inspection form + presentation and analysis of relevant instrumentation data		
	Orange	Water & Tailings Engineer or Geotechnical Engineer	Water storage and transport + physical stability of ramp	Daily	Simplified inspection form	Geotechnical Coordinator	Engineering Geotechnical Team, EOR, designer, Management
				Weekly in area of concern	Detailed Inspection + report on summary of surveillance activity		

6.1.2.1 Special Visual Inspection

Special inspections are conducted during and after unusual or extreme events that may impact the facility. Special inspection are conducted by the geotechnical engineer or Engineer of Record using the detailed inspection form and using the same procedure for review and documentation. Special visual inspection must be done on each structure after each of these events:

- Following a blast that exceed the vibration limits of the structure
- After an earthquake
- After a high intensity rainfall event (higher than a 1:2 years recurrence)
- Immediately after a site observation notice a change in condition
- Prior or immediately after increasing or decreasing the TARP level of a structure

6.1.2.2 Dike Safety Inspection (annual geotechnical inspection)

A dike safety inspection is a more comprehensive technical inspections, integrating inspections and results of monitoring instrument. This type of inspection is conducted by an external geotechnical engineer and supported by the Engineer of Record to have a more complete understanding of the facility performance and identify deficiencies in performance or opportunity for improvement. This will provide information to be used to revise the OMS manual.

Such inspection need to occur on an annual basis between the month of July and September. The following components need to be inspected during this review:

- Saddle Dam 1, Saddle Dam 2, Saddle Dam 3, Saddle Dam 4, Saddle Dam 5, North Cell Internal Structure, Stormwater Dike, Central Dike, RF1, RF2
- North Cell and South Cell pond and reclaim infrastructure
- Tailings deposition infrastructure
- Ditches and channel

In addition to field inspection done as part of the safety inspection the following point should be addressed during the review:

- Review of all inspections report performed since the last review
- Review of monitoring instruments data;
- Identify deficiencies in performance or opportunity for improvement
- Review OMS performance and operational criteria and confirm that these meet the performance objective of the design
- Review and provide recommendations regarding OMS for the following year.

After each safety inspection a report must be submitted to the Engineering Superintendant which include the results of the inspection done and addressing all point above. These report will be stored electronically.

6.1.2.3 Independent Dam Safety Review

Independent dam safety review are carried out by an independent third party to review all aspects of the design, construction, operation, maintenance, processes and other systems affecting the dam's safety, including the dam safety management system. The review defines and encompasses all components of the "dam system" under evaluation including the dam, foundations, abutments, instrumentation and seepage collection works. The independent third party for the tailings management infrastructure is the Meadowbank Dike Review Board (MDRB).

Modification to the MDRB composition can only be made by the Engineer of Record.

The Meadowbank Dike Review Board (MDRB) is comprised of the following member.

- Anthony Rattue
- Don Haley

An annual MDRB meeting will be held every year at the Meadowbank site. Other event that could trigger a MDRB meeting are:

- Major modifications to the design or design criteria;
- Discovery of unusual conditions that can compromise the integrity the water management infrastructure;
- After extreme hydrological or seismic events; and
- Decommissioning.

During the annual MDRB meeting, a dam safety review will be carried out according to the recommendations laid out in the Dam Safety Guidelines (CDA, 2013).

This review will include, but is not limited to:

- Review of the dikes classification;
- Site inspection;
- Review of design and construction records;
- Review of monitoring practices and the instrumentation records
- Assessment of the operation of the facilities;
- Provide recommendation on operation, maintenance and surveillance based on the results of the instrumentation readings, construction records and site observations;

6.2 INSTRUMENT MONITORING PROGRAM – DATA ACQUISTION

Instrument monitoring provides information on parameters or characteristics that cannot be detected through site observation or inspections, cannot be observed with sufficient precision and accuracy or need to be monitored at high frequency or continuously.

The objective of instrument monitoring is to collect data to be used to assess the performance of the infrastructure against the performance objectives and indicators and the critical controls (refer to Table 4-2). Instrument monitoring and inspections work together as a comprehensive data set to enable assessment of the water management infrastructure performance and provide a basis for informed decision. All are essential, and none of these forms of surveillance can be neglected if performance objectives are to be met and risks are to be managed.

More information on the type of in-situ instruments installed on each structure, how they were installed and their location can be found in Section3.4 of this OMS manual.

Table 6-3 indicate the type of information collected through instruments monitoring and how it is collected. Table 6-4 summarise the data acquisition program related to instrument monitoring

Table 6-3: Information collected using instrument monitoring

Direct collection of information
• In-situ thermistors to measure temperature profile within the structure and its foundation and within the tailings • In-situ piezometer to measure pore-water pressure providing information about flow of water through the structure and foundation stability • Survey monument to provide information on settlement and deformation • Staff gauge to inform about water level of a pond versus its operating level • Blast monitor to inform on potential impact of blasting vibration on the structure • Flow meters and seepage monitoring station to inform on volume of water movement • Surveys conducted to measure ice cover, water level, update height and slope of containment structure
Collection of information from remote sensing
• Data acquired from airborne survey to generate detailed topographic map
Collection of information based on laboratory analyses
• Water quality analysis of seepage and surface runoff • Water quality analysis of water discharged through diffuser to inform on Environmental compliance • Water quality analysis of water stored in the various pond on site to inform on water movement decision
Collection of information related to the conduct of OMS activities
• Automatic data collection and transmission system for in-situ instruments (datalogger, solar panel, antenna, battery)

Table 6-4: Summaries of data acquisition program related to instrument monitoring of Whale Tail water management infrastructure

Instrument monitoring	Location of monitoring (3)	Parameter measured	Acquisition Methodology	Standard Acquistion frequency	Acquisition Responsible	Documentation methodology	Documentation Responsible
Thermistors	SD1, SD2, SD3,SD4,SD5, RF1, RF2, SWD, CD, NCIS, North Cell pond	Temperature (C^0) point for each bead on the chain	In-situ instrument connected to automatic data acquisition and transmission system	New data are acquired and transmitted to VDV every 3 hrs	Geotechnical Technician	Data are exported from VDV into instrumentation report emited at a predetermined frequency (1)(2)	Geotechnical Engineer
Piezometer	Central Dike, Stormwater Dike	Pressure (kpa) point for each instrument	In-situ instrument connected to automatic data acquisition and transmission system	New data are acquired and transmitted to VDV every 3 hrs	Geotechnical Technician	Data are exported from VDV into instrumentation report emited at a predetermined frequency (1)(2)	Geotechnical Engineer
Survey monument	NCIS, SWD, CD	Elevation of monument which is then converted into mm of displacement (minimum precision of 3 mm required)	Data are acquired using a total station	Monthly in winter and bi-weekly from May to September	Geotechnical Technician	Data are exported into geoexplorer. Instrumentation report are emited at predetermined frequency (1)(2)	Geotechnical Technician
Staff Gauge	North Cell Pond	Water level in pond	Take picture of the gauge	During each inspection	Inspection officer	Within inspection report	Inspection officer
Blast Monitor	SD1, SD2, SD3,SD4,SD5, RF1, RF2, SWD, CD, NCIS, North Cell pond	Peak particle velocity (PPV) measured by the blast monitor (mm/s)	Placement of blast monitor at a predetermined area on the dike	Before each blast in the vicinity of the dike	Geotechnical Technician	Update the blast vibration log. Discussion on recorded vibration in instrumentation report	Geotechnical Technician
Flow meter	Central Dike D/S	Volume of water pump (m^3)	Pumpman operator will inscribe flowmeter value ona pumping sheet	Daily when pump is operating	E&I Pump crew supervisor	Data will be integrated in the water balance	Water & Tailings engineer
Seepage monitoring station (manual reading with a V notch)	Where umpumped seepage is observed	Seepage flow (m^3/s)	Using a bucket and a stopwatch	Weekly during period of flow	Geotechnical Technician	Documented within instrumentation	Geotechnical Engineer
Bathymetry / Scan of tailings beach	North Cell / South Cell	Aerial and sub-aerial topography	Surveyor will take a scan and a bathymetry with a boat	At beginning and end of freshet	Surveyor Leader	Integrated in the tailings deposition plan	Water & Tailings engineer
Airborne survey	Whole TSF	Topographic aerial survey made using drone	Surveyor will take a drone survey	Once per year after freshet	Surveyor Leader	Within survey database	Surveyor Leader
Water quality	Central Dike seepage (4)	Parameter indicated within water management plan	Water quality sample taken and sent for laboratory analyses	Acquisition frequency within water management plan	Environment General Supervisor	Within Env water quality database	Environment General Supervisor

(1)Refer to section 6-4 for more information on reporting methodology and the frequency of reporting
(2) Refer to section 6-5 on how to present instrumentation data from VDV in a report
(3) Exact location of each instrument can be found in the instrumentation database
(4) Location of water quality sampling point can be found in water management plan

6.3 ADDING INSTRUMENT TO THE MONITORING PROGRAM

Any addition to the monitoring program must be validated by the Engineering Superintenant or by the Environment Superintendant for aspect relating to water quality. In-situ instrument installation must be recorded in an as-built report and added to the instrumentation database and map. After each installation of instrumentation the following must be done:

- Document the calibration sheet and initial data reading
- Document instrument specification (manufacturer sheet)
- Document Information to which datalogger the instrument is connected
- Survey instrument coordinate (x,y,z)
- If the instrument is drilled, a schematic view of the depth of the instrument versus the stratigraphy must be produced
- Photo of installation must be documented

6.4 ANALYSIS OF SURVEILLANCE RESULTS

For the effective use of surveillance results and decision making, results must be collated, examined, analysed and reported in a timely and effective manner.

For visual inspection the process of analysing the data and communicating the results is describe in Section 6.1 and happen at the same time the inspection is done and the report is sent. The information gained from the analysis of these results is then compared during the inspection and review to the TARP criteria which will then inform the action to take if performance indicator are not met.

For the instrumentation monitoring to be effective the data must be reviewed, analysed and reported at the proper frequency. Table 6-5 summarise the requirement for review, analyses and reporting of instrumentation data.

The person responsible for instrumentation data review need to update the surveillance log each time an instruments results has been reviewed and analysed. The person responsible for review of reporting and distribution need to update the surveillance log once the report has been reviewed and distributed.

Table 6-5 : Requirement for Review, Analyses and Reporting of Instrument Data

Instrumentation	TARP Level	Expected range of observation	Responsible for review & analyse	Frequency of review	Responsible for reporting	Reporting frequency	Responsible for review and distribution	Distribution List
Piezometer, thermistor, survey monument	Green	Define in TARP of each structure	Geotechnical Engineer	Bi-Weekly	Geotechnical Technician	Quaterly instrumentation report	Geotechnical Engineer	Engineering geotechnical team, designer, EOR
			Geotechnical technician	Weekly				
	Yellow	Define in TARP of each structure	Geotechnical Engineer	Weekly	Geotechnical Technician	Instrumentation reporting included within monthly inspection report	Geotechnical Engineer	Engineering geotechnical team, designer, EOR
			Geotechnical technician	Every 3 days				
	Orange	Define in TARP of each structure	Geotechnical Engineer	Daily	Geotechnical Engineer	Instrumentation reporting included within weekly update report	Geotechnical Coordinator	Engineering Geotechnical Team, EOR, designer, Management
			Geotechnical technician	Daily				
Staff Gauge / Survey shot (freeboard)	Green	Define in TARP of each structure	Water & Tailings Engineer	Weekly	Water & Tailings Engineer	Within the monthly attenuation pond and pumping infrastructure inspection report	Geotechnical Coordinator	Engineering geotechnical team, designer, EOR
	Yellow	Define in TARP of each structure	Water & Tailings Engineer	Daily	Water & Tailings Engineer	Within the monthly attenuation pond and pumping infrastructure inspection report	Geotechnical Coordinator	Engineering geotechnical team, designer, EOR
	Orange	Define in TARP of each structure	Water & Tailings Engineer	Twice a day	Water & Tailings Engineer	Included within weekly update report	Geotechnical Coordinator	Engineering Geotechnical Team, EOR, designer, Management
Blast Monitor	-	PPV> 50 mm/s	Geotechnical Technician	After retrieving a blast monitor on a water management structure	Geotechnical Technician	In Quaterly instrumentation report	Geotechnical Engineer	Engineering geotechnical team, designer, EOR
Flow meter / Seepage monitoring	Green	Define in TARP of each structure	Water & Tailings Engineer	Weekly	Water & Tailings Engineer	During the monthly update of the water balance	Geotechnical Coordinator	Engineering geotechnical team, designer, EOR
	Yellow	Define in TARP of each structure	Water & Tailings Engineer	Daily	Water & Tailings Engineer	During the monthly update of the water balance	Geotechnical Coordinator	Engineering geotechnical team, designer, EOR
	Orange	Define in TARP of each structure	Water & Tailings Engineer	Twice a day	Water & Tailings Engineer	Included within weekly update report	Geotechnical Coordinator	Engineering Geotechnical Team, EOR, designer, Management
Water quality	Green	Define in TARP of each structure	Environment General Supervisor	As per water management plan	Environment General Supervisor	As per water management plan	Environment Superintendant	Engineering geotechnical team
	Yellow	Define in TARP of each structure	Environment General Supervisor	As per water management plan	Environment General Supervisor	As per water management plan	Environment Superintendant	Engineering geotechnical team
	Orange	Define in TARP of each structure	Environment General Supervisor	As per water management plan	Environment General Supervisor	As per water management plan	Environment Superintendant	Engineering geotechnical team

6.4.1 Procedure in case of data exceeding expected range of observation

If data exceeding the expected range of observation or anomalous data readings are observed, the following actions need to be taken:

- Re-read to check the reading (if the reading is from VDV, take a manual reading in the field);
- Check readout equipment to verify that it is functioning correctly;
- Verify calibration;
- If instrument has stopped functioning, notify the Engineering Superintendent immediately. If considered critical, a replacement instrument should be installed;
- If an anomalous reading is confirmed, a detailed review of the effects of the reading should be carried out and design or remedial actions should be implemented if determined necessary by the Engineering Superintendent. Any malfunctioning instrument or frozen piezometer must be documented.
- In the case of valid data that would exceed the TARP level do a special inspection if possible.

Before modifying the TARP level due to in-situ instrumentation reading that cannot be confirmed by other visual observation the EOR must be consulted for further guidance.

6.4.1.1 Blast Monitor

If a reading exceeding the PPV limit for a water management structure (50 mm/s) is observed this event must be communicated to the drill and blast engineer who will need to ensure that the blasting pattern is modified to avoid re-occurrence of this event. Afterward a special inspection will need to be done on the structure to look for changing condition.

If more than one occurrence of blast vibration exceeding the limit are observed within a 2 weeks period the Engineering Superintendent needs to be notified of the situation.

6.4.2 Anomalous Instrumentation Data

Anomalous instrumentation data includes the following as presented in Table 6-6. These anomaly could happen without triggering a TARP level change and need to be investigated and recorded:

Table 6-6: Example of anomalous data and some common cause

Thermistors
• Increase or decrease in measurements (over two or more readings) that cannot be explained by seasonal temperature variations; • Progressive loss of data (starting from the bottom and progressing). This is usually a sign of water infiltration • Observation of a spike in temperature in one bead. This is usually due to a capacitive effect • Loss of data (could be a transmission error, faulty hardware or a sheared cable)
Piezometer
• Increase or decrease in pore water pressure measurements that cannot be explained by seasonal lake level variations (verify that the instrument has not been installed in a casing); • Sharp increase in reading (verify that the instrument is not frozen) • Loss of data (could be a transmission error, faulty hardware or a sheared cable)
Inclinometer
• Cumulative increases in displacement (greater than 3 cm); • Erratic movement. This is usually a sign of water infiltration
Survey Monument
• Accelerating displacement rate of the survey monuments (x, y, z directions) (over two or more readings) (could be due to a prism shooting error or problem with the total station)
Blast Monitor
• Vibrations during a blast are not observed (the blast was cancelled, the blast monitor was not properly installed or vibrations were too weak to be recorded)
Flowmeter, survey shot and staff gauge
• Sudden change in staff gauge reading. Or reading that seem to not reflect the probable water elevation. This could be due to a settlement or displacement of the staff gauge. • Increase or decrease in flowmeter reading that are inconsistent with pumping rate or rainfall or observed water level. • Survey elevation that has a sharp fluctuation from last reading. This can be caused by the reading not taken at the good location, wave actions or daily variances in GPS signal

6.5 SURVEILLANCE DOCUMENTATION & REPORTING

One visual inspection report per structure needs to be completed, reviewed and distributed per the frequency in Table 6-2.

An instrumentation report need to prepare at predetermined frequency to present all instrumentation monitoring data as described in Table 6-4.

Table 6-7 describe how instrumentation data should be reported.

Instrumentation report need to include the following information :

- Table presenting all the instruments installed on each structure, their status and pertinent installation information
- Graph of all instruments for all structure covered by the report. The graph need to present data for a minimum period of 1 year. Higher recurrence should be presented if clarity of the presented information allows it. The graph need to be presented in a way that allow for data interpretation without referring to other document
- Analyses of all instruments data presented highlighting specific trend
- Discussion on anomalous trend

For the structure having a yellow Tarp level the instrumentation data relevant to the cause of the alert need to be included with each visual inspection report.

For the structure having an orange Tarp level the instrumentation data relevant to the alert level need to be included with each inspection report. In addition the weekly update report need to be written with the following information:

- Context on why the structure is at the orange level
- Change in condition since the last weekly report
- What is the mitigation plan and what action have been taken since the last update report
- Discussion on the result of the instrumentation data

Table 6-7 : How data should be presented in report for instrumentation monitoring

Thermistance
• Temperature vs. depth plots over time. • The plot should indicate the thermistor string reference number and date of each measurements presented • The plot need to indicate relevant stratigraphy and their depth • Plot need to be presented with a cross-section of the installation (if on a structure) as well as a plan view showing the instrument location
Piezometer
• Plots of total head as elevation versus time; and • Plot need to be presented with a cross-section of the installation showing lithology with depth as well as a plan view showing the instrument location • The plot need to indicate the instrument number, the dates of each measurement and a mention if the temperature read by the instrument is less than 0 degree
SAA
• Cumulative displacement plots (to view total displacement); • Incremental displacement plots (to present increasing or accelerating movements between readings); • Cumulative displacement at crest versus time; and • Time plots at zones of identified displacement. • The plot need to indicate the SAA number, what is considered positive and negative displacement and the dates of each measurement • Both elevations and depths should be presented together with the lithology. • A plan view need to be included showing the instrument location
Survey Monument
• Total net movement plots (to present total displacement); • Vertical displacement plots; and • Lateral displacement plots parallel and perpendicular to the dike axis • The plot need to indicate the survey monument number, what is considered positive and negative displacement and the dates of each measurement • A plan view need to be included showing the instrument location

6.6 DATA MANAGEMENT

An electronic library or database, which is easily accessible, shall be set up to catalogue and store inspection documents, maintenance reports and instrumentation measurements. The following will be stored in the hard copy and/or electronic format.

- Instrumentation report
- Visual inspection report
- Weekly report for structure in orange Tarp level
- Dike safety inspection (annual geotechnical inspection)
- Dam Safety Review report;
- Surveillance log
- Instruments database and map
- Maintenance log of geotechnical instrument
- Maintenance log of water management infrastructure
- Pump maintenance record

SECTION 7 • REFERENCES

Canadian Dam Association (CDA) 2007. Dam Safety Guidelines.

Golder Associates Ltd. (Golder) 2008. Detailed Design of Tailings Storage Facility, Meadowbank Gold Project. December 17, 2008. Doc. 784 Ver. 0.

Golder 2009. Stormwater Dike and Saddle Dam 1 Geomembranes, Meadowbank Gold Project. July 20, 2009. Doc. 917 Ver. 0.

Golder 2011. 2011 Tailings Deposition Plan Update, Meadowbank Gold Project. July 18, 2011. Doc. 1272 Ver. 0.

Golder (Golder Associates Ltd.). 2014. Meadowbank Gold Project – Interim Closure and Reclamation Plan. Prepared for Agnico Eagle Mines Limited – Meadowbank Division. Prepared by Golder Associates Ltd., January.Golder 2015. 2015 Detailed design report for Saddle Dams 3, 4 and 5. Meadowbank Gold Project. May 12, 2015. Doc. 1504 Ver. 1.

Mining Associate of Canada (MAC) 2005 Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities.

Mining Association of Canada (MAC) 2008. A Guide to the Management of Tailings Facilities. Second Edition.

AEM, Emergency Response Plan, Ver.10, August 2016

Appendix A
Tailings Storage Facility – Inspection Form

XX INSPECTION REPORT

The instrumentation data for TARP yellow level structures is attached at the end of each inspection report

Inspecting Officer	
Report No.	XX-VIR-XX
Inspection Date	

Dike name	
Crest Elevation (m)	
D/S Toe Pond Elev. (m)	
South Cell Water Elev. (m)	

Last Inspection Date						
Weather during the current inspection	-XX C°	Sunny ☐	Overcast ☐	Rain ☐	Snow ☐	Wind ☐
	Comments:					
Main changes since the last inspection	None					

Tarp level (Based on OMS manual revision from February 2019)	Green

GENERAL CONDITION SUMMARY

➢

RECOMMENDATIONS

➢

XX INSPECTION REPORT

AGNICO EAGLE
MEADOWBANK

FIELD OBSERVATIONS

Location	Observations	Recommendations
Downstream slope	▪	▪
Upstream slope	▪	▪
Crest	▪	▪

XX INSPECTION REPORT

AGNICO EAGLE
MEADOWBANK

SEEPAGE REPORT

Location	*Observations*	*Recommendations*
	▪	▪

Appendix B
Tailings Storage Facility Instrumentation List

Legend	
	Instrument fully working
	PZ frozen or TH bead missing but still giving data
	Instrument not communicating

Central Dike

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
465-P3	465-P3-A	Piezo	Frozen	Automatic (DL37)	65	Bedrock	-	-
	465-P3-B	Piezo	Frozen	Automatic (DL37)	85	Bedrock	-	-
	465-TH-P3	Thermistor	✓	Automatic (DL37)	-	-	10/13	105/69
545-P1	545-P1-A	Piezo	✓	Automatic (DL12)	65	Bedrock	-	-
	545-P1-B	Piezo	× (since Nov. 2018)	Automatic (DL12)	76	Bedrock	-	-
	545-P1-C	Piezo	✓	Automatic (DL12)	80	Dense Till	-	-
	545-P1-D	Piezo	× (since Dec. 2018)	Automatic (DL12)	88	Dense Till	-	-
	545-TH-P1	Thermistor	✓	Automatic (DL12)	-	-	13	111/63
545-P2	545-P2-A	Piezo	× (since Jan 2, 2019)	Automatic (DL44)	65	Bedrock	-	-
	545-P2-B	Piezo	× (since Jan 2, 2019)	Automatic (DL44)	85	Bedrock	-	-
	545-P2-C	Piezo	× (since Jan 21, 2019)	Automatic (DL44)	100	Bedrock	-	-
	545-P2-D	Piezo	Frozen	Automatic (DL44)	104	Rock fill/Till	-	-
	545-TH-P2	Thermistor	✓	Automatic (DL44)	-	-	13	105/51
580-P1	580-P1-A	Piezo	× (since July 2016)	Automatic (DL12)	-	-	-	-
	580-P1-B	Piezo	× (since July 2016)	Automatic (DL12)	-	-	-	-
	580-P1-C	Piezo	× (since July 2016)	Automatic (DL12)	-	-	-	-
	580-P1-D	Piezo	× (since July 2016)	Automatic (DL12)	-	-	-	-
	580-P1-E	Piezo	× (since July 2016)	Automatic (DL12)	-	-	-	-
	580-TH-P1	Thermistor	× (since July 2016)	Automatic (DL12)	-	-	-	-
595-P1	595-P1-A	Piezo	✓	Automatic (DL12)	69.25	Bedrock	-	-
	595-P1-B	Piezo	✓	Automatic (DL12)	85.2	Bedrock (Casing)	-	-
	595-P1-C	Piezo	✓	Automatic (DL12)	92.2	Bedrock (Casing)	-	-
	595-P1-D	Piezo	× (June 2017)	-	96.2	Dense Till (Casing)	-	-
	595-P1-E	Piezo	× (June 2017)	-	105.2	Rock fill (Casing)	-	-
	595-TH	Thermistor	✓	Automatic (DL12)	-	-	16	114.60/69.60
650-P1	650-P1-A	Piezo	× (since February 2016)	Automatic (DL11)	-	-	-	-
	650-P1-B	Piezo	× (since September 2016)	Automatic (DL11)	-	-	-	-
	650-P1-C	Piezo	× (since September 2016)	Automatic (DL11)	-	-	-	-
	650-P1-D	Piezo	× (since September 2016)	Automatic (DL11)	-	-	-	-
	650-TH-P1	Thermistor	× (since August 2016)	Automatic (DL11)	-	-	-	-

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
650-P2	650-P2-A	Piezo	✓	Automatic (DL11)	65	Bedrock	-	-
	650-P2-B	Piezo	✓	Automatic (DL11)	85	Bedrock	-	-
	650-P2-C	Piezo	✓	Automatic (DL11)	99.5	Bedrock	-	-
	650-P2-D	Piezo	✓	Automatic (DL11)	103.5	Rock fill/Till	-	-
	650-TH-P2	Thermistor	✓	Automatic (DL11)	-	-	13	105/51
650-P3	650-P3-A	Piezo	Frozen	Automatic (DL38)	65	Bedrock	-	-
	650-P3-B	Piezo	Frozen	Automatic (DL38)	85	Bedrock	-	-
	650-TH-P3	Thermistor	✓	Automatic (DL10)	-	-	13	105/51
750-P1	750-P1-A	Piezo	✓	Automatic (DL10)	65	Bedrock	-	-
	750-P1-B	Piezo	✓	Automatic (DL10)	76	Bedrock	-	-
	750-P1-C	Piezo	✓	Automatic (DL10)	80	Dense Till	-	-
	750-P1-D	Piezo	✓	Automatic (DL10)	88	Dense Till	-	-
	750-P1-E	Piezo	✓	Automatic (DL10)	100	Rock fill	-	-
	750-TH-P1	Thermistor	✓	Automatic (DL10)	-	-	13	111/63
810-P1	810-P1-A	Piezo	× (since Dec. 2017)	-	67.7	Bedrock	-	-
	810-P1-B	Piezo	× (since January 2017)	-	-	-	-	-
	810-P1-C	Piezo	× (since Sept 2018)	-	86.9	Dense Till	-	-
	810-P1-D	Piezo	× Elev. Working only	-	93.9	Dense Till	-	-
	810-TH	Thermistor	× (since February 2018)	Automatic (DL18)	-	-	0/16	134.84/114.84
825-P1	825-P1-A	Piezo	✓	Automatic (DL18)	74.15	Bedrock	-	-
	825-P1-B	Piezo	✓	Automatic (DL18)	93.5	Bedrock	-	-
	825-P1-E	Piezo	✓	Automatic (DL18)	101	Till (Casing)	-	-
	825-TH	Thermistor	✓	Automatic (DL18)	-	-	14/16	131.25/71.25
850-P1	850-P1-A	Piezo	✓	Automatic (DL18)	72	Bedrock	-	-
	850-P1-B	Piezo	✓	Automatic (DL18)	93.7	Bedrock	-	-
	850-P1-E	Piezo	✓	Automatic (DL18)	106	Rock fill	-	-
	850-TH	Thermistor	✓	Automatic (DL18)	-	-	13/16	133.02/73.02
875-P3	875-P3-A	Piezo	✓	Automatic (DL41)	65	Bedrock	-	-
	875-P3-B	Piezo	✓	Automatic (DL41)	85	Bedrock	-	-
	875-TH-P3	Thermistor	✓	Automatic (DL41)	-	-	11/13	105/51
875-P2	875-P2-A	Piezo	✓	Automatic (DL10)	65.08	Bedrock	-	-
	875-P2-B	Piezo	✓	Automatic (DL10)	85.08	Bedrock	-	-
	875-P2-C	Piezo	Frozen	Automatic (DL10)	105.38	Bedrock	-	-
	875-P2-D	Piezo	Frozen	Automatic (DL10)	107.58	Till	-	-
	TH-875-P2	Thermistor	✓	Automatic (DL10)	-	-	15/16	120.08/63.08
800-P2	800-P2-A	Piezo	✓	Automatic (DL11)	70.07	Bedrock	-	-
	800-P2-B	Piezo	✓	Automatic (DL11)	85.07	Bedrock	-	-
	800-P2-C	Piezo	✓	Automatic (DL11)	95.07	Bedrock	-	-
	800-P2-D	Piezo	✓	Automatic (DL11)	105.07	Rock fill/Till	-	-
	TH-800-P2	Thermistor	✓	Automatic (DL11)	-	-	16	120.07/70.07

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
700-P1	700-P1-A	Piezo	✓	Automatic (DL11)	63.43	Bedrock	-	-
	700-P1-B	Piezo	✓	Automatic (DL11)	86.93	Bedrock	-	-
	700-P1-C	Piezo	✓	Automatic (DL11)	97.43	Bedrock	-	-
	700-P1-D	Piezo	✓	Automatic (DL11)	101.43	Void before bedrock	-	-
	TH-700-P1	Thermistor	✓	Automatic (DL11)	-	-	16	118.43/63.43
580-P1 (R)	580-P1-R-A (R)	Piezo	✓	Automatic (DL12)	69.55	Sand	-	-
	580-P1-R-B (R)	Piezo	✓	Automatic (DL12)	75.55	Bedrock	-	-
	580-P1-R-C (R)	Piezo	✓	Automatic (DL12)	79.05	Bedrock	-	-
	TH-580-P1 (R)	Thermistor	✓	Automatic (DL12)	-	-	16	120.55/65.55
1050-P3	1050-P3-A	Piezo	Frozen	Automatic (DL43)	66.37	Bedrock	-	-
	1050-P3-B	Piezo	Frozen	Automatic (DL43)	86.37	Bedrock	-	-
	TH-1050-P3	Thermistor	✓	Automatic (DL43)	-	-	16	134.77/65.77
975-P3	975-P3-A	Piezo	✓	Automatic (DL42)	64.53	Bedrock	-	-
	975-P3-B	Piezo	✓	Automatic (DL42)	84.53	Bedrock	-	-
	TH-975-P3	Thermistor	✓	Automatic (DL42)	-	-	16	131.12/64.12
800-P3	800-P3-A	Piezo	✓	Automatic (DL40)	62.95	Bedrock	-	-
	800-P3-B	Piezo	✓	Automatic (DL40)	82.95	Bedrock	-	-
	800-P3-C	Piezo	✓	Automatic (DL40)	96.45	Till	-	-
	TH-800-P3	Thermistor	✓	Automatic (DL40)	-	-	16	118.95/62.95
745-P3 (WR-P3)	TH-745-P3	Thermistor	✓	Automatic (DL39)	-	-	8/16	125.08/102.08
CD_US-0+650	CD-US-1	Thermistor	✓	Automatic (DL29)	-	-	16	126.40/111.056
	CD-US-2	Thermistor	✓	Automatic (DL29)	-	-	16	143/127
SD5	TH-02	Thermistor	✓	Automatic (DL58)	-	-	12/16	144/129
	TH-03	Thermistor	✓	Automatic (DL58)	-	-	16	141/126
	TH-04	Thermistor	✓	Automatic (DL58)	-	-	9/16	144/129

Stormwater Dike

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
SWD-01	SWD-01	Thermistor	✓	Automatic (DL19)			16	148/118
SWD-02	PZ-SWD-02-A	Piezo	✓	Automatic (DL19)	62	Bedrock		
	TH-SWD-02	Thermistor	✓	Automatic (DL19)			6	127/117
SWD-03	PZ-SWD-03A	Piezo	×	Automatic (DL19)	110	Bedrock		
	PZ-SWD-03B	Piezo	×	Automatic (DL19)	122			
	TH-SWD-03	Thermistor	✓	Automatic (DL19)			14	125/111
CRK	#1	Crakcmeter	✓	Automatic				
	#2	Crackmeter	✓	Automatic				
	#3	Crackmeter	✓	Automatic				
EXT	#2	Extensometer	Removed	Manual				
	#3	Extensometer	Removed	Manual				
	#4	Extensometer	✓	Manual				
	#5	Extensometer	Removed	Manual				
PSM	000 to 119	Prisms	✓	Manual				

SD1

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
SD1-T2	SD1-02	Thermistor	✓	Automatic (DL14)	-	-	16	140/110
SD1-T4	SD1-04	Thermistor	✓	Automatic (DL14)	-	-	16	134/119
SD1-T1	SD1-01	Thermistor	✓	Automatic (DL14)	-	-	16	149/132.84
SD1-T3	SD1-03	Thermistor	✓	Automatic (DL14)	-	-	15/16	148/118

SD2

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
SD2-T1	SD2-01	Thermistor	✓	Automatic (DL15)	-	-	16	148.05/145.31
SD2-T2	SD2-02	Thermistor	✓	Automatic (DL15)	-	-	16	148/118
SD2-T3	SD2-03	Thermistor	✓	Automatic (DL15)	-	-	16	144/129
SD2-T4	SD2-04	Thermistor	✓	Automatic (DL15)	-	-	16	148/123

SD3

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
SD3-T2	SD3-02	Thermistor	✓	Automatic (DL16)	-	-	16	139.1/123.1
SD3-T3	SD3-03	Thermistor	✓	Automatic (DL16)	-	-	15	138.6/121.6
SD3-T4	SD3-04	Thermistor	✓	Automatic (DL16)	-	-	15	137.3/122.3
SD3-T5	SD3-05	Thermistor	✓	Automatic (DL16)	-	-	16	138.4/122.4
SD3-T6	SD3-06	Thermistor	✓	Automatic (DL16)	-	-	16	143.9/113.9

SD4

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
SD4-T2	SD4-02	Thermistor	✓	Automatic (DL17)	-	-	16	139/129
SD3-T3	SD3-03	Thermistor	✓	Automatic (DL17)	-	-	16	144/129
SD4-T4	SD4-04	Thermistor	✓	Automatic (DL17)	-	-	5/14	137.3/127.8
SD4-T1	SD4-01	Thermistor	× (since August 2018)	Automatic (DL17)	-	-	16	143.4/139.6

SD5

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
SD5-02	SD4-02	Thermistor	✓	Automatic (DL58)	-	-	16(cap)	144/129
SD5-03	SD3-03	Thermistor	✓	Automatic (DL58)	-	-	16	141/126
SD5-04	SD4-04	Thermistor	✓	Automatic (DL58)	-	-	16(cap)	144/129

RF1-RF2

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
121-1	121-RF1-1	Thermistor	✓	Manual	-	-	16/16	136/90
73-6	73-6-RF1-2	Thermistor	✓	Manual	-	-	14/16	149.5/133
RF1-3	RF1-3	Thermistor	✓	Manual	-	-	11/11	148/144
122-1	122-1RF2	Thermistor	✓	Manual	-	-	14/16	137/90

North Cell

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
NC-T1	NC-T1	Thermistor	✓	Manual	-	-	16	146.6/86.6
NC-17-01	NC-17-01	Thermistor	✓	Automatic (DL20)	-	-	16	148/112
NC-17-02	NC-17-02	Thermistor	✓	Automatic (DL21)	-	-	16	147.6/102
NC-17-03	NC-17-03	Thermistor	✓	Automatic (DL22)	-	-	16	147.6/102.6
NC-17-04	NC-17-04	Thermistor	✓	Automatic (DL23)	-	-	16	148.5/122
NC-17-05	NC-17-05	Thermistor	✓	Automatic (DL24)	-	-	16	146.6/112.6
NC-17-06	NC-17-06	Thermistor	✓	Automatic (DL25)	-	-	16	148/112
NC-17-07	NC-17-07	Thermistor	✓	Automatic (DL26)	-	-	16	148/112
NC-17-08	NC-17-08	Thermistor	✓	Automatic (DL27)	-	-	16	146/99

North Cell Internal Structure (NCIS)

Hole	Instrument ID	Type	Status	Readings	For PZ		For TH	
#	ID	PZ/TH	Operational (✓)/Not operational (×)	Manual/ Automatic	Elevation (m)	Stratigraphic unit	Number of operational beads	Elevation interval in meters (top/bottom)
NCIS-T1	NCIS-18-01	Thermistor	✓	Automatic (DL55)	-	-	16	140/110
NCIS-T2	NCIS-18-02	Thermistor	✓	Automatic (DL55)	-	-	16	134/119
NCIS-T3	NCIS-18-03	Thermistor	✓	Automatic (DL56)	-	-	16	149/132.84
NCIS-T4	NCIS-18-04	Thermistor	✓	Automatic (DL57)	-	-	15/16	148/118
PSM	NCIS1 TO NCIS16	PRSME	✓	Manual	-	-	15/16	148/118

Appendix C
Potential Mitigation for Upset Condition

Potential Mitigation Plan for Upset Condition on Tailings Management Infrastructures

Upset Condition	Area / Cause		Comments/Monitoring	Contingency or Corrective Action
Overtopping and Subsidence	1a	Water level rise / storm event	Water levels and crest elevations is monitored as part of the surveillance program Outflow channels are inspected during thaw, open water season and during ice break-up.	Add additional pumping unit If rise is caused by a channel obstruction, remove the obstruction
	1b	Dam crest settlement	This scenario requires extensive loss of support in the foundation since the rockfill of the dikes is essentially not settlement prone itself after construction and dewatering. For foundation settlement of this magnitude to occur, a piping event must develop or there is unexpected layer of compressible soil in the foundation. The situation would develop slowly with crest settlement evident at least several weeks before a run-away event develops. Easily observed cracks should be evident. Monitoring of the crest settlement is conducted routinely.	The crest is wide and comprises of coarse rockfill. Significant damage to the dike is not credible, based on performance of other rockfill structures subjected to overtopping or flow through events Rockfill from the mining operations can be placed to raise the dike crest and compensate settlement. Mining operations may need to be suspended, but there will be considerable warning time given the slow development of the scenario.
	1c	Wave action	Large freeboard and wide crest zone makes this a low concern	rip-rap can be added and/or dam crest can be raised.
Internal Erosion	2a	Dike section: geomembrane is defective, allowing high water flow. This defect occurs at a location where the core allows high flows and where the fills/geomembrane are defective; the combination allows erosion of the Core Backfill.	The geomembrane and/or core backfill will develop a progressively increasing void ratio, thereby increasing the rate of water flow through the dike. This is not a catastrophic failure mode but could lead to an inability to manage water on site	Monitor seepage from downstream face for rate of seepage and for presence of sediment in seepage. Identify zone of seepage and establish a seepage capture and monitoring station with sufficient pumping capacity Re-evaluate the impact of this water inflow on the site wide water balance
	2b	Dike section: geomembrane is defective.	Results in increasing the rate of water flow through the dike. This is not a catastrophic failure mode as the rockfill will be stable and at its worst would lead to temporary suspension of mining.	Monitor seepage from downstream face for rate of seepage and for presence of sediment in seepage. Identify zone of seepage and establish a seepage capture and monitoring station with sufficient pumping capacity Re-evaluate the impact of this water inflow on the site wide water balance
	2c	Foundation till is possibly non-uniform with more transmissive zones and not self-filtering. Seepage could erode the foundation tills at the downstream toe or into the downstream rockfill because of the lack of filtering.	Limited seepage at the toe or into the rockfill would accelerate in to a large inflow, and could lead to the undermining of the dike if no action was taken. This is a credible catastrophic mode if increased seepage is not detected in time. No particular instrumentation is needed as this failure mode will show itself as localized and increasing seepage. It could be detected by walk-over inspection by an experienced engineer or technician.	Remedial action could comprise a reverse filter and rockfill buttress depending on location of the flow and configuration of the foundation, freezing or grouting, if identified in time.
Seepage	3a	Within the Embankment	Seepage on its own is not a credible failure scenario. The downstream rockfill shell has extremely high flow through capacity. The rockfill zone is both large and pervious, so that seepage will not daylight and lead to instability.	Monitor seepage from downstream face for rate of seepage and for presence of sediment in seepage. Identify zone of seepage and establish a seepage capture and monitoring station with sufficient pumping capacity Re-evaluate the impact of this water inflow on the site wide water balance
	3b	Within the Foundation	Defective construction of cut-off leading to transfer of unexpectedly high fraction of the reservoir head into the downstream part of the dike foundation, or leading to a piping event as described in internal erosion (2c). If this mechanism arises it should show itself during initial dewatering or very shortly thereafter.	Monitor seepage from downstream face for rate of seepage and for presence of sediment in seepage. Identify zone of seepage and establish a seepage capture and monitoring station with sufficient pumping capacity Re-evaluate the impact of this water inflow on the site wide water balance Re-assess stability (numerical modelling) and construct a stabilising berm

Upset Condition	Area / Cause		Comments/Monitoring	Contingency or Corrective Action
Structural - Slope Instability	4a	Normal Operation: Slope Failure	The rockfill shoulders of the dike are wide and have high shear strength Slope failure requires failure in the foundation and which would extend into the overlying dike. Sliding failure is considered unlikely given the low horizontal forces generated by the water and ice relative to the normal frictional force due to the weight of the dikes and the frictional angles of foundational materials. This mechanism should develop during construction, due to the increase in load and associated pore water pressure development. Initial stages of failure should be observable as tension cracks in the dike crest. Walk-over inspection of the dike by trained inspector is an appropriate monitoring strategy in addition the instrumentation. Survey of crest face and toe is conducted.	Re-assess stability (numerical modelling) and construct a stabilising berm if required Fill inactive tension cracks with bentonite
	4b	Earthquake Induced: Slope Failure	Site is located in a low seismic zone. Dike consisting of massive rock zone has a low sensitivity to seismic motion.	Do an inspection and repair damage
	4c	Erosion; washout, ice scour	Crest – minimum 50 m section, Downstream – large quarry rock face.	Repair erosion by placing additional rockfill and material
Subsidence	5	Foundation Soils	Unexpected foundation soils consolidated during dike construction. A significant quantity of clay would be required to generate settlement resulting in a water release event. Prism and monument monitoring is done routinely.	This scenario would be readily repaired by excavating rockfill above the cut-off wall and placing more till. Soil conditions will be observed during dewatering to accommodate actual conditions.
Premature Closure	6	Corporate Bankruptcy or Early Resource Depletion	Bond is provided for this eventuality. Design of rehabilitation is the same as rehabilitation at closure of project.	This would trigger the closure plan
Pump and Pipeline Failure	7	Pumping infrastructures	Freezing protection is provided by heat tracing and insulation. Pipelines monitored pump pressures at plant and frequent site inspection.	Replace defect in pipeline Repair the pump and use another pump in the meantime

Oil Handling Facility: oil Pollution Emergency Plan, Version 9

AGNICO EAGLE

OIL HANDLING FACILITY

OIL POLLUTION EMERGENCY PLAN

For

Meadowbank and Whale Tail Project Fuel Farm in Baker Lake

EC ID number EC-00025772 P-50 Diesel fuel and EC ID number EC-00026142 for Jet-A

June 2018

Version 9

EXECUTIVE SUMMARY

This document presents the Oil Pollution Emergency Plan for Agnico Eagle Mines Limited (Agnico) Meadowbank Division. This plan is pursuant to the Canada Shipping Act 2001; and all the subtending regulations.

Oil Pollution Emergency Plan (OPEP) designates lines of authority, responsibility, establishes proper reporting and details plans of action in the event of a spill. This plan applies to the operational phase of the fuel transfer which takes place at Agnico Eagle Ltd.'s Baker Lake Marshaling Facilities and Oil Handling Facility located at latitude 64°18'36"N and longitude 95°58'04"W.

A hard copy of the OPEP will be available at the Baker Lake Marshalling facility during the transfer operations.

ACRONYMS

Agnico	Agnico Eagle Mines Limited
ECC	Emergency Control Center
ERT	Emergency Response Team
ERP	Emergency Response Plan
Fuel	P50 Arctic Grade diesel fuel and/or Jet-A aviation fuel
IMO	International Maritime Organization
MARPOL	*The International Convention for the Prevention of Pollution from Ships,* 1973, and the *Protocols* of 1978 and 1997, as amended from time to time
OHF	Oil Handling Facility
OPEP	Oil Pollution Emergency Plan
SCP	Spill Contingency Plan
SOPEP	Ship Oil Pollution Emergency Plan
SMP	Spill Management Plan
TCMSS	Transport Canada Marine Safety & Security
TEU	Twenty-foot equivalent unit

DISTRIBUTION LIST

Agnico - Environmental Superintendent

Agnico – General Mine Manager

Agnico – Health and Safety Superintendent

Agnico – Energy and Infrastructures Superintendent

Agnico – Energy and Infrastructures Superintendent

Agnico – ERT Emergency Measures Councilor

Baker Lake – Baker Lake Hamlet Office

Baker Lake – Fire Department

Petro-NAV Inc. – Director of Operations

Transport Canada – Marine Pollution Officer

Canadian Coast Guard Environmental Response

DOCUMENT CONTROL

Version	Date (YMD)	Section	Page	Revision
0	12/09/02	All	All	Comprehensive plan for Agnico's Baker Lake Fuel Farm Facilities
1	12-09-17		10, 12, 13	P10: Tide and Currents reference change; P12: Rephrasing of the last paragraph title; P13: in INITIAL SPILL RESPONSE PRIORITIES table into Section 2 RESPOND SAFELY, rewording to show only diesel fuel actions.
2	13-03-30	6 & App. D	10	Oil Handling Facility Declaration; 2013 Jet-A to start being stored at OHF
			12	Adequate lighting required during fuel transfer
		9	20 21	Item list on inside door of each Sea can. Internal Contacts Updated
		10 & App. C	23	Update to Agnico site spill training & Location of training records
		13	29	Major Failure At Helicopter Island
		14 & App. E	30	In-situ Burning
		16	32	New for 2013
3	January 2014	ALL		Comprehensive Review
4	July 2014	ALL		Comprehensive Review after Transport Canada Assessment
5	November 2014	ALL		Comprehensive Review following non-compliance letter received from Transport Canada
6	July 2015			Annual Comprehensive Review
		Sec 1	1	Update Declaration
		Fig 5	18	Update Pager numbers
		Table 5,6,7	26&27	Update Contact numbers
		Footnote 3	35	Contact date for JJ Brickett with CCG
		Table 8	44	Update Training Dates
7	May 2016	Sec 1	1	Update Declaration
		Fig 5	18	Update Pager number
		Tables 5,6,7	26-28	Update Contact numbers
		Table 8	45	Update Training Dates

		Appendix A		Update Contact numbers
		Appendix D		Update Meeting Minutes
8	May 2017	Sec 1	1	Update Declaration
		Fig 5	18	Update Pager number
		Tables 5,6,7	31-33	Update Contact numbers
		Section 10.2.1	40	Add details related to the Fisheries Act Regulation and Birds Migratory Convention
		Table 8	50	Update Training Dates
		Appendix B	55	Removed Appendix B Transfer Conduit Annual pressure Test as per TC Inspector's comments
9	May 2018	Section 1	1	Update Declaration
		Fig 5	18	Update Pager number
		Tables 5,6,7	31-33	Update Contact numbers
		Section 10.2.1	40	Add details related to the Fisheries Act Regulation and Birds Migratory Convention
		Table 8	50	Update Training Dates
		Appendix B	55	Removed Appendix B Transfer Conduit Annual pressure Test as per TC Inspector's comments

Prepared By: *Meadowbank Environment Department*

Approved by: _____

Nancy Duquet-Harvey
Environmental Superintendent - NU

Table of Contents

SECTION 1. Oil Handling Facility Declaration 1
SECTION 2. General Introduction 2
2.1 Fundamental Principles 2
2.2 Legislative Requirements 2
2.3 Related Documents 3
2.4 Meadowbank Mine Oil Pollution Emergency Plan 3
SECTION 3. Planning Standards 4
3.1 Facility Category 4
3.2 General Planning Guidelines 4
3.2.1 Response Time Standards 4
3.2.2 On-Water Recovery 4
3.2.3 Dedicated Facility Spill Response Equipment 5
3.2.4 Transfer Conduit 5
3.2.5 MBK-ENV-0013: OHF / Ship to Shore Fuel Discharge Procedure 5
SECTION 4. Baker Lake Marshalling Area and Fuel Storage Facility 6
4.1 General Overview and Site Description 6
4.2 Fuel Storage Facilities Infrastructure 7
4.2.1 P-50 Fuel Tanks 7
4.2.2 Jet-A Fuel 8
4.3 Baker Lake Shoreline and Marine Characteristics 9
4.3.1 Topography 9
4.3.2 Geology 9
4.3.3 Flora and Fauna 9
4.3.4 Subsurface Conditions 9
4.3.5 Water Quality 10
4.3.6 Bathymetric Data 10
4.3.7 Tides and Currents that Prevail at the Facility 10
4.3.8 Meteorological Conditions Prevailing at the Facility 10
4.3.9 Surrounding Area Environmental Sensitivities 10
SECTION 5. Site Activities 13
5.1 Nature of the Oil Product 13
5.2 Bulk Transfer 15

5.3 Measures to Minimize a Diesel and Jet-A Pollution Incident 15
5.4 Portable Containment Pools 16
SECTION 6. Meadowbank Response to Emergencies 17
6.1 Response Management Structure 17
6.2 Logistics and Planning 19
SECTION 7. Equipment and PPE 20
7.1 OHF Response Equipment for spills up to ~5m^3 20
7.2 Additional Response Equipment or for Spills >5m^3 20
7.2.1 General Equipment 21
7.2.2 Spill Response Kits and Containers 22
7.3 PPE 23
7.3.1 PPE at OHF for Spills <5m^3 23
7.3.2 PPE for Spills >5m^3 24
SECTION 8. Communication 25
8.1.1 Communication with the Public 25
8.1.2 Hand Held Radio Communication 25
8.1.3 Contacts 26
SECTION 9. Roles and Responsibilities 29
9.1.1 First Responder (Third Party Contractor (Intertek Personnel) and Spud Barge Supervisor) 29
9.1.2 Supervisor (Spud Barge Supervisor) 29
9.2 Roles & Responsibilities of the Emergency Control Group 29
9.2.1 Official In-Charge 29
9.2.2 General Superintendents 30
9.2.3 Incident Commander: A Trained Staff Member (ERT Coordinators or Supt.) 31
9.2.4 Emergency Response Team (ERT Team) Duties: 31
9.2.5 Environmental Superintendent/Designate Duties: 32
9.2.6 Health and Safety Superintendent/Designate Duties: 32
9.2.7 Energy and Infrastructures Superintendent/Designate Duties: 32
9.2.8 Human Resources Superintendent/Designate Duties: 32
9.2.9 Health Care Professional (Nurse/Medic): 33
9.2.10 Security Department: 33
9.3 Debriefing 33
SECTION 10. General Spill Procedures 34

10.1 Coordination with Government Agencies 34
10.1.1 Coordination with Transport Canada Technical Service Environmental Response 34
10.1.2 Coordination with Canadian Coast Guard 35
10.1.3 Other Government Agencies 35
10.2 Reporting Requirements 35
10.2.1 Government of Nunavut Reporting Requirements 35
10.3 Treatment and Disposal 36
10.4 Resuming Unloading 36
SECTION 11. Spill Scenarios and Response Strategies 37
11.1 Product Properties and Response Strategy 37
11.2 Pipeline safeguards 38
11.3 Wildlife 38
11.4 Scenarios 38
Scenario 1: 39
Scenario 2: 40
Scenario 3: 41
SECTION 12. Preventive Measures 42
12.1 Training 42
12.1.1 Meadowbank site Personnel 42
12.1.2 OHF Personnel Training 43
12.1.3 Boat Operators 44
SECTION 13. Coastal Shipping 46
13.1.1 Coastal Shipping 46
SECTION 14. References 47

FIGURES

Figure 1 - Location of the Community of Baker Lake 6
Figure 2 - Agnico's Baker Lake Oil Handling Facility – Ship to Shore Transfer Area 8
Figure 3 - Location of Community Freshwater Intake at Baker Lake 12
Figure 4 - Location of Helicopter Island 14
Figure 5 - Response Management System 18

TABLES

Table 1 - Category of OHF 4
Table 2 - Material available in the Spill Response Sea Can at Agnico's OHF 20
Table 3 - PPE available at OHF 23
Table 4 - Agnico Radio Channels 25
Table 5 - Agnico Contact 26
Table 6 - Contractors / Local Contacts 27
Table 7 - External Contacts 28
Table 8 - Spill Response Training 45

APPENDICES

APPENDIX A 1.1- COASTAL SHIPPING LTD. SOPEP 48
APPENDIX A 1.2- COASTAL SHIPPING LTD. CONTACT INFO 49
APPENDIX B - The Central and Arctic Regional Response Plan (2008) 50
APPENDIX C - MSDS Jet-A and Diesel 51
APPENDIX D 1.1– Agnico Pre-discharge and Spill Response Sea Can checklists 52
APPENDIX D 1.2 – OHF Ship to Shore Fuel Discharge Procedure 53
APPENDIX D 1.3 – 2016 Meeting Minutes of Fuel Transfer Procedure Revision Meeting 54
APPENDIX D 1.4 – 2016 Mock Spill Minutes 55
APPENDIX E 1.1– COASTAL SHIPPING LTD. GENERAL CHECKLIST 57
APPENDIX E 1.2– COASTAL SHIPPING LTD. SHIP TO SHORE CHECKLIST 57
APPENDIX E 1.3– COASTAL SHIPPING LTD. CARGO PRE ARRIVAL 58
APPENDIX F – Agnico Internal Spill Report Form 59

SECTION 1. OIL HANDLING FACILITY DECLARATION

Pursuant to paragraph 168(1) (b) (i) of the Canada Shipping Act 2001, Agnico Eagle Mines Ltd. (Agnico) has signed an Oil Handling Facility Declaration. This Declaration can be found posted at the Oil Handling Facility (OHF).

OIL HANDLING FACILITY DECLARATION

Pursuant to paragraph 168(1) of the Canada Shipping Act 2001, I, Nancy Duquet-Harvey (Name of the operator of the oil handling facility) declare that to comply with the Oil Handling Facility Regulation, Respecting the circumstances in which operators of oil handling facilities shall report discharges or anticipated discharges of pollutants, the manner of making the reports and the persons to whom the reports shall be made; all the information contained in the submission is true and complete to the best of my ability and accurately reflect our interpretation of the regulations.

The persons listed below are authorized to implement the oil pollution emergency plan:

NAME	COMPANY	ADDRESS	PHONE	EMAIL
Nancy Duquet-Harvey	Agnico Eagle Mines Ltd.	P.O. Box 540; Baker Lake, Nunavut X0C 0A0	(819) 759-3555 ext 6980	nancy.harvey@agnicoeagle.com
Martin Archambault			(819) 759-3555 ext 6744	martin.archambault@agnicoeagle.com
Robin Allard			(819) 759-3555 ext 6744	robin.allard@agnicoeagle.com
Markus Uchtenhagen			(819) 759-3555 ext 6720	markus.uchtenhagen@agnicoeagle.com
Yves Leveque			(819) 759-3555 ext 6720	yves.leveque@agnicoeagle.com
Bruce Waugh			(819) 759-3555 ext 6803	bruce.waugh@agnicoeagle.com
Steven Tremblay			(819) 759-3555 ext 6822	steven.tremblay@agnicoeagle.com
Andre Rouleau			(819) 759-3555 ext 6809	andre.rouleau@agnicoeagle.com
Philippe Beaudoin			(819) 759-3555 ext 6809	philippe.beaudoin@agnicoeagle.com

(Signed by the operator of the oil handling facility or its representative)

June 5, 2018
(Date)

AGNICO EAGLE

SECTION 2. GENERAL INTRODUCTION

The Oil Pollution Emergency Plan (OPEP) is to set in motion the necessary actions to stop or minimize the loss of fuel resulting from a mishap at Agnico Eagle Mines Limited's Baker Lake Fuel Farm Oil Handling Facility located in Baker Lake, Nunavut during the ship to shore fuel transfer. Additionally, it provides direction to Agnico personnel and/or contractors at the laydown and tank farm areas, and to Agnico's Emergency Response Team (ERT) for emergency spill response situations; describes oil pollution scenarios, defines the roles and responsibilities of management and responders; and outlines the measures taken to prevent spills. The purpose of the OPEP is to minimize potential health and safety hazards, environmental damage and cleanup costs.

2.1 Fundamental Principles

The following OPEP is submitted for compliance to the Canada Shipping Act 2001 and all the subtending regulations and to outline the appropriate spill response protocol during fuel transfer operations at the Baker Lake OHF. A hard copy of the OPEP will be located on site for reference and review during transfer operations. This OPEP will be reviewed annually and updates will be provides to TCMSS for compliance prior to every shipping season. The following priorities shall be taken into account when responding to an oil pollution incident and in the following order:

1. Safety of the workers;
2. Safety of the OHF;
3. Safety of the community of Baker Lake;
4. Prevention of fire and explosion;
5. Minimize of the oil pollution incident;
6. Notify and reporting of the oil pollution incident to associated Governing bodies;
7. Environmental impact of the spill;
8. Complete clean-up from the oil pollution incident.

2.2 Legislative Requirements

This plan was prepared in accordance with federal legislation listed below, which lists legislative instruments applicable to Agnico's Baker Lake Fuel Oil Handling Facility. All requirements found in the Canada *Shipping Act*, *2001*, ss. 168 are laid out in the Meadowbank Mine site OHF Concordance Table which will be submitted to Transport Canada as a stand-alone document.

The OPEP complies with the requirements for procedures, equipment and resources as set out in the *Canada Shipping Act* (s.s. 660.2(4)) specific to a fuel handling facility - the bulk incoming transfer of fuel from ship-to-shore and spill scenarios directly relating to this operation.

The following standards and regulatory requirements have been reviewed in preparation of this document:

- Canada Shipping Act;
- Response Organizations and Oil Handling Facilities Regulations;
- Vessel Pollution and Dangerous Chemical Regulation;
- Environmental Response Arrangements Regulations;
- Oil Handling Facilities Standards (TP 12402E);
- Response Organization Standards (TP 12401);

- Arctic Waters Oil Transfer Guidelines (TP 10783);
- Environmental Prevention and Response National Preparedness Plan (TP 13585);
- Release and Environmental Emergency Notification Regulations;
- Guidelines for reporting Incidents Involving Dangerous Goods, Harmful Substances and/or Marine Pollutants; and
- Requirements of the Central & Arctic Regional Response Plan.

2.3 Related Documents

Management and monitoring plans for Meadowbank mine that provided input to the Oil Pollution Emergency Plan include the following:

1. Spill Contingency Plan;
2. Emergency Response Plan; and
3. Shipboard Oil Pollution Emergency Plan[1].

The cornerstones of contingency planning for Agnico are the Spill Contingency Plan and the Oil Pollution Emergency Plan. These, coupled with the Emergency Response Plan, describe the processes to be followed in responding to a spill. The OPEP on its own provides the necessary information in the event of a mishap where fuel is lost during the transfer of fuel from a tanker vessel to the Fuel Tank Facility.

The OPEP complements the Spill Contingency Plan and it should not be construed as superseding it. The Spill Contingency Plan addresses a wider scope of operations stretching 110 kilometers from the Meadowbank mine site in the north to their infrastructure in the south. The OPEP strictly covers the transfers of fuel from ship to OHF.

2.4 Meadowbank Mine Oil Pollution Emergency Plan

This Plan is a working document that will be reviewed annually and updates provided to TCMSS for compliance prior to every shipping season.

This plan specifically centres on the activities in ship-to-shore transfer of fuel from a small tanker delivering fuel to Agnico's Baker Lake Fuel Tank Facility constructed in Baker Lake. On site personnel at the Facility are expected to respond to spill incidents (generally smaller than 1 m^3) that can be contained and cleaned up without assistance, while the Emergency Response Team will respond to larger spills.

Fuel is being delivered to Agnico's Baker Lake Fuel Farm by Petro-Nav Inc., a Division of Desgagnes. Fuel is stored within the existing tank farm owned and operated by Agnico. The Shipboard Oil Pollution Emergency Plan (SOPEP) is the responsibility of the shipping company. The outline of the SOPEP prepared by Petro-Nav Limited can be found in Appendix A – 1.1.

[1] *The Shipboard Oil Pollution Emergency Plan (SOPEP) contains all information and operational instructions as required by the "Guidelines for the development of the Shipboard Marine Pollution Emergency Plan" as developed by the International Marine Organization. Woodward's, the shipping company, is responsible for this Plan.*

SECTION 3. PLANNING STANDARDS

3.1 Facility Category

Oil handling facilities are categorized according to their maximum oil transfer rate in cubic meters per hour, in respect of the oil product loaded or unloaded to or from a ship, as follows (Table 1):

Table 1 - Category of OHF

Category of Oil Handling Facility	Maximum Oil Transfer Rate (cubic meters/hour)
Level 1	150
Level 2	750
Level 3	2 000
Level 4	More than 2 000

The product transfer rate (Diesel and Jet-A) for the Agnico's Baker Lake Fuel Farm OHF at Baker Lake is 400m^3/hr. As indicated in the OHF Standards TP 12402, this flow rate requires the onsite spill response capacity to meet a Level 2. To do this, the OHF will have the equipment and resources to respond to a 5m^3 spill within the required timelines specified in the Response Organization and Oil Handling Facility Regulations:

1. Contain and control in one hour of spill detection; and
2. Commence cleanup within six hours after spill detection.

3.2 General Planning Guidelines

3.2.1 Response Time Standards

Agnico and contractor personnel at Baker Lake Fuel Farm have appropriate training to respond to spills, if it is safe to do so (see Table 8). The material onsite can be deployed within one hour to contain a spill of 5m^3 or less, unless deployment within one hour will be unsafe. Generally, for spill greater than 1m^3, the OPEP and the Emergency Response Plan (ERP) will be activated and the Emergency Response Team (ERT) located at Meadowbank mine site will come in Baker Lake to help. Realistically, the ERT can be on site within 125 minutes (or less) ready to help for the clean-up activity. If the spill is greater than 5m^3, material from the Meadowbank Mine site will be required and will be bring at the Baker Lake OHF within 125 minutes to finalize the containment (if not complete) and recovered of the oil pollution incident.

3.2.2 On-Water Recovery

Agnico will have a registered boat at the Baker Lake barge area that is ready to be deployed in the case of an emergency situation. It will have all required components for an industrial use vessel. All personal involved in a response situation will need to have or complete the pleasure craft operator's certification.

If additional water crafts are required to help with the containment of a spill from the OHF, local resources such as Peters Expediting Ltd. and Baker Lake Contracting & Supplies (BLCS) can be use. Contact info for these companies can be found in Table 6.

3.2.3 Dedicated Facility Spill Response Equipment

Agnico has 3 sea cans with spill response equipment at the Baker Lake shore within Agnico's Marshalling area and includes booms that can rapidly be deployed to limit the spread of any spill on water. The list of equipment can be found in Table 2. The spill supplies and resources are in place to respond to a $5m^3$ spill within the required timelines as specified in the Response Organizations and Oil Handling Facility Regulations. These sea cans will be inspected before each transfer season to ensure that all the spill response material and PPE are there and stored in a manner that is organized and accessible in order to comply with regulatory requirements and allow an efficient spill response. See Appendix D – 1.1 for the checklist inspection sheet that can be found in the sea can.

3.2.4 Transfer Conduit

The transfer conduit or hose that is used to transfer fuel from Petro-Nav to the Agnico Baker Lake Fuel Farm OHF will be pressure tested annually by Petro-Nav according to the regulation prior it being placed into service. A copy of the annual pressure test will be made available to TCMSS on request. The transfer conduit will always have a bursting pressure of not less than 4 times its maximum design pressure and the design pressure will be clearly marked on the conduit.

3.2.5 MBK-ENV-0013: OHF / Ship to Shore Fuel Discharge Procedure

Agnico has created an internal procedure to ensure all planning and precautions are in place prior to the transfer of any fuel from the vessels to the OHF. This procedure can be found in Appendix D – 1.2.

SECTION 4. BAKER LAKE MARSHALLING AREA AND FUEL STORAGE FACILITY

4.1 General Overview and Site Description

Agnico's Oil Handling Facility (OHF) is located in the area of Baker Lake at latitude 64°18 22.778" N and longitude 95°57'33.990" W. The location shown on Figure 1 provides more detail. The Fuel Tank Facility consists of six - 10 million litres diesel fuel[2] (10,000 m^3) storage tanks all holding P50 grade diesel), and 18 tanks holding 1,800,000 litres of Jet-A fuel (Figure 2). The Facility is located adjacent to Agnico's Marshalling area, approximately 250 meters from the shore of Baker Lake at high tide. Power is provided by a generator for the fuel pump module located next to the tank farm.

Figure 1 - Location of the Community of Baker Lake



[2] *1000 litres = 1 m^3 of fuel. Cubic meters are used throughout this document.*

4.2 Fuel Storage Facilities Infrastructure

4.2.1 P-50 Fuel Tanks

The diesel fuel tanks are contained within an impermeable lined and bermed area. The steel fuel tanks have been field-erected and built to API-650 standards with each bermed area holding two tanks. This area is capable of containing 110% of the volume of one 10,000 m^3 storage tank. Each impermeable lined and bermed cell has the following:

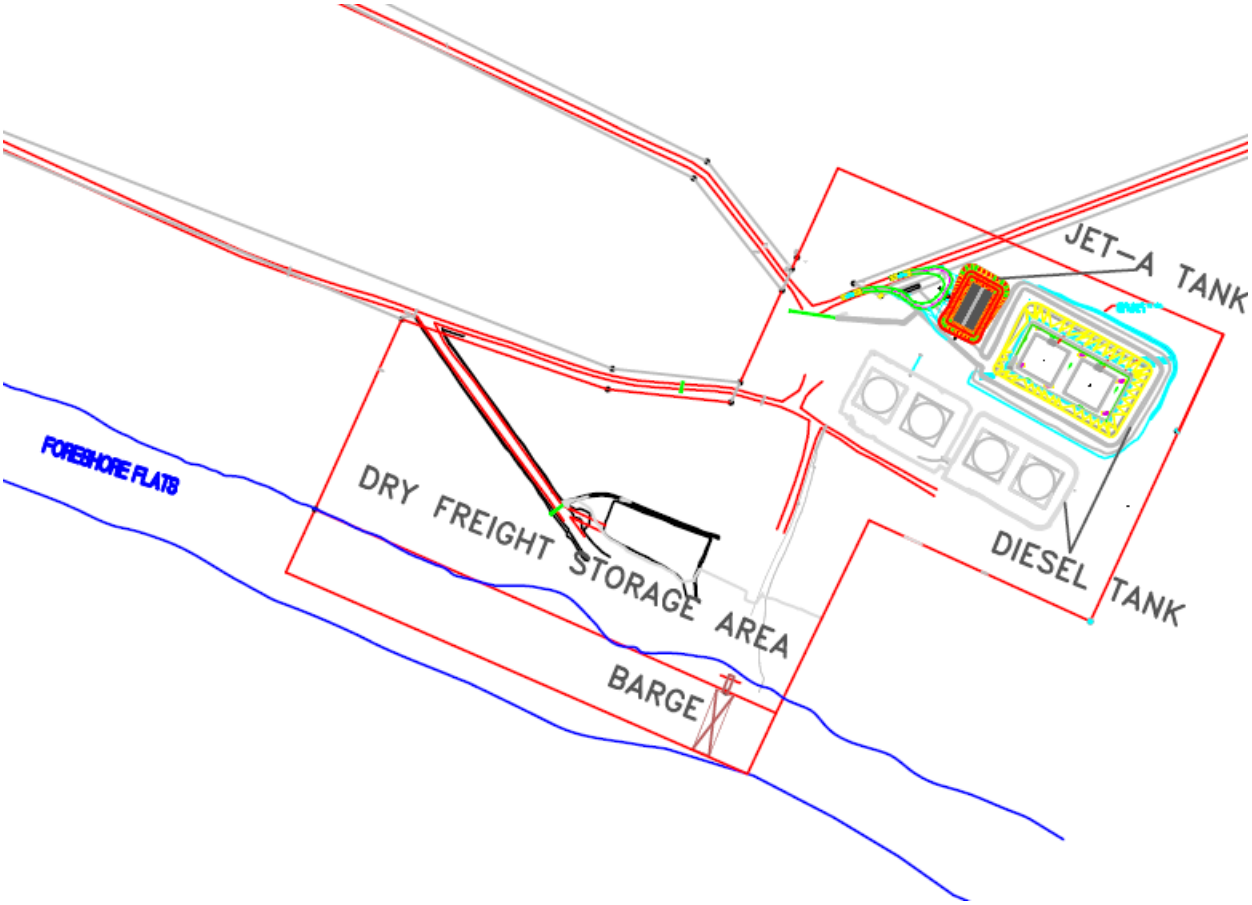
- A granular base for the tank completed with an impermeable LLDPE liner system and granular dikes;
- Two – 10,000 m^3 tanks complete with the required appurtenances such as stairs, base manholes, water draw offs, re-supply nozzle, suction nozzle, tank lighting, tank level monitoring, roof manhole, manual gauge hatch, tank temperature and P/V vent;
- Piping for unloading and loading; and
- Site lighting via fixtures mounted from the dispensing building.

The Tank Farm Facility is designed to meet the following standards:

- National Fire Code 2010;
- *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations* – 2008; and
- Canadian Council of Ministers of the Environment, "*Environmental Code of Practice of Aboveground and Underground Storage Tank Systems Containing Petroleum Products and Allied Petroleum Products – 2003* (Updated in 2013) (PN1326)".

The Oil Handling Facility (OHF) is constructed and operated in accordance with Transport Canada Arctic Waters Oil Transfer Guidelines (TP 10783E) and Oil Handling Facility Guidelines (TP 12402E). A fuel dispensing pad area completed with a dispensing unit is located in a lined facility with a provision to capture any and all spills at the fueling area and direct them to a containment area provided at the tank farm.

Figure 2 - Agnico's Baker Lake Oil Handling Facility – Ship to Shore Transfer Area



4.2.2 Jet-A Fuel

The Jet-A fuel tanks are contained within an impermeable lined and bermed area. The steel fuel tanks have been field-erected and built to API-650 standards with the bermed area holding eighteen tanks. This area is capable of containing >110% of the volume of one 100,000L storage tank. The impermeable lined and bermed cell has the following:

- A granular base for the tank completed with an impermeable bituminous liner system and granular dikes;
- Eighteen (18) – 100,000L tanks completed with the required appurtenances such as stairs, base manholes, water draw offs, re-supply nozzle, suction nozzle, tank lighting, tank level monitoring, roof manhole, manual gauge hatch, tank temperature and P/V vent; and
- Piping for unloading and loading.

The Jet-A Fuel Facility is designed to meet the following standards:

- National Fire Code 2010;
- *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations* –

2008; and

- Canadian Council of Ministers of the Environment, "*Environmental Code of Practice of Aboveground and Underground Storage Tank Systems Containing Petroleum Products and Allied Petroleum Products – 2003* (Updated in 2013) (PN1326)".

4.3 Baker Lake Shoreline and Marine Characteristics

The following Baker Lake Shoreline and Marine Characteristics were gathered during the Environmental Impact Assessment that was performed prior to construction of the Baker Lake Marshalling facility and Tank Farm.

4.3.1 Topography

The bulk fuel storage area is located east of the Hamlet of Baker Lake, approximately 350 m north of Baker Lake. The OHF sits on a low terrace parallel with the shoreline of the lake. There is a gradual slope (5 to 10% grade) toward Baker Lake with an approximate elevation change of 35 m from the OHF to the Baker Lake shoreline. The Baker Lake shoreline is gently sloping, well-drained and is lined with marine gravels, sands and boulders.

4.3.2 Geology

The regional surficial geology is characterized by sandy till, bedrock outcrops, felsenmeer (ice-shattered bedrock) and shallow lakes (Golder, 2007). The most common soil type in this region is glacial till. Marine beach deposits are found along the north shore of Baker Lake.

The soil near the bulk fuel storage facility is comprised of silts, sands, gravels, cobble and boulders and frost-susceptible glacial till overlying weathered bedrock (Golder, 2007). The soil thickness is typically less than 1.4 m with permafrost or bedrock encountered at less than 2 m. Approximately 60% of the surface area surrounding the bulk fuel storage facility is comprised of bedrock outcrop.

4.3.3 Flora and Fauna

There are no trees and few shrubs in the area surrounding the bulk fuel storage facility. The site is covered by low-lying vegetation; predominated by grassy hummocks, dwarf willow, sedge, green moss and lichen.

Arctic ground squirrels, ptarmigan and songbirds are inhabitants in the area surrounding the bulk fuel storage facility. Lake cisco, lake trout, arctic char, lake whitefish, round whitefish, slimy sculpin and stickleback are predominant species found in Baker Lake.

4.3.4 Subsurface Conditions

Test pits excavated in 2005 near the Bulk Fuel Storage Facility and between the tanks and the shoreline indicate a saturated top layer (0.2 m) of organic material (primarily green moss) (Golder, 2005; 2007). A layer of grey to black medium sand is present up to 0.7 m thickness throughout the area, below which a saturated, grey brown, sand and silt layer is found.

Bedrock is exposed at shallow depths throughout the site in locations where topsoil or till soils are present (Golder, 2005). Bedrock is encountered at a maximum depth of 1.4 m. As predicted by the soil

conditions, seepage flows in test pits indicate high site drainage (*Baker Lake Bulk Fuel Storage Facility Environmental Performance Monitoring Plan Version 3; June 2014*).

4.3.5 Water Quality

Baker Lake water quality closely resembles distilled water as many conventional water chemistry parameters are at or below detection limits (BAER, 2005). The water column is generally well mixed and the water chemistry homogenous. During the open water season there is limited vertical stratification in temperature and dissolved oxygen, with observed higher salinity in the bottom strata.

4.3.6 Bathymetric Data

As required by Water License 2AM-MEA1525 Schedule B, Item 4: *A bathymetric survey(s) conducted prior to each year of shipping at the Baker Lake Marshaling Facility*. The result of this annual bathymetry can be provided if needed.

4.3.7 Tides and Currents that Prevail at the Facility

There is a general southward current in Hudson Bay at Chesterfield Inlet of about 19 km/day (CCG 2008). Tides are 4.6 meters with strong cross-currents at Chesterfield Inlet; usually flowing south-west at about 1.85 km/hr.

4.3.8 Meteorological Conditions Prevailing at the Facility

Monthly meteorological data has been collected from 1971 to 2000 from the Baker Lake “A” climate station, which is a Meteorological Service of Canada climate station. Snow and rain are combined to give monthly average precipitation. The prevailing winds for the area are generally from the north to north-west and average 20.4 km/hr.

4.3.9 Surrounding Area Environmental Sensitivities

The community of Baker Lake is a hamlet in the Kivalliq Region, in Nunavut on mainland Canada. Located 320 km inland from the west coast of the Hudson Bay, it is near the nation's geographical centre, and is notable for being the Canadian Arctic's sole inland community. The hamlet is located at the mouth of the Thelon River on the shore of Baker Lake.

The freshwater provided to the community is taken in Baker Lake. The freshwater intake is located approximately 3.4 km from the Meadowbank OHF. See Figure 3 below for the exact location. In case of a spill during fuel transfer, preventive action will be taken to avoid any contamination in close proximity of the water intake and cause health and safety problems to the community:

1) As part of the spill procedure, Agnico will make the community of Baker Lake aware of any spill to ensure measures can be taken to ensure safety of the community by contacting Mayor / Hamlet counsel and Fire department;
2) As part of the spill procedure, boom and absorbents pads will be deployed to confined and limit the progression of the spill into the water;
3) Booms will be deployed to capture the spill;
4) If spill cannot be captured prior to spreading towards the freshwater intake, booms will be deployed around the freshwater pump and regular inspection will be done to see if there are

visible sheen;

5) As a precaution and depending of the spill size, Agnico will work with the Baker Lake Hamlet Counsel to provide a notice to the community of Bake Lake to stop the consumption of the freshwater during the time spill is recovered and until a test on water is conducted. During this time Agnico will provide potable water to the community. [A]As soon as the spill will be recovered and it's determined that the freshwater intake and distribution system is not contaminated the consumption of freshwater will resume;

[A] The Meadowbank project keeps a supply of 120 twenty litre bottles of drinking water in supply at all times in case of emergency. As well the water treatment plant is capable of producing >200m^3 of water a day and the current usage for the mine site is ~110m^3. Thus if required the Meadowbank mine can produce drinking water for the community for an emergency cease in the consumption of potable water due to a spill at the Baker Lake Marshalling Facility.

Figure 3 - Location of Community Freshwater Intake at Baker Lake



SECTION 5. SITE ACTIVITIES

5.1 Nature of the Oil Product

The main fuel stored at the Agnico's Baker Lake Fuel Farm will be P50 diesel and Jet-A. You can find, in Appendix C, the MSDS for Diesel and Jet-A. All other fuels such as gasoline and possibly other grades of diesel will be purchased in drums or 1m^3 totes and brought to the mine site for storage into the Meadowbank Fuel Storage Facility, or purchased and brought to site from a contractor in Baker Lake.

Petro-Nav Inc, a division of the Desgagnes Group, is contracted by Agnico to supply and deliver diesel fuel and Jet-A to Agnico's OHF facilities in Baker Lake. The tanker picking up the fuel will be double hulled, Motor Tank type ship, will have segregated ballast compartments and would be able to carry up to 20,000 m^3 of diesel and Jet-A fuel collectively. Ballast will not be required during the inward voyage to Baker Lake by the smaller ships. However, ballast will be picked up while on anchor outside the access passage after offloading the diesel and Jet-A fuel for its outward journey. A total of three (3) tanker loads of fuel will be required to fill the six diesel tanks in the tank farm, cumulatively holding 60,000 m^3 and one (1) tanker load to fill the 18 Jet-A tank, cumulative holding 1,800 m^3.

Figure 4 - Location of Helicopter Island



5.2 Bulk Transfer

It is expected that the large tankers delivering diesel fuel and Jet-A will anchor in the same general location as the dry cargo vessels, shown on Figure 4. Ship-to-ship transfer of fuel will occur at this location from the larger tanker to a smaller tanker that can navigate the access passage. The carrying capacity of the small tanker will be either 7,300 m^3 or 10,500 m^3. The Ship to be used at any one time will be subject to its availability at the time when the large fuel tanker is set to deliver fuel to Agnico Eagle Mines Limited's Baker Lake Fuel Farm Oil Handling Facility. The small tanker will anchor directly to Agnico's spud barge. From there, transfer hoses (Conduit) are connected to a shore based pipeline for transfer of P-50 diesel fuel to the diesel tank farm. For Jet-A fuel separate hoses will be laid out from the vessel to the Jet-A storage containment. These hoses or conduit will carry the Jet-A fuel from the vessel to the Jet-A tanks.

Ballast will not be required for the inward voyage of the small tanker as it arrives at Baker Lake loaded with diesel fuel and Jet-A. After transferring the diesel fuel or Jet-A fuel to the tank farm, the small tanker will take on ballast in its segregated ballast compartments before sailing out to Helicopter Island to pick up another load of fuel from the large tanker anchored outside the access passage. Ballast will be dispelled as ship-to-ship transfer of diesel or Jet-A occurs and the small tanker is loaded. This sequence of events will be repeated until the large tanker is empty or the tank farm is full.

Due consideration will be given to prevailing and expected wind, weather and tide conditions when undertaking ship-to-ship and ship-to-shore fuel transfers. The large tanker anchored near Helicopter Island and the small tanker anchored near Baker Lake will be clear of land and traffic routes, and in open water of a depth exceeding the draught of the vessel(s). For ship-to-ship transfers, the ships will be secured alongside or anchored.

The small tanker will discharge at a rate of 400 m^3/hr for diesel fuel and 200 m^3/hr for Jet-A taking approximately one (1) day to fill. Communications between the shore and the small tanker will be maintained throughout to ensure the safe transfer of the fuels and to avoid the overfilling of the tanks. The ship-to-shore transfer to be used will be similar to that used at communities throughout Nunavut.

5.3 Measures to Minimize a Diesel and Jet-A Pollution Incident

The small tanker will be anchored offshore in water of sufficient depth to allow for draught and tidal changes during transfer.

The transfer of the fuels will use sound, well-rehearsed practices, include an adequate number of trained and alert personnel, have sufficient materials, and use well maintained, thoroughly tested equipment. A team of trained personnel on the tanker will be in charge of the tanker fuel transfer equipment, while an onshore team will be in charge of the land based transfer equipment. Agnico will have at least 2 trained personnel on the land to observe for any leak detection: a third part contractor (Intertek) and the Baker Lake Supervisor. The role of the third part contractor will be to apply procedure and oversee operation during the fuel transfer. To do this, the third part contractor will need to come on site at least one (1) day before the first day of transfer to receive the appropriate training given by the Environmental Department. Fire-fighting, spill response equipment and supplies will be located on the tanker and onshore near to the transfer point as required by Transport Canada. This will include readily available absorbent material at the flexible hose connections on deck and onshore to quickly address minor spills at predictable minor spill locations. Additionally, Agnico has placed a sea can with spill response supplies (including boat) and equipment at Agnico's Baker Lake Fuel Farm area where it can quickly be accessed in the event of a

spill.

Four-inch (10 cm) steel piping able to accommodate a flow rate of approximately 400 m^3/hr will lead down to the shore from the diesel tank farm. Conduit from ship-to-shore will be connected to the fuel-receiving manifold located onshore using a dry-break coupling(s). For Jet-A fuel separate hoses will be laid out from the vessel to the Jet-A storage containment. Other measures to be taken to minimize and prevent spills include and must be followed by the on land responsible:

- Complete checklist before / during transfer for the on-land responsible (See Appendix E);
- Complete checklist, provide by Woodward, with vessel captain before transfer begin (Appendix E);
- Complete inspection / inventory of spill response sea can before transfer;
- During the transfer, regular monitoring will be undertaken for detection of incipient spills and leaks between the tanker and the tank farm;
- Radio test before transfer and after that each hour between the personnel on land and the captain of the vessel;
- Transfer operations will be suspended should any leak be detected or filling alarm are activated;
- The onshore area and ship deck will be well light as fuel transfers could continue around the clock;
- Minimization of land drainage containing spilled diesel or Jet-A to limit the amount reaching the marine environment;
- Have a good knowledge of the OPEP requirement and protocol to follow is case of a spill by receiving a training / review each year before the transfer season; and
- The regular update of the OPEP.

During the ship-to-shore transfer, Agnico will have competent personnel on location at all times to monitor the fuel transfer and maintain contact with the tanker's crew. Should problems arise, the ship can be called to shut down the transfer and onshore piping will be closed down. In the event of a spill that escapes the containment boom, diversion booming will be deployed to minimize migration of a spill throughout Baker Lake. Adequate lighting will be put in place during all transfers, to allow for proper inspections of transfer locations around the clock. The lighting system intensity will be not less than 54 lx at each transfer connection point of the vessel and OHF and a lighting intensity not less than 11 lx at each transfer operation work area around each transfer connection point of the vessel and OHF.

See *APPENDIX D: MBK-ENV-0013: OHF / Ship to Shore Fuel Discharge Procedure.*

5.4 Portable Containment Pools

At the connection of the ship's conduit to the OHF manifold a portable containment pool will be erected and in place during the transfer of product. This pool is capable of holding ~250L of liquid in the case that there is a leak at the flange or residual drips out of the conduit or hard wall pipe.

Spill "pop-up" pools will be in place under each joint for the conduit used to fill the Fuel tanks. These pop-up pools are only capable of holding 20-50 L of fuel and are in place to catch residual and be a first line of defense in the case of a leak.

SECTION 6. MEADOWBANK RESPONSE TO EMERGENCIES

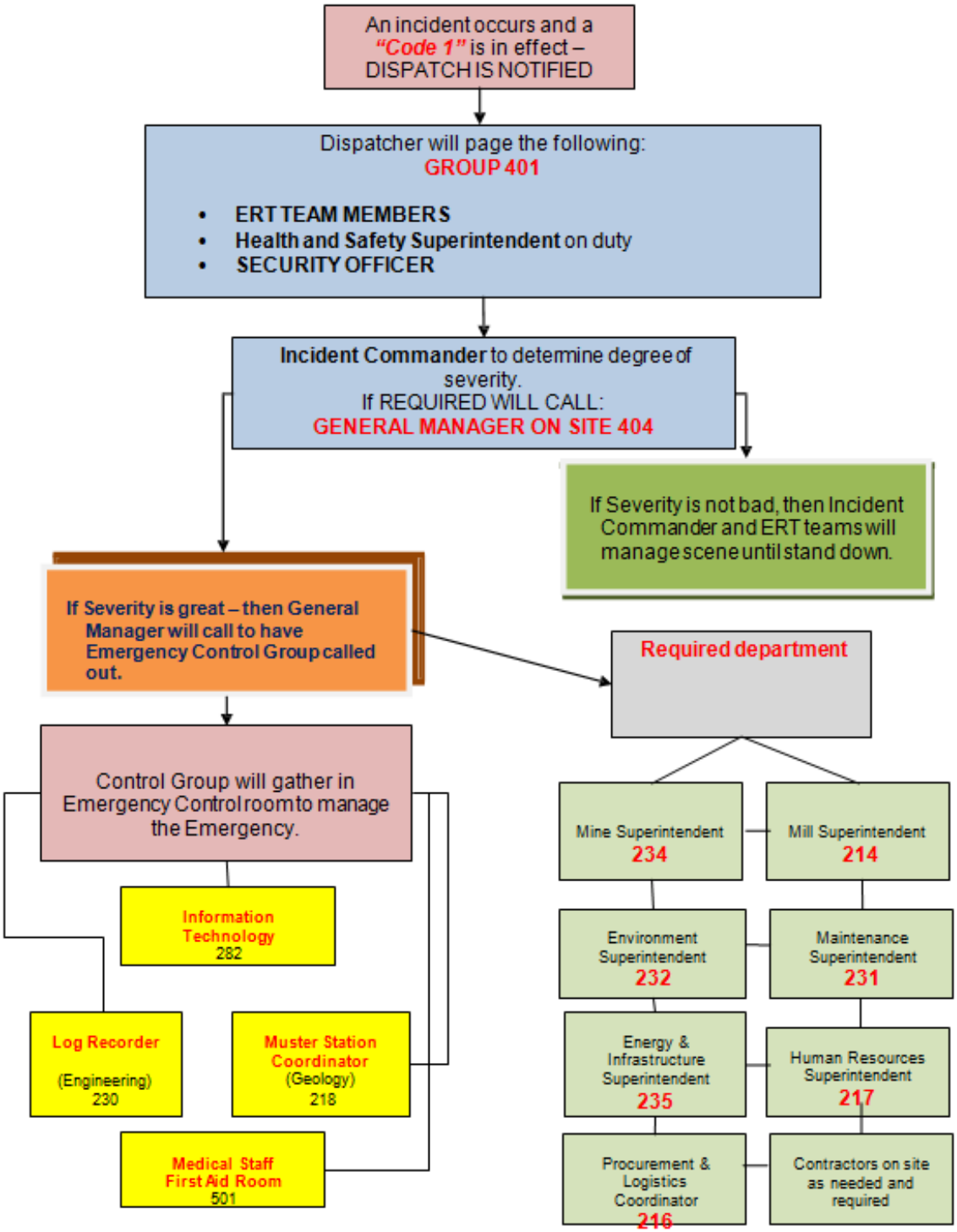
The Agnico Baker Lake Tank Farm OHF is considered Level 2 Handling facility as indicated in the OHF Standards TP 12402. With a transfer rate of ~400 m^3/hr Agnico's OHF must have the spill response capacity to respond to a minimum of a 5m^3 spill.

6.1 Response Management Structure

Agnico has an Emergency Response Team (ERT) at the Meadowbank Mine trained and responsible for controlling the Level 2 or greater spills at the Agnico's Baker Lake laydown and tank farm, and for assisting with medical and other emergencies that may occur at the mine site or the OHF.

Figure 5 depicts the Response Management System.

Figure 5 - Response Management System



6.2 Logistics and Planning

The Emergency Measures Counsellor (EMC) will ensure that site drawings and equipment lists are posted conspicuously in key locations throughout the site so that important information is always readily available. This will include the following:

- Location and isolation points of energy sources;
- Location of emergency equipment (e.g., fire water pumps, fire extinguishers, monitors, self-contained breathing apparatus);
- Emergency procedures outlines, such as specialist firefighting, chemical neutralization;
- Location of equipment for combating pollution (e.g., booms, pumps, absorbents, dispersants);
- Availability of internal and external emergency medical support (e.g., hospitals, clinics, ambulances, medical supplies, personnel with medical or first aid training);
- Location of toxicity testing facilities (e.g., gas and water);
- Location of wind direction / speed indicators;
- Directions on how to contact the local or regional weather forecasting service;
- Location of personal protective equipment and directions on its proper use; and
- Location of first aid stations and muster areas.

The Incident Commander, EMC, and Health and Safety Superintendent will know where, throughout the project site, all of this information is posted and where emergency equipment is stored. These individuals will also be trained in the proper use of emergency equipment.

SECTION 7. EQUIPMENT AND PPE

The following sections describe the items that are available in the case of a spill at the Agnico Eagle Mines Limited's Baker Lake Fuel Farm Oil Handling Facility. Equipment has been classified into items available for spill sizes either up to or greater than $5m^3$. However, any and all means will always be used to respond to a spill in a timely manner and ensure a prompt clean-up of any spill.

7.1 OHF Response Equipment for spills up to ~$5m^3$

The following equipment (Table 2) is available right at the OHF at any given time in a sea can designated for ***Environmental Emergency*** and can be deployed on scene within one hour, if it's safe to do, to contain and control the spill. Agnico can deploy this material within one hour.

Table 2 - Material available in the Spill Response Sea Can at Agnico's OHF

Quantity	Equipment/tool name
3	Empty drums (sealed)
2	Mini Berm 36"x 36"
2	4 Drums Berm 4'x 8'
4	Tarp 20'x 30'
4	Tarp 30'x 50'
10	Oil Spill Absorbent Pads
5	Universal Absorbent Boom 5"x 10' (For Hydro-soluble Chemical)
5	Universal Absorbent Boom 8"x 10' (For Hydro-soluble Chemical)
5	Petroleum base Absorbent Boom 5"x 10' (for Petroleum product)
4	Maritime Barrier (Baffle)
5	ABS pipe: 10' long x 4" diameter
2	Cell-U-Sorb (Absorbent)
2	Amerisorb Peat moss (Absorbent)
2	Oil Gator Absorbent
1	Plug Patties
4	Quatrex bags
2	Fork Lift Crate
4	Hand Shovel
1	Crow Bar Chisel
1	Ice Breaker Chisel
1	Sledge hammer
15	Rod bar 4'
1	½ drum containment
1	16ft Boat with motor and gasoline jerry can (sea can #321225)

7.2 Additional Response Equipment or for Spills >$5m^3$

All equipment previously mention is available for use during any emergency situation for a spill greater than $5m^3$. The following equipment would take time to get to the spill site; time would vary depending on distance from the spill. All these equipment and resources can be deployed on scene in <6 hours for the

recover and clean-up of the spill.

7.2.1 General Equipment

This section addresses the emergency response machinery, equipment, tools and other resources that will be made available on-site for spill counter measures.

7.2.1.1 Mobile Equipment

Mobile Equipment available to Agnico, that will be used for spill contingency include:

- Graders-4
- Cranes-6
- Snowmobiles-3
- Vacuum Truck-1
- Loaders-14
- Backhoe-10
- Bulldozer-8
- Forklift & Hysters-16
- Water Trucks-2
- Winch Trucks-2
- Pickup Trucks-70
- Generator Sets-20
- Fire Truck-1
- Boats-4
- Fuel Trucks-2
- Bobcat-2
- Haul Trucks-25
- Snow Cat-1

All the previous listed equipment can be found on the Meadowbank mine site. Wheeled equipment can be at the OHF in Baker Lake in 3-6 hours. Tracked equipment would have to be loaded and transported which would take 5-6 hours.

7.2.1.2 Containment System

Temporary containment systems are also available on site and include:

- Absorbent Booms - 130 kits; 4 booms per Kit; each boom 8”x10’
  - 122 Universal booms; each boom 5”x10’
- Open top Drums x 80@200L
- Tanks – 2 x 100,000L tanks
- Tailings Pond – capable of holding contaminated fluids >1,000 m^3 capacity
- Spill absorbent material packages/pads - Quantity changes depending on demand on the Meadowbank site

7.2.1.3 Emergency Transportation

Emergency transportation that will be used under an emergency situation are:

- Aircraft (fixed wing or helicopter)
- 4-wheel drive vehicles >70
- Snowmobiles x 3
- Boats and motor x 4

7.2.2 Spill Response Kits and Containers

7.2.2.1 Kits

Spill response kits are strategically located where required. Each department and work area is responsible for providing sufficient spill response kits in their respective work areas. The kits are kept in marked and accessible locations. The locations include all fuel storage areas, chemical storage areas and so on.

All of the mobile equipment on site (including heavy equipment) contains an emergency spill kit.

7.2.2.2 Emergency Trailer

Agnico also have an Environmental Emergency Trailer which is easily accessible and mobile. The trailer is located on site east of the Environmental Office at the Meadowbank Mine Site. This trailer contains the following items:

- Pump Elastec
- Pump accessories
- Vaccum ends
- 45 gallons top
- Tubing 2 inches diameter
- Tubing 3 or 4 inches diameter
- Diesel Fuel jerry can (place on a miniberm)
- Spill kit accessory (red box)
- Drums opener
- Wescot (to open empty drum screw)
- Empty drums
- 2 drums berm
- 4 drums berm 4x8
- Tarp 20x30
- Tarp 30x50
- Oil white spill pads
- Universal boom 5x10
- Universal boom 8x10
- ABS pipe: 10' (4")
- ABS pipe: 10' (6")
- Cell U-Sorb
- Sphagsorb
- 3 Size of Wedge wood
- Plug pattie
- Quattrex bags
- Hand shovel
- Ice chisel
- Sledge hammer
- Rod bar (4')

7.2.2.3 AWAR Sea cans

Along the AWAR there are 9 environmental emergency sea cans. These sea cans are strategically placed along the road at water crossings. Each environmental emergency sea can contains the following material:

- Empty drums (Sealed)
- Mini berm 36"x36" x4'
- 4 drum spill berm 4x8
- Tarp 20'x30'
- Tarp 30'x50'
- Oil white spill pads
- Universal boom 5"x10' (Chemical)
- Universal boom 8"x10' (Chemical)
- Oil only booms 5"x10' (Hydro-carbons)
- Maritime barrier (Baffle)
- ABS pipe: 10' (4")
- Cell U-Sorb
- Amerisorb peat moss
- Oil gator absorbent
- Plug pattie
- Quattrex bags
- Fork lift crate (pallets)
- Long handle round point shovel
- Chisel point crow bar 16 lbs 57"
- Ice chisel
- Sledge hammer 12 lbs 36"
- Rod bar (4')

7.3 PPE

7.3.1 PPE at OHF for Spills <5m^3

The following PPE (Table 3) will be found in the Emergency Trailer and also on sea can at the OHF:

Table 3 - PPE available at OHF

Quantity	Equipment/tool name
3	Rain gear -- Pants and Top (L & 2-XL)
3	Rubber boots (size 8,10,12)
6	Rubber gloves
3	Goggles
3	Tyvex suits (L & 2 XL)
3	Safety glasses
3	Leather gloves

This is adequate PPE intended for 3 persons. Additional PPE will be available from the Meadowbank mine site.

7.3.2 PPE for Spills >5m^3

Personal Protective Equipment is stored in bulk quantities at the Meadowbank Warehouse. Quantities of each can be found on site using the JD Edwards system. In addition, the community of Baker Lake has certain PPE that can be purchased through Agnico Eagle after consulting the Agnico Eagle Procurement and Logistics department; however quantities of this PPE cannot be relied on within Baker Lake.

SECTION 8. COMMUNICATION

The primary basis for communication will be the phone system; back-up communication will be available via satellite phone. For on-site communication, hand-held radios will be mandatory for all employees working or travelling in remote areas from the OHF. Cell phones can be used as an additional means of communication however only CDMA service is available at the OHF. Back-up power sources and replacement batteries for communications equipment will be available to provide continuous, uninterrupted operation either at fixed facilities or at emergency sites.

Key site personnel will be accessible at all times by either portable radios, radios in vehicles, or office radios. The Health Care Professional will carry a hand-held radio and will be available at all times. Security personnel will monitor the emergency channel twenty-four hours per day. Senior management personnel will rotate as "On-Call Managers" for after-hour emergencies. An accommodations list that highlights key personnel will be posted and updated as required.

In the event of a major emergency all external communications for the mine site and associated areas will be cut and all external contact will take place solely through the Emergency Control Center at the Meadowbank Site.

During fuel transfer operation, the vessel master and the operator of the OHF will always have a two-way communication on a continuing basis. This two-way communication will be the direct communication by radio and the use of the cell phone.

8.1.1 Communication with the Public

Communication with public bodies during the state of emergency will be the responsibility of the General Mine Manager or by the Communications & Public Affairs Corporate Director.

In the case that the communities of Baker Lake should need to be evacuated on short notice, the Emergency Response Team will immediately assist in the evacuation of the community. The General Mine Manager will immediately contact the Mayor of the Hamlet to inform regarding the situation. In addition, if safe to do so, a radio notification should be immediately broadcast on the Baker Lake Radio station.

8.1.2 Hand Held Radio Communication

The channels used for hand held radio communication on the Meadowbank mine site, the All Weather Private Road, OHF, and associated facilities are as follows in Table 4:

Table 4 - Agnico Radio Channels

Surface
1. Spare RPTR
2. Mill Simplex
3. Mill Repeater
4. Exploration
5. Simplex 5
6. Baker Lake
7. Project
8. Auto-Patch

9. Agnico Surface
10. MB Dykes
11. Goose Operation
12. Portage Operation
13. Vault Operation
14. RD MB
15. RD KM37
16. RD Baker

The colors in each zone represents that they are 'linked' together. For instance, the RD MB, RD KM37 and RD Baker are connected in a way that 3 persons talking on those 3 channels separately will hear each other as if they were on the same channel.

8.1.3 Contacts

Internal contact information is contained in Table 5 for all Agnico personnel involved in spill recovery. Table 6 contains contact information for contractor contacts which can be called for assistance with spill recovery. Table 7 is a list of government officials and external contacts to notify and provide subsequent reporting.

Table 5 - Agnico Contact

Title	Name	Telephone No.
Sr. Vice President, Environment and Sustainable Development	Louise Grondin	416.847.8656 Cell: 819.724.2020
Vice President of Environment	Michel Julien	416.947.1212 ext. 3738 Cell: 514.244.5876
Director of Environment, Environment and Sustainable Development	Pascal Lavoie	819.759.3700 ext. 5822 Cell: 819.277.0045
Corporate Director, Communications & Public Affairs	Dale Coffin	416.847.8669 Cell: 647.274.4154
Director, Regulatory Affairs	Stephane Robert	819.759.3700 ext. 5188 Cell: 819.763.0229
Director, Shared Services Nunavut	Jason Allaire	819.759.3555 ext. 8004 M: 819.355.2608
Meadowbank General Mine Manager	Luc Chouinard	819.759.3555 ext. 6896 Cell: 819-856-8160
Meadowbank Assistant General Manager	Christian Bourcier	819.759.3555 ext. 6843 Cell: 819-856-8109
H&S Superintendent or H&S Ass. Superintendent	Markus Uchtenhagen or Yves Levesque	819.759.3555 ext.6720 Cell: 819.856.8715 or 819.759.3555 ext.6720 Cell: 819.856.9051
Incident Commander	André Rouleau or Philippe Beaudoin	819.759.3555 ext.6809

Environmental Nunavut Superintendent	Nancy Duquet-Harvey	819.759.3555 ext.6980 Cell: 819.856.4385
Environmental Senior Coordinator	Martin Archambault or Robin Allard	819.759.3555 ext. 6744
Environmental Department	Environmental Technicians	819.759.3555 ext.6747/6759
On-site Medics	On-site Nurses	819.759.3555 ext.6734/6751
Site Security	On-site Security	(867) 793.4610 ext. 6748

Table 6 - Contractors / Local Contacts

Title	**Telephone No.**	**Contact in Emergency for:**
Nolinor Aviation Services	Protocol Agent (867).759.3700 ext. 8008 Emergency (450) 476.0018 (888) 505.7025	Flight services for additional crew, or additional supplies
First Air	1.800.267.1247 Emergency (867) 669.6694 (867) 444.2002	Flight services for additional crew, or additional supplies
Calm Air	1.800.839.2256 Emergency (204) 677.5013 (204) 677.5019	Flight services for additional crew, or additional supplies
Dyno Nobel Explosives Ltd.	(819) 825.5441	Heavy Equipment, Man power, Emergency Blasting
Woodward Group of Companies (Shipping)	(709) 896.2421	Fuel Hauler
Baker Lake Contracting & Supplies	(867) 793.2831 Press #1 (867) 793.1679	Man power, equipment, trades personnel i.e. pipefitter, plumber, electrical
Peter's Expediting	(867) 793.2703 Cell (867) 793.1701	Equipment, man power, Ground transportation services
Arctic Fuel Services	(867) 793.2311 Office (867) 793.2301 Supervisor	Fuel hauling, trucking, man power.

Table 7 - External Contacts

Organization/Authority	Telephone Number	Fax Number
NT-NU 24-Hour Spill Report Line	(867) 920-8130 spills@gov.nt.ca	(867) 873-6924
Workers Safety and Compensation Commission	(877) 661-0792 (Emergency) or (800) 661-0792	
Kivalliq Inuit Association	(867) 645-2800 (867)645-2810 (reporting line)	(867) 645-2348
Nunavut Water Board	(867) 360-6338	(867) 360-6369
INAC Inspector	(867) 645-2830	(867) 979-6445
Department of Fisheries and Ocean (DFO) – Nunavut Regional Office	(867) 979-8000	(867) 979-8039
Government of Nunavut – Department of Environment	(867) 975-7700	(867) 975-7742
Kivalliq Health Services – Baker Lake	(867) 793-2816 or (867) 793-2817 *Dial 0*	(867) 793-2812
Baker Lake Hamlet Office	(867) 793-2509	
Baker Lake Fire Emergency	(867) 793-2900	
RCMP Regular Hour RCMP 24 Hour Emergency Number	(867) 793-0123 (867) 793-1111	
Canadian Coast Guard (in the event of a spill to the marine environment) Superintendent Environmental Response	(800) 265-0237 (519) 383-1954 (519) 381-6186 (cell)	(519) 337-2498
Transport Canada – Tech services Stephen Sherburne Philip Levesque	(780) 495-6325 (204) 984-5786 Cell : 204-801-6951	 (780) 495-8607

All above phone numbers are current as of April 2017.

SECTION 9. ROLES AND RESPONSIBILITIES

9.1.1 First Responder (Third Party Contractor (Intertek Personnel) and Spud Barge Supervisor)

The person who has caused a spill or is the first to observe the spill is the first responder.

The responsibilities of the First Responder are as follows:

- Oversee the fuel transfer operation;
- Follow procedure set-up in the OPEP to prevent and minimize spill (See Section 5.3)
- In case of spill to land, ice or water, contact the Baker Lake Gatehouse to report the incident;
- Identify and contain the spill, IF SAFE TO DO SO; commence preparing spill response equipment, and
- Participate in spill response as a member of the clean-up crew.

9.1.2 Supervisor (Spud Barge Supervisor)

The responsibilities of the Supervisor are as follows:

- Contact the Baker Lake Gatehouse; contact Environment Department;
- Gather facts about the spill; and
- Participate in spill response.

9.2 Roles & Responsibilities of the Emergency Control Group

Below are the roles and responsibilities of the Emergency control group.

9.2.1 Official In-Charge

The Official In-Charge (General Manager or designate) will take charge for overseeing and approving the overall emergency strategy.

Immediate duties of the Official In-Charge include:

- Consult with the Incident Commander the status of emergency;
- Appoint an Emergency Log Recorder to maintain a written record of the time and events, including all discussions, instructions and decisions made by the Emergency Control Team;
- Issues specific tasks to the members of the Management as they arrive at the Control Room, as per this guideline;
- Brief the Emergency Control Team;
- Ensure that the safety of personnel is maintained, throughout the operation;
- Ensure procedures are in place for prompt dispatch of requested personnel, materials and

equipment to the emergency area;

- Arrange for all reports to be presented at specific intervals to the Emergency Control Team;

- Finalize the recommendations of the Incident Commander for rescue and recovery operations;

- The Official In-Charge is the only person authorized to release information to Government Agencies, Corporate Office or the Local Communities. He may delegate this activity to other members of the Emergency Control Team;

    - Verify all information you release;
    - Keep a record of all inquiries (media and non-media);
    - Do not speculate on causes;
    - Do not speculate on resumption of normal operations or when the problem will be solved; and
    - Advise that further updates will be forth coming.

- Notify the corporate management, if the following appear probable:

    - Fatalities;
    - Injuries that could probably become items of local, regional or national media interest;
    - There is a public health or environmental risk;
    - An incident involving chemicals where there is a large volume or the potential for over reaction (e.g., cyanide);
    - A spill of effluent or contaminated water or chemical substance to an area that lies outside the area of drainage control of the mine site (i.e., an external spill);
    - Mine operations may be stopped for more than two (2) days; and
    - Government authorities will become involved.

- Ensure all response teams, regulatory agencies and any other agency on emergency alert notice are advised when the emergency has ended;

- Ensure all documentation (i.e., notes, log sheets, written instructions, etc.) is gathered for the creation of the final report; and

- Participate in debriefing.

9.2.2 General Superintendents

- General Services, Operations and Maintenance will report to the Emergency Control Room and support the General manager/Designate in whatever capacity required;

- They will also ensure that the Superintendent/Designate in each of their respective Department's is aware of the emergency; and

- They will assist with the investigation and write up of the final report.

9.2.3 Incident Commander: A Trained Staff Member (ERT Coordinators or Supt.)

The responsibilities of the Incident Commander include:

- Ensure Security has been notified of emergency;
- Ensure the evacuation procedures have been activated, if required;
- Ensure that there are sufficient ERT members available to respond to the emergency;
- Ensure that the ERT has back-up support, a standby Team;
- Ensure that ERT Team has refreshments and nourishment (if the emergency requires several hours to resolve);
- Assess the size and severity of the emergency and the likely consequences. Establish response priorities; as well coordinate prevention of fire or explosion;
- Maintain communication with the ERT Captain;
- Advise the Official In-Charge of the ERT Team's activities, regarding the rescue and recovery operations;
- Appoint sufficient personnel, equipment and outside services are available. Utilize the members of the Emergency Control Team to organize these resources;
- Advise Official In-Charge when the emergency situation is under control and give the "All Clear";
- Participate in emergency investigation;
- Coordinate an orderly return to normal operating conditions;
- Arrange for a debriefing session, and utilize the services of all involved in resolving the emergency; and
- Assist to write the final report.

9.2.4 Emergency Response Team (ERT Team) Duties:

- The ERT Team Members must report to the Fire Hall, when paged for a "Code One" emergency;
- ERT Team Members will be given instructions on the emergency by the Incident Commander;
- ERT Team Members will follow instructions from the Incident Commander and will not put the Team at risk; and
- The ERT Team Captain will maintain radio contact with the Incident Commander throughout the emergency.

9.2.5 Environmental Superintendent/Designate Duties:

The following are the responsibilities of the Environmental Superintendent/Designate;

- Provide technical advice on probable environmental effects resulting from a spill and how to minimize them;
- Ensure that the ERT Members of his crew have responded to the "code One" emergency;
- Provide advice to the Official-in-Charge for appropriate spill response procedures;
- Ensure that Environmental Staff are available to direct the spill response action plan; and
- Assist with restoring of the Operations back to normal operating standards.

9.2.6 Health and Safety Superintendent/Designate Duties:

The Health and Safety Superintendent/Designate will be responsible for:

- Ensure that an Incident Commander is in place to oversee the ERT Teams;
- Ensure that all Management respond to the emergency and meet in the emergency control room;
- Oversee all activities that require Security or Nursing and arrange for Medevac transport, if required;
- Assist with getting a "head count" for the Official in-charge; and
- Assist with obtaining outside help if required.

9.2.7 Energy and Infrastructures Superintendent/Designate Duties:

The following are the responsibilities of the Site Services Superintendent/Designate;

- Ensure that all his employees are accounted for;
- Ensure that all ERT Member on his Crew, respond to the " Code One" emergency;
- If the " Emergency" is involves the site facilities, assist the Official-in-Charge with the action plan to deal with the emergency;
- Assist as required by supplying equipment and/or manpower; and
- Assist with restoring of the Operations back to normal operating standards.

9.2.8 Human Resources Superintendent/Designate Duties:

The following are the responsibilities of the Human Resources (HR) Superintendent/Designate:

- Ensure that all HR employees are accounted for; and
- Provide assistance to the Official-in-Charge if there are employees issues, such as injuries, transportation requirements, etc.

9.2.9 Health Care Professional (Nurse/Medic):

The on-site health professionals are responsible for the following:

- Providing on-site first aid and other medical support;
- Establish a triage location if there are multiple casualties;
- Arrange for medevac transportation, if required; and
- Ensuring that the first aid room is maintained at all times, by using First Responders as support.

9.2.10 Security Department:

The on-site Security Supervisor is responsible for the following:

- Ensure that access points to the emergency are properly guarded;
- Notify the Baker Lake Gatehouse if the emergency involves the all-weather private road (AWPR); and
- Assist with other duties as requested by the Emergency Control Group.

9.3 Debriefing

After an incident has taken place and the location is brought back to normal operating standards a debriefing session will occur between ECG, Field Supervisors for the incident, ERT Captain(s), and the supervisor of the department involved with the spill.

The point of this debriefing session to determine the *who, what, where, when, why, and how* the incident occurred. It will also be the time to reflect on the steps that were taken to carry out the response and to determine what was done right and what corrective measures need to be put in place to better the response if needed in the future.

SECTION 10. GENERAL SPILL PROCEDURES

SPILL RESPONSE PRIORITIES

1. **Safety of the personnel working at or around the OHF**
    a. Contact all personnel working around the spud barge area and make them aware
    b. Make contact with the vessels Captain to make aware the ship and stop the transfer of the product
    c. Dawn appropriate PPE
    d. STOP the spill
2. **Make safe the facility**
    a. Create a no entry perimeter to ensure unaware persons do not enter the area in which the incident took place.
    b. Barricade entrances to the facility with red danger tape
    c. Have a person designated to watch entrances to ensure no community persons come on to site.
3. **Make the community of Baker Lake aware of the Spill to ensure measures can be taken to ensure safety of the community**
    a. Contact Mayor / Hamlet counsel
    b. Fire department
    c. RCMP
4. **Prevent fires or explosions / Stop all ignition sources**
    a. Disconnect power supplies
    b. Do not contain diesel or Jet-A fuel if vapors might ignite
    c. Allow fuel vapors to evaporate before intervention
5. **Minimize the Spill**
    a. When safe to proceed stop the spread of the product
    b. Use spill response equipment in emergency sea cans and ask for additional material if the spill is greater than $5m^3$
6. **Notice and Report the Spill**
    a. Spill need to be reported to Transport Canada, Coast Guard and Government of Nunavut immediately
    b. Other governing bodies will also be notified (see section 10.2)
7. **Environmental Impact**
    a. Deter wildlife from entering spill area. Keep track of any wildlife mortalities
    b. Determine what impacts the spill will have on the Environment
8. **Clean-up**
    Commence clean-up of the spill

10.1 Coordination with Government Agencies

10.1.1 Coordination with Transport Canada Technical Service Environmental Response

In the event of a marine spill Transport Canada Technical Service Environmental Response (TC) will be contacted immediately regarding the incident. Agnico will adhere to further recommendations from TC in response to the spill.

TC will also be contacted annually prior to the deposition of fuel at the OHF. As well, annual approval of this OPEP will be required by TC Pollution prevention Officer.

10.1.2 Coordination with Canadian Coast Guard

In the event of a marine spill, the coordination with Canadian Coast Guard (CCG)[3] is required and they will be contacted to report the incident. A description of the event will be provided to the CCG Environmental Response. Agnico will adhere to further recommendations from CCG in response to the spill.

On an Annual basis prior to the shipment of fuels to the OHF commencing, Agnico will contact the CCG and make them aware that the shipping season will be starting so they are aware that fuels will be travelling to Agnico's Baker Lake Fuel Tank Facility constructed in Baker Lake.[4] Also Agnico will inquire if there is any update to "*The Central and Arctic Regional Response Plan (2008).*"

Agnico's Environmental Group will annually, prior to fuel transfer, review "*The Central and Arctic Regional Response Plan (2008).*" A copy of this plan can be found in Appendix B for reference. The plan will be reviewed to ensure that the OPEP and the actions of Agnico's OHF meet all requirements listed for an OHF.

10.1.3 Other Government Agencies

Agnico will contact all government agencies associated with the Meadowbank Gold Project as is the norm for any reportable spill. These groups include: Government of Nunavut (GN) via 24 hour spill reporting line, Indigenous and Northern Affairs Canada (INAC)), Nunavut Water Board (NWB), Environment and Climate Change Canada (ECCC) and Kivaliq Inuit Association (KIA).

10.2 Reporting Requirements

10.2.1 Government of Nunavut Reporting Requirements

As per the Canada Shipping Act spills to the marine environment will be reported to the Transport Canada Technical Service Environmental Response and Canadian Coast Guard (contact numbers in Table 7). Marine spills will be reported in accordance with Transport Canada Guideline TP- 9834E, *Guidelines for Reporting Incidents Involving Dangerous Goods, Harmful Substances and /or Marine Pollutants*. Others to receive the spill report include the Kivalliq Inuit Association, Hamlet of Rankin Inlet, Fisheries and Oceans Canada, Canadian Coast Guard and Indigenous and Northern Affairs Canada Canada and Environment and Climate Change Canada (ECCC). Incidents that require media communications will be the responsibility of Agnico General Mine Manager or Public Affairs Corporate Director.

To ensure compliance with Section 36(3) and 38(5) of the *Fisheries Act* and Section 5(1) of the *Migratory Birds Convention Act*, all spills of fuel or hazardous materials, regardless of quantity, into a water body or

[3] CCG: 1-800-265-0237, Superintendant Environmental Response Phone: 519-383-1954 Cell phone:519-381-6186
[4] Plan submitted by email to CCG before the 2016 Shipping Season and will be for the 2017 Shipping Season once approve by TC.

onto ice will be reported immediately to the NT-NU 24-HOUR SPILL REPORT LINE (phone: (867) 920-8130, fax: (867) 873-6924, spills@gov.nt.ca).

Agnico possess a thorough internal spill reporting system that documents all spills for internal tracking. A copy of this Agnico internal spill report can be found in Appendix F, this is the spill report that the first responder will have to complete. Regardless of the volume, these spills are all reported to the Environment Department and if the NT-NU spill limits are exceeded or if the spill occurs in a water body (regardless of quantity), the Environmental Department reviews the incident, produces the NT-NU spill report and submits the NT-NU spill report to the regulator listed above. Investigation of all reportable spills is completed by the Meadowbank Environment Department.

10.3 Treatment and Disposal

All diesel or Jet-A fuel recovered through the spill response and any contaminated material will be taken to the Meadowbank mine site for recovery and, if applicable, incineration. It could also be packaged for disposal/recycling by a certified hazardous waste management company in southern Canada.

10.4 Resuming Unloading

The unloading of fuel from the tanker to the OHF will not resume if it hinders the response to the spill in any way. Unloading will resume once all problems are corrected, thus ensuring that the spill will not continue.

SECTION 11. SPILL SCENARIOS AND RESPONSE STRATEGIES

Agnico will strive to prevent any accidental spills and take all reasonable steps to minimize the risk of spill incidents and their impact on the environment. In 2016, an exercise program scenario was developed as a prevention protocol for the OHF operation. Safety, including use of personal protective equipment around water, and spill response training were part of this training. This exercise program evaluated the effectiveness of all the aspects of the procedure, equipment and resources that are identified in the OPEP. A summary of the 2016 exercise is provided in Appendix D - 1.4. An exercise will be conducted this year and the summary will be provided in next year's revision of the OPEP.

11.1 Product Properties and Response Strategy

Jet fuel, Jet-A, Jet-A1, or kerosene is a type of aviation fuel designed for use in aircraft powered by gas-turbine engines. It is colourless to straw-coloured in appearance.

P50 Diesel is a bright oily substance that has a low viscosity. It spreads rapidly on the water, has a low solubility in salt water (60 mg/L), and a high evaporation rate as described in the text box below.

At Baker Lake, the wind is largely from the NW to N.

Predicted Evaporation Rate of Spilled Diesel

Weight percent Evaporation = (5.8 + 0.045T) in(t)
Where T = water temperature
t = time in minutes

After a time span of 60 minutes at a surface temperature of 5°C, up to 25 % weight of the spilled diesel would have evaporated.

After 240 minutes, or 4 hours, the weight percent of the diesel that would have evaporated would be 33%.

Source: *Environment Canada, Emergencies Science and Technology Division*

In relation to Jet-A Fuel we will use the same evaporation rate as diesel as per Journal of Petroleum Science Research states; "*Diesel fuel and similar oils, such as jet fuel, kerosene and the like, evaporate as a square root of time. The reasons for this are simply that diesel fuel and such like have a narrower range of compounds which evaporating at similar rates, yield rates which together sum as a square root.*"[5]

As a result of the properties of diesel and Jet-A and the environmental conditions that predominate at Baker Lake, the spill response will need to aim to stop the spilled product from spreading across Baker Lake. This could include activating the Shipboard Oil Pollution Emergency Plan. The tanker would have response equipment on board and a fully trained crew in spill response. This, coupled with a shore based response under the OPEP, would ensure sufficient resources are available to control and recover as much diesel and Jet-A fuel as feasible.

[5] Journal of Petroleum Science Research (JPSR) Volume 2 Issue 3, July 2013 - *Modeling Oil and Petroleum Evaporation* by Merv F. Fingas

11.2 Pipeline safeguards

There are a number of safeguards in operating the ship-to-shore pipeline; these include:

- Save-all trays to capture any minor spills at the ends of the floating pipeline;
- Dry-break couplings at both ends of the floating pipeline;
- A pressure test will be performed before the diesel transfer to confirm the system is free of leaks; and
- Both the crew on the tanker and Agnico's shore based personnel will be fully trained in spill response and spill recovery.

11.3 Wildlife

During a spill event, Agnico will take care to deter any animal that will be near the spill area to minimize the risk to wildlife. In a case of mortalities, Agnico will track any mortality and report these numbers to the GN.

11.4 Scenarios

Three scenarios are considered, these being:

1. A spill between the ship and the flange of the OHF, the floating pipeline, resulting in a spill smaller than 1000 L of diesel or Jet-A fuel;
2. A major failure between the ship and the flange of the OHF, the floating pipeline, resulting in a spill greater than 1000 L but smaller than 5000L of diesel or Jet-A fuel; and
3. Spill greater than 5000 litres.

In most instances Agnico personnel and/or contractors will be able to respond to the spill but if necessary, backup can be requested by calling for the assistance of the Agnico Emergency Response Team that is stationed at the Meadowbank site located 110 kilometers away. The ERT can be at Baker Lake within 125 minutes to take charge of the spill response. Agnico will make every effort to have its equipment and resources deployed within 6 hours of an incident.

Diesel and Jet-A spills will be responded to in the same way. Review of the CANUTEC Emergency Response Guidebook designates the spill response to both products as the same.[6]

[6] 2012 Emergency Response Guidebook

Scenario 1: **Loss between the ship and the flange of the OHF, the floating pipeline, resulting in spill smaller than 1000L of diesel or Jet-A fuel.**

Appropriate Actions	Resources
1. Communicate with vessel and immediately stop the ship-to-shore transfer of fuel, if it's safe to do. The transfer should not restart in a manner that would interfere with the immediate, effective and sustained response to the oil pollution. 2. Make sure that the environment is safe for the facility and vessel personnel, the facility and Baker Lake community. 3. Make sure that risk of fire or explosion are minimize. 4. Contact person found on OHF Declaration to initiate the OPEP. 5. Minimize the oil pollution incident by containing the spilled fuel to spreading within the marine environment, if it's safe to do. 6. Notify CCG, local and regulatory authorities. 7. Containment boom is manned to prevent the escape of fuel outside the boom. 8. If necessary, place a diversion boom outside the containment boom to stop the diesel from getting onto the beach. 9. Spread absorbent material on the spill to capture it. 10. Monitor any fuel that could not be recovered and collect water samples near the spill site and in the access passage for analysis. Repeat as necessary. 11. If diesel reaches the beach, excavate the contaminated beach material and take it to the Landfarm area at the Meadowbank site.	a. Crew on the tanker trained in spill response. b. Agnico's shore based personnel trained in spill response and recovery. c. Emergency Response Team to take control of the spill response and recovery. d. Spill response equipment and supplies maintained on board the tanker and also in the sea can located on shore of Agnico's Fuel Farm and Marshalling area. e. Save-alls (Pop-up pools) placed under the pipeline manifolds to collect minor spills. f. Shore-based boat to position booms. g. Absorbent booms to recover spilled diesel on sea water. h. Heavy equipment such as excavators, back hoes, vacuum trucks, and dump trucks available if beach is contaminated.

Scenario 2: **Loss between the ship and the flange of the OHF, the floating pipeline, resulting in spill greater than 1000L but smaller than 5000L of diesel or Jet-A fuel.**

Appropriate Actions	Resources
1. Communicate with vessel and immediately stop the ship-to-shore transfer of fuel, if it's safe to do. The transfer should not restart in a manner that would interfere with the immediate, effective and sustained response to the oil pollution. 2. Make sure that the environment is safe for the facility personnel, the facility and Baker Lake community. 3. Make sure that risk of fire or explosion are minimize. 4. Contact person found on OHF Declaration to initiate the OPEP. 5. Minimize the oil pollution incident by containing the spilled fuel to spreading within the marine environment, if it's safe to do. 6. Notify CCG, local and regulatory authorities. 7. Containment boom is manned to prevent the escape of fuel outside the boom. 8. If necessary, place a diversion boom outside the containment boom to stop the diesel from getting onto the beach 9. Spread absorbent material on the spill to capture it 10. For larger amounts of spilled materials on water, use absorbent booms to collect the spilled diesel 11. Monitor any fuel that could not be recovered and collect water samples near the spill site and in the access passage for analysis. Repeat as necessary. 12. If diesel reaches the beach, excavate the contaminated beach material and take it to the Landfarm area at the Meadowbank site.	a. Crew on the small tanker trained in marine spill response. b. Crew from the large tanker anchored outside the access passage. c. Agnico's shore based personnel trained in near shore spill response and recovery. d. Emergency Response Team trained for near shore spill response. e. Shore-based boat to position booms and spread absorbent material. f. Spill response equipment and supplies maintained on board the tanker, in Agnico sea can locate at Agnico's Marshalling area. g. Additional booms to place outside the containment boom. h. Additional boats can be transported from the Meadowbank site as well local boats can be rented from local contracting companies i Heavy equipment such as excavators, back hoes, vacuum trucks, and dump trucks for waste materials. j. in the case of larger spills an Incident Command System will be set up at the Meadowbank site as laid out in the Meadowbank Emergency Response Plan.

Scenario 3: **A spill >5,000 litres**

In the case of an ***Extreme*** spill, Agnico follow the actions listed in Scenario 2 to complete the best clean up possible. Between the spill response equipment that the tanker delivering fuel has on board and the spill response supplies at the OHF, a spill up to the size of 5, 000 - 10, 000L will be able to be controlled and cleaned up. However if the spill is greater than 10, 000L, at this point Agnico will require external assistance with the clean-up.

The Canadian Coast Guard (CCG) will be made aware each year prior the fuel transfer, there is a possibility that under direction of CCG that there spill depot supplies located in Baker Lake may be used.

SECTION 12. PREVENTIVE MEASURES

Agnico recognises that spill prevention is more desirable than any modern efficient cleanup measures after the fact. Preventive measures have been adopted in relation to any transport, transfer, use and storage of diesel and Jet-A fuel. The tankers carry a Ship Oil Pollution Emergency Plan (SOPEP) as per the MARPOL 73/78 requirement under Annex I. All ships with 400 GT and above must carry an oil prevention plan as per the norms and guidelines laid down by the International Maritime Organization (IMO).

A SOPEP contains the following things:

- The action plan contains duty of each crew member at the time of spill, including emergency muster and actions;
- General information about the ship and the owner of the ship etc.;
- Steps and procedure to contain the discharge of oil into the sea using SOPEP equipment;
- On-board Reporting procedure and requirement in case of oil spill;
- List of authorities to contact and reporting requirements in case of oil spill. Authorities like port state control, oil clean up team etc. are to be notified;
- Drawing of various fuel lines, along with other oil lines on board vessel with positioning of vents, save-all trays, etc.;
- General arrangement of ship, which includes location of all the oil tanks with capacity, content, etc.; and
- The location of the SOPEP locker and contents of the locker with a list of inventory. (Marine Insight 2012)

The Spill Contingency Plan, Emergency Response Plan and the Oil Pollution Emergency Plan identify potential causes of emergencies and provides for the development and implementation of strategies to minimize the likelihood of the same.

As described in the Spill Contingency Plan, exercises are part of training for the Emergency Response Team. This will include comprehensive spill response exercise to practice the use of spill response equipment, including the use of booms and oil water separator.

The OPEP will be updated annually based on the results of spill exercises, changes to the infrastructure at Agnico's Fuel Handling Facilities, changes to procedures and other variables. The updated OPEP will be distributed to the Agnico Emergency Response Team, Transport Canada, the Kivalliq Inuit Association, the Municipality of Baker Lake and other agencies as appropriate.

12.1 Training

The environmental department and ERT team received training from a response organization and as a result will be able to respond to or assist with incidents that may occur at the OHF.

12.1.1 Meadowbank site Personnel

A designated Emergency Response Team (ERT) consisting of on-site personnel is established at Agnico's Meadowbank Mine Site. Agnico will ensure that the ERT is trained and staffed in sufficient

number so that the ERT is present at all times. All members of the team will be trained and familiar with emergency and spill response resources, including their location and access, the Spill Contingency Plan, the Oil Pollution Emergency Plan and appropriate emergency spill response methodologies. The ERT will have up to 60 members, each of whom will train approximately 8 hours per month.

The training will include the following:

- Worker health and safety during emergency interventions;
- A review of the spill response plan and responsibilities of the ERT members;
- The nature, status, and location of fuel and chemical storage facilities;
- The on-site and off-site spill response equipment and how to use it;
- Emergency contact lists;
- Communication methods and signals;
- Desktop exercises of “worst case” scenarios;
- Emergency evacuation;
- Fires or explosions;
- Emergency equipment and use;
- Personal protective equipment and clothing;
- Marine shoreline recovery operations; and
- The likely causes and possible effects of spills.

Every employee at the Meadowbank project will receive spill and waste management induction during their initial site orientation, so they are able to respond to small spills and raise the alarm if a larger response is required. ERT members will receive more extensive spill response training and learn how to respond while wearing personal protective clothing, use of specific spill response gear, proper deployment of absorbents and maritime boom.

The Environmental Department will regularly provide tool-box sessions to give information on spill response and reporting procedures.

You can find records of different trainings that Agnico personnel have attended in Table 8. Basic spill response training will be completed in 2017 by all Agnico employees and contractors working on the Meadowbank project as part of the induction which is mandatory for all personnel coming to the Meadowbank site.

12.1.2 OHF Personnel Training

Prior to the first discharge of fuel form the vessel to the OHF a mandatory training will take place. This will be a review with all the personnel responsible for the shore based portion of the fuel transfer, including the third party contractor and the Baker Lake supervisor, the current OPEP and make them aware of the procedures to follow in case of a spill before the first fuel barge arrived. A copy of the 2017 log sheet will be provided to TCMSS once the training is completed.

In April 2016, a meeting with all Departments of Agnico involved with fuel transfer was held. The OPEP, prior to and during transfer checklists were reviewed. Meeting minutes can be found in Appendix D – 1.3. The minutes from meeting that will be held in 2017 prior to shipping season will be include in the next OPEP update.

12.1.3 Boat Operators

All people involved in the supervision during operation and / or on the spill response will complete the training course for the pleasure craft operator. Records of pleasure craft operator certification will be retained by the Meadowbank Training department.

All concerned persons working for Agnico Eagle Mines Ltd. must possess a pleasure craft operator card and provide proof of this certification prior to operating any boat relating to the Meadowbank project which includes the Baker Lake Marshalling facility. This includes emergency responders.

Table 8 - Spill Response Training

Agnico Eagle Mines Meadowbank Division

Spill Response Training

	Name	Company	Spill Response Operations Course / CCG	Emergency Planning and Spill Response Awareness / SWAT Consulting	OHF & AWPR Spill Response / Jamie Kataluk	OHF & AWPR Spill Response / Tom Thompson	OHF & AWPR Spill Response / Robin Allard	OHF & AWPR Spill Response / Martin Therialut	OHF Spill Response and Ship to Shore Checklist / Jeffrey Pratt
AEM EE	Jeffrey Pratt	AEM		15/01/2013		14/07/2015			30/09/2014
AEM EE	Robin Allard	AEM	01/01/2012	16/01/2013		14/07/2015			30/09/2014
AEM EE	Martin Theriault	AEM	01/01/2011	15/01/2013				16/07/2016	
AEM EE	Fanny Laporte	AEM		15/01/2013					
AEM EE	Richard Jackson	AEM		15/01/2013					
AEM EE	Tom Thomson	AEM	24/04/2015	15/01/2013					
AEM EE	Jamie Kataluk	AEM	24/04/2015	16/01/2013					30/09/2014
AEM EE	Randy Schwandt	AEM						16/07/2016	
AEM EE	Dave Holmstrom	AEM		16/01/2013					
AEM EE	Potogu Noah	AEM			10/07/2013				
AEM EE	Stephane Larose	AEM		16/01/2013					
AEM EE	Jean-Claude Poitras	AEM					18/06/2013		
AEM EE	Bernard Paradis	AEM					18/06/2013		
AEM EE	Serge Pare	AEM					18/06/2013		
AEM EE	Ray Carlson	AEM					18/06/2013		
AEM EE	Mark Nulait	AEM						20/09/2012	
AEM EE	Tim Chappelle	AEM						20/09/2012	
AEM EE	Alexandre Arcand	AEM						25/09/2012	
AEM EE	Alexande Ouellette	AEM				14/07/2015			30/09/2014
AEM EE	Fredy Riveron	AEM						16/07/2016	
AEM EE	Steve Paquin	AEM							30/09/2014
NOT AEM	Francois Moses	Intertek				14/07/2015			30/09/2014
NOT AEM	Alberto Rodriguez	Intertek				14/07/2015			30/09/2014
NOT AEM	Cerbah Nassim	Intertek						16/07/2016	
NOT AEM	Jose Vergara	Intertek						16/07/2016	
NOT AEM	Sanik Faraq	Intertek				14/07/2015			30/09/2014

SECTION 13. COASTAL SHIPPING

13.1.1 Coastal Shipping

In Appendix A - 1.2 you will find the contact information for Coastal Shipping during the barge season. This contact information will be used again in the 2017 season; no changes are required for this year. This will be reviewed with Coastal Shipping on an annual basis.

SECTION 14. REFERENCES

Transport Canada *Oil Handling Facilities Standards*, TP12402E.

Canadian Coast Guard, Central & Arctic Region, 2008. *Regional Response Plan.*

Marine Insight, 2012. What is Ship Oil Pollution Emergency Plan (SOPEP)? http://www.marineinsight.com/misc/maritime-law/what-is-ship-oil-pollution-emergency-plan-sopep/#ixzz21B2YvDTW http://www.marineinsight.com/misc/maritime-law/what-is-ship-oil-pollution-emergency-plan-sopep/#ixzz21B1dDGL5

Moller, T.H. & Santner, R.S. 1997. *Oil Spill Preparedness and Response: the Role of Industry,* 1997 International Oil Spill Conference, Technical Report IOSC-005.

National Oceanic and Atmospheric Administration
http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/in-situ-burning.html

Transport Canada, TP- 12401, 1995. *Response Organizations Standards.*

Transport Canada, TP-12402, 1995. *Oil Handling Facilities Standards.*

Transport Canada, TP-10783, 1997. *Arctic Waters Oil Transfer Guidelines.*

Transport Canada Guideline, TP-10783E, 1997. *Arctic Waters Oil Transfer Guidelines,* Prairie and Northern Region, Marine (AMNS - OTT).

Transport Canada, TP-13585, 2008. *Environmental Prevention and Response National Preparedness Plan.*

Transport Canada Guideline TP- 9834E, 2009. *Guidelines for Reporting Incidents Involving Dangerous Goods, Harmful Substances and /or Marine Pollutants*.

Journal of Petroleum Science Research (JPSR) Volume 2 Issue 3, July 2013 - Modeling Oil and Petroleum Evaporation by Merv F. Fingas

APPENDIX A 1.1- COASTAL SHIPPING LTD. SOPEP

Appendix 7
Spill Kit Inventory
M/T *Dara Desgagnés*
April 23, 2018

Item	Size	Min Quantity	Quantity Onboard	Location Onboard
Portable Pumps and hoses	Sets	2	4	2 Main Deck 1 Dog House 1 E/R
Absorbent pads	Bales	5	11	7 in stbd rope locker Some in use in spill kits 4 in Chem locker
Absorbent – particulate	Bales	5	45	Boat Deck, port rope locker and Local spill kits
Hand scoops, buckets and shovels	Each	3	6+	Chemical locker drum, stbd rope locker, spill kits
Waste container	55 gal drum	2	7	2 at aft end gangway 1 in chemical locker 4 aft of ER hatch
Emulsifiers	1 gal	5	5	White box at crane
Tyvec coveralls	Various	12	12 +	Chemical locker Spill kit drum, and crew deck stores
Boots, oil resistant	Various	12 pairs	16 pair	10 in chemical locker 6 in change room/CCR
Gloves, oil resistant	Various	12 pairs	12+	Chemical locker drum
Rags	Lbs	20	25+ bags	Stbd rope locker

Dara Desgagnés
Chief Officer
Rigel Shipping

APPENDIX A 1.2- COASTAL SHIPPING LTD. CONTACT INFO

ATLANTIC TOWING

WOODWARD

BAKER LAKE AREA OPERATIONAL PROCESSES

To further support safe operations in the Baker Lake area between Woodward, Atlantic Towing, and Petro Nav, the following information and procedures will be adopted starting in the 2018 season.

1.0 COMMUNICATION PROTOCOL

Daily e-mail sent out by each vessel to all vessels by 8:00am

To include:

- Current position
- ETA thru narrows
- Communication equipment status

Long Distance Communication

- Primary – Satellite phone
- Secondary – Sat-C

Short Distance Communication

- VHF communication – channel 16

2.0 ATL COMMUNICATION INFORMATION

Atlantic Beech

- E-mail: 432525810@stratosmobile.net
- Cellular: (506) 654-1410
- Satellite: 011-870-783-209-055

Atlantic Elm

- E-mail: 431697659@stratosmobile.net
- Cellular: (902) 456-8169
- Satellite: 011-870-773-236-143

ATL VHF working channel is 69

3.0 WOODWARD COMMUNICATION INFORMATION

Vessel
- E-mail:
- Cellular:
- Satellite:

Vessel
- E-mail:
- Cellular:
- Satellite:

WOODWARD VHF working channel is 10

4.0 PETRO NAV COMMUNICATION INFORMATION

Vessel DARA DESGAGNES
- E-mail: captain.dara@desgagnes.com
- Cellular: 1-506-533-4992
- Satellite: 1-418-907-8410

Vessel
- E-mail:
- Cellular:
- Satellite:

PETRO NAV VHF working channel is XX

5.0 RULES OF THE WATER WAYS

Note: Outbound refers to Tanker or Tug & Barge leaving Baker Lake for Helicopter Island

Inbound refers to Tanker or Tug & Barge leaving Helicopter Island for Baker Lake

Helicopter Island to Baker Lake

Inbound ATL Tug will contact outbound Woodward and/or Petro Nav tanker by Sat Phone to get its transit time thru the narrows (confirming information from daily e-mail). Tug and barge will depart Helicopter Island 3 and ½ hours prior to the transit time of the Tanker. It takes 3 hours for the Tug and Barge to reach the narrows from Helicopter Island. This allows plenty of time for all 4 vessels to transit the narrows.

Inbound ATL Tug and Barge **WILL ALWAYS** depart Helicopter Island prior to inbound Woodward and/or Petro Nav tanker. Inbound Woodward and/or Petro Nav tanker **WILL ALWAYS** follow inbound ATL Tug and Barge until to entrance of Baker Lake (no passing). Inbound ATL Tug and Barge and inbound Woodward and/or Petro Nav tanker will communicate on VHF channel 16.

Inbound ATL Tug and Barge will pass thru the narrows first, followed by the inbound Woodward and/or Petro Nav tanker. Outbound Woodward and/or Petro Nav tanker will pass thru the narrows next, followed by the outbound ATL Tug and Barge.

Baker Lake to Helicopter

Outbound Woodward and/or Petro Nav tanker will depart for the narrows. When reaching the narrows, outbound Woodward and/or Petro Nav tanker **WILL NEVER** proceed until inbound traffic has cleared the narrows. Outbound Woodward and/or Petro Nav tanker will hold position above the narrows just south of Bannerman Island.

Outbound ATL Tug and Barge will depart for the narrows. When reaching the narrows, outbound ATL Tug and Barge **WILL NEVER** proceed until inbound traffic has cleared the narrows. Outbound ATL Tug and Barge will hold position above the narrows just south of Bannerman Island.

Once inbound vessel traffic has cleared the narrows, the outbound Woodward and/or Petro Nav tanker will proceed thru the narrows first. The outbound ATL Tug and Barge **WILL ALWAYS** proceed thru the narrows after the outbound Woodward and/or Petro Nav tanker.

6.0 FUEL HOSE POSITIONING

The fuel hose from the Woodward or Petro Nav tanker will be connected to the far side of the vessel away from the spud barge. The fuel hose will lay directly to shore, where a support structure will guide the fuel hose along the shore line until it mates with the shore manifold. This eliminates the risk of the ATL Tug and Barge coming into contact with the fuel hose while departing/ arriving at the spud barge.

APPENDIX B - The Central and Arctic Regional Response Plan (2008)

Canadian Coast Guard
Central & Arctic Region



Regional Response Plan

December 2008

LETTER OF PROMULGATION

The *Central & Arctic Regional Response Plan (2008)* replaces the *Central & Arctic Region Contingency Chapter (2006)* and the *Arctic Response Strategy (1999)*. This plan is a component of the *Canadian Coast Guard National Response Plan* which is the responsibility of the Director of Safety and Environmental Response Systems, Ottawa. It establishes the framework and the procedures by which Central & Arctic Region will prepare for, assess, respond to and document actions taken in response to pollution incidents in this Region.

The saving of life is of paramount consideration and the Plan is subordinate to the operational requirements of marine search and rescue.

The Plan has been reviewed by the internal partners identified in Section 3.3 in context to the services they may provide and by the external partners identified in Sections 3.4 and 3.5 to confirm their mandated response authorities.

Responsibility for the *Regional Response Plan* lies with the Assistant Commissioner Coast Guard Central & Arctic Region. The Central & Arctic Region Environmental Response branch is the custodian of the plan. The responsibility for specific sections is identified in Section 7 - Plan Maintenance and Custodians. Comments, recommendations and communications relating to the various sections are clearly identified in this section.

REVISION RECORD

CENTRAL & ARCTIC REGIONAL RESPONSE PLAN			
Section	Replace	Transmittal No.	Description of Changes
Entire Plan	All	December 1, 2005	Complete revision of Central & Arctic Regional Response Plan
Entire plan	All	April 1, 2006	Complete revision of Central & Arctic Regional Response Plan
7.1 Maintenance Process	Page 7-1	May 8, 2007	Update address to 520 Exmouth Street
8.3 CCG ER Phone List	Page 8-1	June 4, 2007	Update address to 520 Exmouth Street
Entire Plan	All	December 2008	Complete revision of Central & Arctic Regional Response Plan

LETTER OF PROMULGATION i

REVISION RECORD ii

SECTION 1 – INTRODUCTION
- Authority 1-1
- Purpose 1-1
- Area of Responsibility 1-1
- Safety Policy 1-2
- Links to the National Response Plan 1-2
- Regional Response Plan Structure 1-2
- Linkages to International Joint Plans 1-3
- Linkages to International Joint Plans 1-3

SECTION 2 – AGREEMENTS & MEMORANDA OF UNDERSTANDING
- Overview 2-1

SECTION 3 – ORGANIZATION
- General Application 3-1
- Environmental Response Branch (DFO/CCG/ER) 3-1
- Internal Partners – Fisheries and Oceans 3-3
- Internal Partners – Other Federal Departments 3-5
- External Partners 3-8
- Clients 3-9
- External Resources 3-10

SECTION 4 – PREPAREDNESS
- Overview 4-1
- Response Management System (RMS) 4-1
- Planning 4-4
- Training Program and Curriculum 4-6
- Exercise Program 4-12
- Inventory Management, Maintenance and Infrastructure 4-14

SECTION 5 – RESPONSE OPERATIONS
- Pattern of Response 5-1
- Spill Potential or Pollution Risk Assessment 5-5
- Notification 5-5
- Verification 5-5
- Spill Assessment 5-6
- Activation of Canadian Coast Guard Response Resources 5-11
- Response Implementation 5-11
- Summary Report and Post Incident Review 5-16

SECTION 6 – CLAIMS AND COST RECOVERY
Purpose 6-1
Policy Guidelines 6-1
Responsibilities 6-2
Process 6-2
Documentation 6-2
References 6-4
Third Party Claims 6-4

SECTION 7 – PLAN MAINTENANCE AND CUSTODIANS
Maintenance Process 7-1
Canadian Coast Guard Custodians 7-1
Plan Distribution 7-2

SECTION 8 – CONTACTS
Pollution Reports for Canadian Coast Guard (CCG), Central & Arctic Region (C&A) 8-1
Other Lead Agencies that Maintain Spill Report Lines 8-1
Environmental Response Branch Phone List 8-1

SECTION 9 – REFERENCES AND ANNEXES
References 9-1
Annexes 9-1

Section 1 - INTRODUCTION

1.1. Authority

This plan is based upon the policy and guiding principles set forth in the *National Response Plan* of the *Canadian Coast Guard National Response Strategy*.

1.2. Purpose

The *Central and Arctic Regional Response Plan* is designed as a guide to Canadian Coast Guard staff and relevant stakeholders involved in marine spill responses. It outlines the Regional application of the various roles of On-Scene Commander (OSC) (active response), Federal Monitoring Officer (FMO) (ensuring the Responsible Party fulfills their obligations), and as a Resource Agency (in assistance to other Lead Agencies).

It contains the specific information and activities that are pertinent to all spill response activities within Central & Arctic Region (C&A Region).

1.3. Area of Responsibility

For the purposes of marine pollution response Central & Arctic Region is defined geographically as:

- The contiguous waters of the Canadian Arctic (North of 60^{o} Latitude) to the limits of the International Boundary, including the North Slope Area of the Yukon Territories, and internal waters of the Northwest Territories and the Territory of Nunavut; and

- The waterways contained within the provinces of Alberta, Saskatchewan, Manitoba, Ontario, and a western portion of Quebec commencing at the east wall of the Beauharnois Lock in the St. Lawrence River.

(see Figure 1-1 Fisheries and Oceans Central & Arctic Region)

Significant waterways include the Canadian Great Lakes and interconnecting waterways to the international Boundary with the United States, Hudson and James Bays, Lake Winnipeg, Lake Athabasca and interconnecting waterways, Great Slave Lake, Mackenzie River and the Northwest Passage in the Canadian Arctic.

There are also a number of specific geographic locations which, although not excluded from Canadian Coast Guard's mandate, require coordination between the managing authorities and this plan. These areas include the waters associated with

the various Port Authorities (Hamilton, Thunder Bay, Toronto and Windsor) and the St. Lawrence Seaway Authority (Welland Canal, St. Lawrence Locks) as defined by the *Canada Marine Act, 1998*.

Figure 1-1: Fisheries and Oceans Central & Arctic Region



1.4. Safety Policy

Safety is the first and foremost consideration in any pollution response in Central & Arctic Region. This commitment is expressed throughout this and other documents as well as in the programs relied on by the Environmental Response (ER) branch to prepare for such spills (i.e. training and exercising programs). General safety procedures and considerations to be followed by all members of the Regional Response Team are identified in Section 5.7 of this plan.

1.5. Links to the National Response Plan

The Guiding Principles and Mandate (including legislative, interdepartmental, intergovernmental and international agreements) as well as designation of Lead and Resource Agency roles are contained in the *National Response Plan Section 1 – Introduction.* The mechanism for activating the Environmental Response National Response Team is also defined in the *National Response Plan*.

1.6. Regional Response Plan Structure

The Regional Response Plan is structured to reflect the three fundamental phases of Environmental Response activities. These are:

1) Preparedness - through the regional application of Contingency Planning (resulting in specific response strategies), Training (state of personnel readiness), Exercising (state of system readiness) and Inventory Maintenance and Management (state of mechanical/equipment readiness).

2) Response Operations - identifying the mechanisms for:
   - *Initiating* (through a dedicated Duty Officer and Assessment process),
   - *Sustaining* (Operational functions as Lead or Resource Agency),
   - *Controlling* (using the Response Management System), and
   - *Finalizing* the response activity (decommissioning and reporting).

3) Claims, Recovery and After-action activities - for the documentation and recovery of spent resources from the polluter, their agents, national or international funding conventions.

Surrounding these fundamentals are the specifics of the Environmental Response Program in Central and Arctic Region that are too cumbersome to be included in the main text of this Response Plan. They include: Regional Agreements and Memoranda of Understanding, Regional Organization and the specific Annexes which support the program. Finally, the Response Plan includes the preliminary and supplementary matter such as Letter of Promulgation, Record of Revision and the Identification of Custodians and the Plan Maintenance process.

1.7. Linkages to other Response Plans in the Region

When a pollutant is spilled into the water, the Canada Shipping Act is not the only legislation that applies. Recognizing that being designated Lead Agency for pollution response to mystery spills and spills from vessels does not preclude other agencies from completing their mandate CCG acknowledges that the Internal and External Partners listed in Sections 3.4 and 3.5 have plans that are active within Central & Arctic Region.

1.8. Linkages to International Joint Plans

International Joint Plans and agreements affecting Central & Arctic Region include:

- Canada-United States Joint Marine Pollution Contingency Plan
- Canada-Denmark Agreement for Co-operation Relating to the Marine Environment, Annex B (Joint Marine Contingency Plan concerning Incidents resulting from Shipping Activities)
- Great Lakes Water Quality Agreement, Annex 9
- International Boundary Waters Treaty Act

The Canadian Coast Guard Environmental Response Branch also provides technical support for the Emergency Prevention, Preparedness and Response (EPPR) Working Group of the Arctic Council. The EPPR Working Group exchanges information on best practices for preventing spills, preparing to respond to spills should they occur, and practical response measures for use in the event of a spill.

The Arctic Council is an intergovernmental forum of the eight circumpolar countries (Canada, Denmark, Finland, Iceland, Norway, Sweden, the Russian Federation and the United States of America) that provides a mechanism to address the common concerns and challenges faced by the Arctic governments and the people of the Arctic.

Some work has been initiated with the Russian Federation for the development of a Joint Pollution Response Plan. To date no agreements have been signed.

Section 2 - AGREEMENTS AND MEMORANDA OF UNDERSTANDING

2.1 Overview

The Canadian Coast Guard (CCG), both Central & Arctic and National Headquarters, maintain numerous memoranda and letters of understanding and agreement between other government departments which outline shared responsibilities in pollution response. A brief description of the major agreements is listed below.

- Letter of Agreement between Canadian Coast Guard, Environmental Response Branch and Canadian Coast Guard, Operational Services and Canadian Coast Guard, Technical Services regarding the use of Environmental Response First Response Units (FRUs) by non-environmental response staff. This agreement concerns the use of FRUs at the various CCG facility sites (bases, sub-bases and search and rescue stations).

- Northwest Territories/Nunavut Spills Working Agreement. This agreement formalizes procedures whereby spill investigation and monitoring in the Northwest Territories (NT) and Nunavut (NU) can be coordinated.

- Fisheries & Oceans (DFO) and Environment Canada (EC) Letter of Agreement respecting transfer of responsibility as lead agency for mystery spills from Environment Canada (EC) to the Canadian Coast Guard/Fisheries & Oceans Canada (July 1996)

- Transport Canada (TC) and Fisheries & Oceans (DFO) Memorandum of Understanding respecting Marine Transportation Safety & Environmental Protection (May 1996). This MOU outlines the responsibilities transferred from TC to DFO in accordance with the *Public Service Rearrangement and Transfer of Duties Act*. Those pertinent to this plan include:
    a) The responsibility for ensuring the provision of pollution clean up services
    b) The authority to take actions to mitigate or prevent pollution from ships

- Letter of Understanding between the Canadian Coast Guard and the Hamilton Port Authority to outline the roles that the CCG and the HPA will

play in the event of a pollution incident which falls within the mandate of the Canadian Coast Guard.

- Letter of Understanding between the Canadian Coast Guard and the Thunder Bay Port Authority to outline the roles that the CCG and the TBPA will play in the event of a pollution incident which falls within the mandate of the Canadian Coast Guard.

- Letter of Understanding between the Canadian Coast Guard and the Toronto Port Authority to outline the roles that the CCG and the TPA will play in the event of a pollution incident which falls within the mandate of the Canadian Coast Guard.

- Letter of Understanding between the Canadian Coast Guard and the Windsor Port Authority to outline the roles that the CCG and the WPA will play in the event of a pollution incident which falls within the mandate of the Canadian Coast Guard.

Some memoranda of understanding and letters of agreement have been rendered defunct by virtue of the dissolution or reorganization of the entities that signed the original document. It is the Region's intent to assess the need for an MOU and in those cases where renewal is needed, to draft a new MOU and submit to the partner organization the request for re-entry into that agreement. For further information on these memoranda, please contact the Environmental Response Planning Section.

Section 3 - ORGANIZATION

3.1 General Application

This section describes the primary working relationships between Fisheries and Oceans (DFO), Canadian Coast Guard, Environmental Response branch (CCG/ER) and the various internal and external partners, clients and external resources.

Internal partners include: Other DFO sectors, directorates and branches, and other federal departments which provide direct assistance or have specific mandates which directly affect response activities.

External partners include those entities that share the burden of pollution response for their specific area of responsibility. These agencies include the provincial and territorial government ministries with the generic mandate of pollution response.

Clients include those entities that are specifically identified by the *Canada Shipping Act (CSA)* and have direct involvement in the response regime; they include Oil Handling Facilities (OHF), Legislated Ships and Non-legislated Ships.

External resources are those resources outside of the government that the Canadian Coast Guard may engage while conducting spill response activities. These include the Response Organizations (RO) certified by Transport Canada and other independent contractors which may perform more specific functions.

3.2 Fisheries and Oceans, Canadian Coast Guard - Environmental Response Branch (CCG/ER)

The Assistant Commissioner, Canadian Coast Guard through the Maritime Services Directorate and the Superintendent of Environmental Response (ER) directs the Regional Environmental Response Team. This team represents one facet of the overall crisis management structure within Central and Arctic Region and performs the function of the Lead Response Agency for pollution incidents as defined in the *National Response Plan – Section 1* of the *Canadian Coast Guard National Response Strategy.* The branch consists of approximately seventeen (17) full time employees (FTEs).

Internally, the Environmental Response Branch is made up of five (5) distinct but integrated functions:

1) *Direction and Administration* - providing the overall guidance, management and liaison with Headquarters. The Superintendent holds the responsibility for escalating a response and/or dedicating resources.
2) *Planning* - providing the design and management of plans and procedures to facilitate the preparedness posture of the Region (responsible for developing and maintaining intradepartmental, interdepartmental, client and regime stakeholder relationships).

3) *Operations and Inventory Maintenance & Management* - provide the management and maintenance of equipment to ensure the operational response readiness of the Region.
4) *Training* - provides the coordination and delivery of educational materials, to internal as well as external partners and clients, in support of the overall preparedness posture of the Region.
5) *Exercising* - provides the management and coordination of internal and external partners and clients to validate, practice and reinforce all aspects of the Response readiness of the Region.

In addition to these core functions, each staff member is required to actively participate in the operational aspects of the response regime based upon their skill and ability levels. This includes assuming various roles within the Response Management Structure acting as Duty Officer (DO) and supporting the overall emergency preparedness structure within the Region (not necessarily related exclusively to oil spills or pollution).

In the context of this Plan, the Environmental Response Branch is tasked to:

- Fulfill the Canadian Coast Guard's obligations as Lead Agency in an OSC or FMO posture in responding to marine pollution incidents from ships in waters of Canadian interest as well as from unknown sources.
- Act as a Resource Agency in support of a response led by another agency when requested.
- Staff a Duty Officer position on a 24/7 basis which, together with other agency representatives, will assess or direct the assessment of spill reports.
- Ensure that an appropriate response to pollution incidents is initiated on a timely basis.
- Provide initial response capabilities throughout the region.
- Monitor response and clean-up priorities when polluter has accepted responsibility.
- Ensure international commitments in spill preparedness and response are fulfilled.
- Provide a pollution response capability for lightering, salvage and offshore recovery operations.
- Provide Regional and HQ briefings on status of emergency operations.
- Evaluate, acquire and maintain specialized marine emergency countermeasures equipment and develop deployment techniques.
- Develop, distribute and maintain the *Central and Arctic Regional Response Plan* of the *Canadian Coast Guard National Response Strategy* (including area annexes) on behalf of Fisheries and Oceans.
- Review and comment on other government as well as industry pollution response plans upon request.
- Provide pollution response related training to Canadian Coast Guard and civilian personnel.

- Conduct spill response exercises according to the Canadian Coast Guard National Exercise Program (NEP) standards.
- Provide detailed explanations of response operations and policies to representatives of the media, interest groups, industry, police and Provincial and Municipal governments.
- Provide a centre of expertise for pollution concerns.
- Develop and foster a good working relationship with other authorities, shipping and oil/chemical handling communities.
- Working with Environmental Response Headquarters and the Chemical Industry to develop, implement and maintain a corresponding and complimentary regional capability for spills of hazardous and noxious substances other than oil.

3.3 Internal Partners – Fisheries and Oceans

Other branches and directorates within Fisheries and Oceans which directly and in a continuous active way support preparedness and response activities include:

Marine Traffic and Communications Branch (MTCS) – CCG/Marine Programs Directorate

Marine Traffic and Communications Services operates a marine VHF/MF/HF communications system (depending on location) primarily for the provision of marine safety information, distress coordination and marine traffic regulation. MCTS will support Environmental Response (ER) activities by:

- Establishment of Movement Restriction Areas (MRA's) or exclusion zones as directed by the Federal Monitoring Officer (FMO) or On Scene Commander (OSC).
- Providing communications/radio equipment operators in support of off-site ER operations.
- Dissemination of marine information and issuing marine Notices to Shipping (NOTSHIPS).
- Providing vessel tombstone information including, but not limited to, vessel name, call sign, nationality, tonnage, dangerous cargo type and quantity.

Regional Operations Centre (ROC) and Fleet Resources – CCG/Operational Services Directorate

Regional Operations Centre

The ROC provides notification to the Environmental Response Duty Officer (ERDO) when notified of a spill or an occurrence which may result in a spill. Upon receiving information regarding a spill, the ROC confirms the report using reliable resources and agencies. When the incident has been confirmed the Operation Centre begins the alerting and notification procedure. A schedule of ERDOs, approved by the Superintendent Environmental Response Canadian Coast Guard, will be maintained by the ER Regional Emergency Operations Officer (REOO) and forwarded to ROC for distribution.

The Regional Operations Centre will support the Environmental Response Branch during a marine pollution incident by:

- Maintaining up to update contact lists for Canadian Coast Guard and other government agencies for use as incidents progress.
- Coordinating the allocation of CCG resources as required by the FMO or the OSC to respond to a marine pollution incident.
- Provide communications support (when necessary).

Fleet Resources

Fleet Resources may be called upon to provide a host of support and/or lead services depending upon the type and severity of the situation and limitations or constraints of the vessel. Commanding Officers maintain full responsibility for the operation and safety of their vessel and personnel and therefore, will/may:

- Be called upon to be interim On-scene Commander.
- Be the principal point of contact aboard ship for the Environmental Response Duty Officer or On Scene Commander.
- Investigate spill reports for the purpose of confirmation.
- Provide surveillance and monitoring of third party (or pollutant) as required.
- Initiate early spill response; containment, boom or sorbent material deployment, clean up and recovery procedures.
- Provide site safety, (i.e. fire fighting, first aid and crowd control).

Fleet does maintain their own limited capabilities to respond to their needs as required.

Canadian Coast Guard Bases

In preparation for and during a pollution incident, CCG bases may also provide resources for response. These resources are generally within the scope of normal base activities and include:

- Small vessel use
- Base facilities (boardrooms, workshops)
- Helicopter landing pads
- Boat launch and docking slips
- Staging areas

Safety, Security and Emergency Services Branch – DFO Corporate Services

For large spills of a significant nature the Regional Manager of Safety, Security & Emergency Services may provide the following:

- Advice and recommendations to the On Scene Commander on issues of site and employee safety and the application of departmental security policy measures.
- General occupational health & safety and security advice to the On-Scene Commander/Deputy On-Scene Commander as per the departmental Loss Control Manual.

- A Health & Safety Officer to perform the functions of the Heath & Safety Officer described in the Response Management System User Guide. This person will report directly to the OSC or FMO throughout the duration of the response.

On occasions when the Regional Manager of Safety & Security (or delegate) is not available, or when spills are of a minor nature, the On-Scene Commander shall appoint a member of the response team to fulfill the general duties required.

Communications Branch – DFO Communications
Communications team manages the media (external) handling inquiries from print, radio, television and internet news organizations through the application of *Fisheries & Oceans Crisis Communications Plan*. Communications branch coordinates all aspects of information being released to ensure the public is getting the most relevant, accurate information as soon as practicable.

Legal Services
The DFO Legal Services in CCG Headquarters section will provide legal advice and guidance in the event of a marine pollution incident where CCG may or has been engaged. This especially includes advice on the issuance of Letters of Undertaking (LOUs) and in situations where Canadian Coast Guard may have to take command and control of an incident away from the Polluter.

Other DFO Resources
Indirectly, but just as significant in the event of a spill, is the availability of other DFO resources. This includes any and all appropriate functions including, but not limited to the following:

- Trenton Joint Rescue Coordination Centre – CCG, Maritime Services Directorate, Search and Rescue Branch (SAR)
- Finance and Administration – Human Resources and Corporate Services Directorate
- Human Resources - Human Resources and Corporate Services Directorate
- Facilities – Real Property
- Other Technical Resources – CCG, Integrated Technical Services Directorate
- Fish Habitat Branch – Habitat Fisheries and Oceans Management

3.4 Internal Partners – Other Government Departments

Other federal departments which provide direct assistance or have specific mandates which directly affect response activities include:

Environment Canada (EC)
There are two (3) Environment Canada regions located within Central & Arctic region. They are Ontario, Prairie and Northern and Pacific and Yukon Regions.

The Environmental Emergencies Section provides:

- In Ontario, the Co-chair (with the Ontario Ministry of the Environment (MOE)) of the Regional Environmental Emergencies Team (REET).
- In the Arctic (consisting of the three Territories), the Co-chair (with the relevant Territorial Government, Department of Environment) for the Arctic Regional Environmental Emergencies Team.
- Coordination of the Shoreline Cleanup and Assessment Teams (SCAT).
- Advice concerning environmental impacts associated with vessel source spills, resource sensitivity and prioritization, environmental forecasting, spill and cleanup monitoring and clean up techniques and priorities
- Sampling assistance, identification and characterization of materials

The REET serves as a mechanism for the provision of consolidated, coordinated and comprehensive environmental information and advice concerning the fate and effects of hazardous and noxious substances, spill trajectories, resources and shoreline protection strategies, clean up priorities, physical and chemical counter measures, remedial endpoints, damage assessment, and the management of hazardous wastes generated during a spill and other matters which arise while planning and responding to emergency events which affect or risk environmental quality. In the planning mode REET members meet to improve contingency plans, resolve regional preparedness issues and exchange new scientific and response ideas.

In Ontario Region, Environment Canada has divided the province into eighteen (18) REET areas and plans to hold one (1) REET meeting per area per year, consolidating some areas where possible and maintaining annual meetings in the higher risk areas (Windsor, Sarnia, Sault Ste. Marie).

Two of three primary Arctic REET (AREET) areas are in Prairie and Northern Region: the Northwest Territories and Nunavut Territory. There is no REET established in Alberta, Saskatchewan and Manitoba.

The Meteorological Service of Canada (part of EC and REET) provides:

- Meteorological forecasting

The Canadian Wildlife Service (part of EC and REET) provides

- Advice on wildlife protection, rescue and rehabilitation
- Permits for wildlife hazing and capture

Transport Canada (TC)

The Environmental Response Systems Division in Ottawa is responsible for Canada's Marine Oil Spill Preparedness and Response Regime. It:

- works with other federal agencies and departments, such as Fisheries and Oceans Canada, the Canadian Coast Guard and Environment Canada to establish guidelines and regulatory framework for preparedness and response to oil spills and spills of noxious and hazardous substances into Canada's marine environment.

- Manages the National Aerial Surveillance Program

There are two Transport Canada regions located within Central & Arctic region. They are Ontario and Prairie and Northern regions.

The Aircraft Services Directorate provides:

- Aerial surveillance as part of the Prevention mandate within Transport Canada, and can provide aerial spill tracking, recording, and personnel transport.

The Marine Safety Branch provides:

- Technical advice and recommendations to the On-Scene Commander or the Ship Owner regarding, but not limited to, lightering, damage assessment and salvage.

  Note: The MOU between Transport Canada and Fisheries & Oceans Respecting Marine Transportation Safety & Environmental Protection (May 1996) Annex D – E-5 states that "Transport Canada and Fisheries and Oceans will jointly approve salvage operations, emergency lightering or discharge of cargo." After discussing this clause with two senior surveyors, they both agree – Marine Safety does not approve salvage plans. Marine Safety advises and recommends only.
- Restriction of transit or movement of a vessel following a damage assessment.
- Spill investigation and enforcement of the various aspects of the pollution prevention conventions and legislation in Canada
- Regional planning, in conjunction with EC and CCG, for the selection of Places of Refuge. Note: in the Great Lakes and connecting channels, selection of a place of refuge will be determined in conjunction with the USCG and USEPA.
- Monitoring of the spill preparedness activities of Oil Handling Facilities (OHFs) and certified Response Organizations (ROs) through a review and audit process.

Indian and Northern Affairs Canada (INAC)

Canadian Coast Guard (CCG) works most closely with INAC in Nunavut (NU) and the Northwest Territories (NT). INAC has lead responsibilities in the Arctic for spills on water which do not originate at federal facilities, exploration facilities or from ships and barges. INAC also, by letter of agreement, will investigate ship-source spills on behalf of CCG. INAC is also a member of the Beaufort Sea Emergency Preparedness Working Group, along with CCG/DFO, EC, TC and other appropriate agencies.

National Energy Board (NEB)

Based in Calgary, Alberta, the National Energy Board is an independent Agency that reports to parliament through the Ministry of Natural Resources. The NEB is the

Lead Agency for spills that occur at offshore and nearshore oil and gas exploration and production facilities.

In the event of a marine pollution incident where CCG is requested for assistance as a resource agency, CCG is available to provide pollution response expertise as indicated under Section 7.2 of the *National Response Plan* as it relates to NEB.

Public Safety Canada

Public Safety Canada is the federal coordinating department responsible for engaging relevant federal departments in an integrated Government of Canada response to an emergency.

For emergencies requiring an integrated Government of Canada response, federal support is based on a regional "single- window" concept. This concept is intended to facilitate regional interdepartmental and intergovernmental coordination, while not unduly restricting operations. Coordination includes sharing of pertinent information in order to maintain situational awareness.

The Government Operations Centre (GOC) is a 24/7facility where an integrated Government of Canada response is managed. It is the focal point of information management flow and provides strategic-level activities. It's permanent staff includes watch officers, duty officers specializing in national communications as well as a geomatics team to map incidents.

Indirect support from other federal departments in the form of advice or resources also comes from: Heritage Canada (Parks Service) in the form of support to REET, National Defense regarding assistance and resources, RCMP with respect to investigations and those sections or departments specifically identified in the various Memorandums of Understanding (MOU) as outlined in Section 2 of this chapter.

3.5 External Partners - Provincial and Territorial Ministries and Departments

In general, liaison with provincial and territorial concerns is facilitated through REET (Regional Environmental Emergencies Team), which is chaired by Environment Canada (EC) or, in the case of the Province of Ontario, is co-chaired by Environment Canada and the Ontario Ministry of the Environment (MOE). The following agencies have the primary mandate for marine or freshwater pollution response in their province or territory of jurisdiction:

Territory or Province	Department
Northwest Territories	Environment and Natural Resources
Nunavut	Department of Environment
Alberta	Alberta Environment
Saskatchewan	Saskatchewan Environment

Manitoba	Manitoba Conservation
Ontario	Ontario Ministry of the Environment

In emergency situations conflicts sometimes arise with respect to legal and administrative jurisdiction and application of standards and common practices. To facilitate these issues the various Ministries related to emergency measures are usually contacted to provide coordination and clarify where necessary the concerns. These include:

- Government of Nunavut – Department of Community of Government Services, Emergency Management Division
- Government of the Northwest Territories – Department of Municipal and Community Affairs – Emergency Services Division
- Government of the Yukon Territories – Department of Community Services, Emergency Measures Organization
- Government of Ontario - Ministry of the Community Safety & Correctional Service, Emergency Measures Ontario
- Government of Manitoba –Manitoba Emergency Measures Organization
- Government of Saskatchewan – Resource Management and Corrections & Public Safety, Saskatchewan Emergency Measures Organization
- Government of Alberta – Ministry of Municipal Affairs, Public Safety Division, Emergency Management Alberta

Provincial Governments can provide consolidated access to local, municipal and provincial resources.

Central & Arctic Region recognizes that First Nations have a vested interest in response operations that may occur in their territory and will ensure that they are represented on the REET or have access to the Federal Monitoring Officer or On Scene Commander through the CCG Liaison Officer.

3.6 Clients

With respect to ship-source pollution incidents, there are three major groups the Canadian Coast Guard will be directly engaged with. These are Oil Handling Facilities, Legislated Ships and Ships as defined in *Part XV* of the *Canada Shipping Act.*

Oil Handling Facilities (OHF)

Operators of facilities that transfer oil to or from oil tankers over 150 gross registered tonnes or other vessels over 400 gross registered tonnes are required by the Canada Shipping Act (2001) to:

- Have an Oil Pollution Emergency Plan (OPEP) on site.
- Have a declaration conforming to the regulations on site.
- Take reasonable measures to implement their required oil pollution emergency plan in the event of an oil pollution incident.

- Have on site the resources required to contain a spill of oil equal to the facility's rated capability within one hour.
- Begin recovery/cleanup operations of oil equal to the facility's rated capability within 6 hours.
- Have an arrangement with a certified Response Organization (RO) that permits the handling of spills beyond the rated capabilities of the Oil Handling Facility.[1]

Legislated Ships

In Canadian waters, ships over 400 gross registered tonnes and oil tankers over 150 gross registered tonnes are required to have a Shipboard Oil Pollution Emergency Plan (SOPEP) and an arrangement with a certified Response Organization (RO) to respond to an oil pollution incident of an amount equivalent to the maximum amount of product that the vessel can carry as fuel and/or as cargo up to a maximum of 10,000 tonnes.[1]

Other ships as defined by Part XV of the Canada Shipping Act (CSA)

Any ship that is less than 400 GRT or any tanker less than 150 GRT is still covered by the *Canada Shipping Act (2001)* in that it must report the potential or actual pollution incident to a Pollution Response Officer, or in the case of an incident in Canadian Arctic Waters as defined by the Arctic Waters Pollution Prevention Act to a Pollution Prevention Officer. The ship must take immediate steps to mitigate or remedy the situation. These ships are not required to have a Shipboard Oil Pollution Emergency Plan nor an arrangement with a certified Response Organization.

3.7 External Resources

There are two main categories of external resources that the Canadian Coast Guard (CCG) will engage. These are the Response Organizations certified by Transport Canada under the *Canada Shipping Act (2001)* and other contractors.

Response Organizations (ROs)

Response Organizations are privately established pollution response companies certified by Transport Canada. These companies hold a certificate of designation to handle oil spills of up to 10,000 tonnes (T). Response Organizations can provide the polluter or any lead agency with the resources, trained personnel and operational management structure to deal with a marine oil pollution incident within its identified Geographical Area of Response (GAR).

The Eastern Canada Response Corporation (ECRC) is the only certified response organization in Central & Arctic Region. The company is certified to ten thousand tonnes (10 000T) and two of its three regions cover Central & Arctic Region.

[1] There is no requirement for an Oil Handling Facility nor a Legislated Ship to have an arrangement with a Response Organization certified by Transport Canada in Canadian waters north of 60° North Latitude

1) ECRC Great Lakes Region is managed from the Response Centre in Corunna, Ontario. Its area of coverage includes all waters
   - south of 60 degrees north in the provinces of Alberta, Saskatchewan, Manitoba and Ontario to that portion of the St. Lawrence River in the Province of Ontario
   - to a line drawn between Butternut Bay (Latitude 44 31' 12" north and Longitude 75 46' 54" west) on the Canadian side
   - to Oak Point (Latitude 44 30' 48" north and Longitude 75 45' 20" west) on the US side of the St. Lawrence River.

2) ECRC Quebec Region (also known as Societé d'Intervention Maritime Est du Canada - SIMEC) is managed from the Response Centre in Quebec City, Quebec and has staffed Response Centres in Verchères, Quebec and in Sept-Iles, Quebec. Their coverage includes:
   - James Bay, Ungava Bay and in Hudson Bay south of the sixtieth parallel North and that portion of the St. Lawrence River in the Province of Ontario
   - to a line drawn between Butternut Bay (Latitude 44 31' 12" North and Longitude 75 46' 54" West) on the Canadian side to Oak Point (Latitude 44 30' 48" north and Longitude 75 45' 20" West) on the US side of the St. Lawrence River.

There are no certified response organizations established north of 60° N latitude.

Although resources from the Response Organizations in the south may be made available for use north of 60°, they must obtain the necessary approvals to move equipment from their designated area of response.

Contractors

Private sector contractors may be engaged by the CCG as required. All standard government contracting rules apply.

Section 4 – PREPAREDNESS

4.1 Overview

Oil spill preparedness is defined by the advanced planning used to create systems to effectively and efficiently combat the range of spills likely to be encountered.

In Central and Arctic Region, preparedness involves:

- The development of regional procedures to be followed in the event of an incident, coordinated by the Planning section.
- The implementation, training and maintenance of the Response Management System (RMS) to manage and combat the incident.
- The identification of priorities, development of strategies, logistics and tactics necessary to fulfill those priorities, lead by the Planning section.
- The liaising with internal and external partners, clients and resources that may be involved in pollution response activities, lead by the Planning section.
- The training and continued maintenance and upgrading of skills, coordinated through the Training specialist.
- The exercising and quality assurance activities required to continuously reinforce the training and contingency planning activities, facilitated through the Exercise specialist.
- The asset management including the acquisition, lifecycle maintenance, operational readiness and storage of equipment lead by the Operations section and Inventory specialist.
- The integration of other Canadian Coast Guard Assets and Human Resources, when necessary, through the Training and Exercising processes.

The Memorandum of Understanding (MOU) between the Director General/Maritime Services (MS) and the Director General/Integrated Technical Support (ITS) of the Canadian Coast Guard (March 2004) specifies that the ITS Directorate will be the single CCG focus for the life cycle management of all CCG physical assets and for the development of all technical solutions. It is unknown when ITS will assume the services of design, procurement, in-service support and disposal of all equipment and systems required to satisfy ER's mandate. In the interim, ER will remain the focal point.

4.2 Response Management System (RMS)

The Canadian Coast Guard uses the Response Management System (RMS) as its emergency management system. It is based on, and operates under the same principles as the Incident Command System (ICS) which was developed in the U.S. to coordinate multi-agency responses to large forest fires. The system was adjusted to reflect the current marine oil spill response regime and Canadian law. The Canadian Coast Guard does not implement the ICS principle of unified command, but will participate in any command structure used by the Polluter or Other Lead Agency.

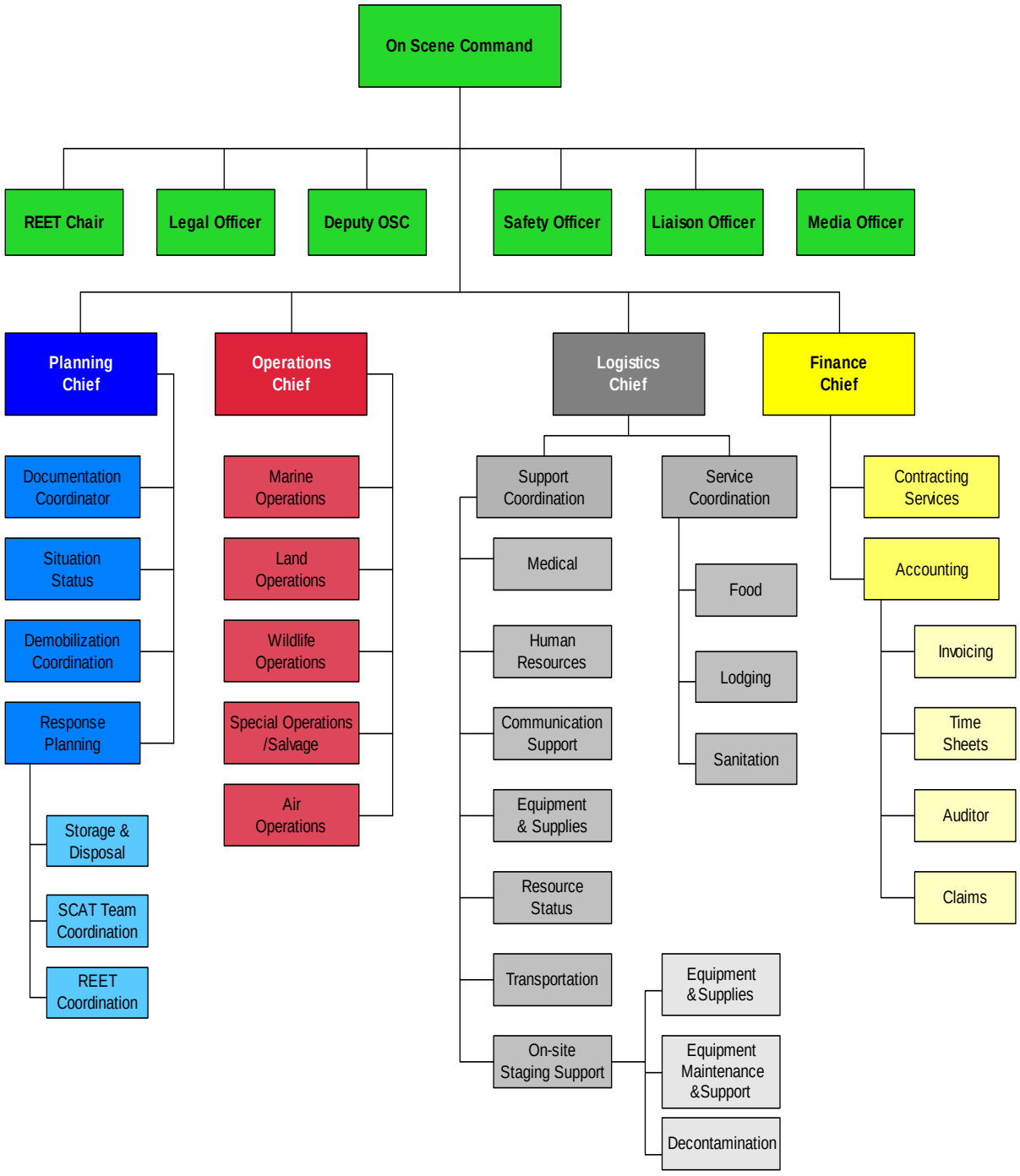
The RMS uses a “management by objectives” approach. It outlines the roles and responsibilities of individual positions, identifies the reporting structure, establishes a common set of terminology and uses standardized forms and paperwork. The central document in the RMS process is the Incident Action Plan, which documents the existing conditions and outlines objectives and strategies for recovery and response.

The system structure is designed to expand or contract to best fit the specific circumstances of the incident. Not all positions within the system will be staffed for every incident; in those cases the supervising position shall be responsible for all subordinate tasks/roles. Regional staff members have been designated as members of the Regional Response Team and may be called upon to fill specified roles in this management system (see Figure 4.1 for a fully expanded system design).

The system also contains management tools that can be used by the On Scene Commander and response personnel to better manage the system and the spill incident. These tools include a field operations guidebook, forms, reports, established meeting schedules and agendas. The RMS will also be used by the Federal Monitoring Officer and their Incident Monitoring Team while monitoring the Polluter’s response to an incident.

The detailed RMS process is contained in a separate document referenced in Section 9.1 of this plan (Response Management Systems User’s Guide, Version 3.0 (May 2006)).

Figure 4.1 - CCG RMS Command Structure



4.3 Planning

Area Plans

To facilitate an effective and efficient response, Canadian Coast Guard administers 16 area plans as an annex to the Central & Arctic Regional Response Plan. They are Keewatin, Baffin, Beaufort Sea & Amundsen Gulf, Great Slave Lake, Hudson & James Bay, Kitikmeot, Mackenzie River & Delta, Inland Waters S of 60, Lake Erie, Lake Huron, Lake of the Woods, Lake Ontario, Lake Superior, St. Lawrence, St. Mary's and St. Clair & Detroit areas. These plans incorporate detailed response information for specific manageable geographic areas or response communities. The normal operating period for an area plan is the first 12-24 hours of a spill response.

They are developed and maintained as follows:

1) Risk Analysis
   The risk analysis determines which communities or areas are most likely to be endangered by a potential oil spill and why, their associated environmental sensitivities, plus the typical type of spill that could be expected. When considering the environmental sensitivities, the focus is on what is most likely to be impacted and to consider as many factors as are applicable. A single factor discovered in the risk assessment is just one of many layers in the decision to make a site a priority.

2) Priority Identification/Verification
   Current priorities are discussed with members of the Regional Environmental Emergencies Team (REET) at planning meetings. It provides the opportunity for additions, deletions or modifications. Where there are no REET meetings held, community consultations are organized by the Planning section.

3) Strategy and Tactics Development
   Canadian Coast Guard determines RMS objectives for the agreed upon priorities. Strategies are designed, that name the activities relative to those objectives. Those activities may be response actions to be implemented, or may be the type of resources that could be affected by the spill. For area plan development, tactics provide the detail for implementing the selected strategies. Tactics then specify the resources, both human and equipment, to facilitate, to install or to maintain the strategy.

4) Updating
   Area plans are reviewed and updated annually.

Regional Procedure Development

Regional procedures for notification, verification, activation and cost recovery of a response are all described in the *Central & Arctic Regional Response Plan* of the *Canadian Coast Guard National Response Plan*. Supporting documentation in the

form of Standard Operating Procedures and supplementary plans (e.g. Health & Safety Plan and Media Relations Plan) are not included in the Regional Response Plan but are referenced in Section 9.

Liaison with External and Internal Partners, Clients and Resources

To ensure that all partners, clients and resources are aware of the Canadian Coast Guard's mandate and responsibilities as they pertain to pollution preparedness and response, the Environmental Response Planning Section takes the initiative to:

- Work with Internal Partners within Fisheries & Oceans to communicate the branch's needs in the event of a pollution incident.

  Exception: Coordination of the Duty Officer (DO) function between Environmental Response (ER) and the Regional Operations Centre (ROC) is coordinated by the Regional Emergency Operations Officer REOO).
- Work with other government departments that have a mandate for pollution response within their jurisdiction to communicate the role that Canadian Coast Guard plays in marine and freshwater pollution incidents and to share what resources Canadian Coast Guard maintains for pollution response activities and the mechanism to access these resources in the event that another Lead Agency may require them for a non-CCG mandated spill or other type of emergency.
- Liaise with potential clients (oil handling facilities, shipping companies and other operators) so that CCG expectations in the event of an incident are understood.
- Provide copies of area plans to CCG vessels that are relevant to their area of operations. CCG ER will brief Operations at the pre and post season conferences on any changes to the plans and/or to the captain and/or crew's responsibilities.
- Maintain a network of contractors that can provide services to Canadian Coast Guard in the event of a pollution incident that exceeds the resource capability of the region.
- Upon request of the Regional Advisory Councils (RACs) or Secretariat (Transport Canada) on Marine Oil Spill Response, provide information on Central & Arctic Region's preparedness and spill response activities.

Arctic Community Emergency Plans

The Canadian Coast Guard is committed to assisting Arctic communities in the development of the marine pollution component of their Community Emergency Plans. This commitment was made in 1999 when the CCG Arctic Response Strategy (ARS) was published. The Arctic Response Strategy has since been re-assessed and viable components have been incorporated into the text of this Plan.

4.4 Training Program and Curriculum

Introduction

The Training Curriculum of the Environmental Response Branch is focused on providing the necessary skills and knowledge for responders to function effectively during a spill response operation. As the competencies required for an effective spill response are described and organized within the Response Management System (RMS), so too can the training curriculum be described in the context of RMS.

With RMS as the framework for spill response, all response team members will be trained in theory and application of RMS. The level of training complexity will vary by level of individual responsibility, but all members will have fundamental knowledge of the structure and processes that drive the RMS.

In addition to the training curriculum described in this section, it is understood that there are competencies and certifications required that are not specific to ER or spill response. These would include driver's licenses, radio operator's licenses, and familiarity with basic electronic equipment such as phones, fax machines, cell phones and laptop computers.

Training Curriculum

Command Staff

During a spill response operation, the command staff will vary depending on the size and complexity of the spill.
On a smaller spill, senior ER staff members may be appointed to command positions with few subordinate or supporting positions.
On larger scale spills, the OSC may be the Director of Maritime Services, or Assistant Commissioner Canadian Coast Guard, with multiple support positions from ER staff, CG fleet, base personnel and contractors.

To adequately prepare personnel for the management functions of spill response, the following curriculum has been identified:

On Scene Command Course (OSC)
This course trains participants in all aspects of spill response including planning, implementation, and supervision. Other topics include legislation, legal issues, financial responsibilities, and media relations. Prerequisites include BOSRC, MSROC, PPO designation, media relations and management training.

Response Management System Course (RMS)
The current RMS curriculum is an introductory two-day course on the system and its user's guide. It is anticipated that future development will include multiple levels of training which will include organizational structure and

responsibilities, as well as in-depth requirements of each position within this emergency management structure.

Federal Monitoring Course (FMO) - Proposed
Subject to national development, this course will augment the On Scene Command Course to provide those persons designated as Canadian Coast Guard Federal Monitoring Officers the necessary skills and knowledge to perform FMO duties.

Operations Section

During a spill response operation, the operations section of the RMS may be populated by regional ER staff, CCG fleet officers and crew, CCG/DFO base personnel or contractors. The resident knowledge of this group will vary, and a comprehensive ER training program exists to train responders in spill response operations. Training for members of the CCG Regional Response Team (RRT) personnel is offered in the following three areas:

(a) Safety Training
(b) Operational Training
(c) Specialty Training

(a) Safety Training

Health and Safety training is required to ensure compliance with federal and provincial legislation with the ultimate goal of ensuring the health and safety of response personnel. Additional video and printed reference material is available through the Canadian Coast Guard ER Training Officer.

Site Safety Course
The Site Safety Course is designed for response personnel prior to commencing work on a response site. Topics include employer and employee responsibilities, classification and hazards of petroleum products, and the safety practices and considerations associated with both water-based and shore-based operations. Site safety training is mandatory for Regional Response Team members and all volunteers or short time workers who may be employed during a response.

Workplace Hazardous Materials Information System (WHMIS)
This 3-hour course is provided to Canadian Coast Guard employees to ensure compliance with appropriate worker safety legislation. It was developed to ensure workers have the necessary information to work safely with hazardous materials in their workplace.

First Aid/CPR
This 16 hour course provides the participants with the skills and knowledge to successfully obtain the St. John Ambulance Standard First Aid Certificate. The primary focus of this 14-hour course is to provide adequate knowledge

and level of skill to persons in positions of responsibility to provide for persons suffering from respiratory and circulatory arrest. Preventative measures are discussed.

Small Non-Pleasure Vessel Basic Safety Course - MED A3
The 8-hour MED A3 course is *required by regulation* for crewmembers of small non-pleasure vessels of not more than 150 GT operating not more than 20 miles offshore. Topics include marine hazards and emergencies, marine firefighting, lifesaving appliances and abandonment and survival and rescue skills.

Transportation of Dangerous Goods (TDG)
This 6-hour course provides personnel with the responsibility for the transportation of dangerous goods to be aware of and comply with safety measures and appropriate legislation concerning TDG.

(b) Operational Training
There are various levels of oil spill response courses designed for response team members, ships crews and other responders who may be expected to assist with marine oil spill response. Operational training related to the assessment and response to petroleum spills is delivered by ER while training for response to hazardous and noxious materials spills is obtained outside of the Branch.

First Responder Oil Spill Training (FROST)
This 1 day course is designed specifically for CCG personnel in Central & Arctic Region who are designated custodians of First Response Units (FRUs), and may be tasked with deployment of the pollution countermeasures equipment. It has also been adapted for use in communities north of 60° where Arctic Community packs function as first response units.
It teaches First Responders to:

- assess an oil spill according to its extent, possible source and likely behavior
- deploy boom for containment and protection purposes and in support of response activities
- work safely at the spill site

Basic Oil Spill Response Course (BOSRC)
This 20 hour course instructs First Responders how to:

- assess an oil spill according to its extent, possible source and likely behavior
- deploy boom for containment and protection purposes and in support of response activities
- operate oil recovery equipment
- undertake basic shoreline cleanup operations
- work safely at the spill site

Marine Spill Response Operations Course (MSROC)
This 40-hour course will enable trained and experienced personnel to coordinate and supervise the response operations of a marine oil spill. It is intended to train individuals to be On Scene Commander (OSC) for small (tier 1) spills, or operations section chief on larger spills. Topics include legislative framework, safety, equipment suites and strategies, media relations, RMS, shoreline assessment and cleanup techniques, and disposal. Prerequisites include BOSRC, a Radio Operator License and current or future deployment to a spill response team.

Environmental Response Duty Officer (ERDO) Training
This 15 hour course is a prerequisite for duty officers for the ER branch and the regional operations centre. It introduces the participant to CCG mandate, lead agency responsibilities and introductory spill assessment techniques. It also integrates delivery of training on the Marine Pollution Incident Reporting System (MPIRS), the database used to capture spill report and response information.

Pollution Response Officer (PRO) Training
This three day course is currently provided by the Environmental Response Branch of the Canadian Coast Guard and is required training for all Environmental Response personnel. Participants who successfully complete this course earn the designation of Pollution Response Officer under Part 8 of the Canada Shipping Act (2001). This course examines the powers of a PRO, specific procedures related to vessel directions and detentions and the legal framework and implications surrounding the execution of those powers. Course participants also learn sampling procedures and gain an understanding of the role of other government agencies involved in a marine pollution incident.

Pollution Prevention Officer (PPO) Training
This 40 hour course is currently provided by the Marine Safety Branch of Transport Canada. It is a prerequisite for any officer of the Canadian Coast Guard to be delegated Pollution Prevention Officer (PPO) powers under the *Arctic Waters Pollution Prevention Act*. Participants learn the existing pollution prevention and response regime, the powers of a PPO and the specific tasks of prevention, control, investigation and prosecution.

Small Vessel Operator Proficiency
This 21-hour course meets the training needs of the small vessel master. This course is required by regulation (for vessels less than 5GT on sheltered and near coastal voyages) and teaches participants to effectively manage safety of those on board, protect the vessel from damage and protect the marine environment.

Basic Barge Operator Training
This course was developed and is delivered by regional ER staff. Through both classroom and practical sessions, the course introduces participants to safe boating practices and procedures, rules of the road, collision regulations, load plans for pollution response vessels, safe deployment of oil spill response equipment and basic trailer towing and maneuvering.

Single Side Sweep System
The single side sweep is an equipment suite designed to allow one vessel to perform oil containment and recovery, and allow for temporary storage. This two day training session is provided to some ER staff and crews of Canadian Coast Guard vessels that can support this equipment. This training typically is conducted with crews who have previously completed BOSRC.

HAZMAT Awareness
This 6-hour course is intended for First Responders on the scene of a hazardous materials incident and shows how to assess the incident. Topics include; First Responder's role and responsibilities, scene safety, recognizing and identifying hazardous materials, incident management, and sources of assistance.

HAZMAT Technicians Level
This 40-hour course is designed for responders to releases or potential releases of hazardous substances. The focus is on recognizing and evaluating a hazardous materials incident, organizing the response team, protecting response personnel, identifying and using response resources, implementing basic control measures, decision-making, and protecting the public and environment. Emphasis is on hands-on use of equipment practically applying lecture information through exercises. Participants will wear fully encapsulating suits.
Prerequisite: Hazmat Awareness.

(c) Specialty Training
Specialty training includes training that only select members of the Regional Response Team (RRT) will have to apply.

Shoreline Clean up and Assessment (SCAT)
This 24-hour course covers how oil impacts the shoreline. Specific topics include shoreline types and effects of oil, wind, waves and ice on shorelines. Shoreline protection and cleanup methods are described in depth. Field exercises are conducted as part of the training.

Media Training
This 16-hour course is designed to provide participants with the skills and knowledge to communicate effectively and proficiently with various forms of media. Topics include; developing and disseminating incident information to

news media, incident personnel, other appropriate agencies and organizations.

Communications System Training
This 8 hours hands-on course provides participants with the knowledge and skills to provide communications in support of a spill response. Topics include; mobile telephone, fax, and intercom set up, preparing communication plans, and internal/external spill response communications.

Wildlife Rehabilitation
The capture and treatment of oiled wildlife is typically assigned to the trained experts at Canadian Wildlife Service (CWS). This CWS training is periodically made available to outside agencies, and some ER staff may participate to facilitate a better understanding of each others' role at the time of a spill.

Financial Management
This training is provided by the Public Service Commission (PSC) and teaches government spending and cost accounting principles. It is imperative that any response team member who may have to purchase assets or manage contracts be familiar with these practices and procedures.

Planning Section
During a spill response operation, the planning section of the RMS will likely be populated with ER staff whose substantive positions are as Planning Officers within the branch. Therefore, the planning skills and training required to effectively and efficiently perform these tasks should be resident within our branch staff.

Should additional personnel be required to fulfill these roles, they would require training in RMS, as well as Site Safety (as required by OSH regulation). The required planning skills and spill response knowledge may be acquired through various training or experience factors, and would be assessed prior to assignment on the response team. In addition to planning skills, preferred training might include SCAT, FROST and/or BOSRC, and MSROC.

Logistics Section
During a spill response operation, the logistics section of the RMS will likely be populated with ER staff whose substantive position involves the tracking of spill response equipment inventory and human resources within the region. Therefore, the skills and training required to efficiently and effectively perform the logistics function should be resident within our regional ER staff.

Should additional personnel be required to fulfill these roles, they would require training in RMS, as well as Site Safety (as required by OSH regulation). The required logistical skills may be acquired through various training or experience factors (knowledge of IRCMS and TMA, BOSRC training) and would be assessed prior to assignment on the response team.

Finance Section
During a spill response operation, the finance section of the RMS will likely be populated by regional finance staff whose substantive positions involve government expenditure and cost accounting knowledge and application. Therefore, the skills and knowledge required to effectively and efficiently perform the finance function should be resident within regional Canadian Coast Guard staff. These personnel will require RMS and Site Safety training prior to deployment on a spill response team.

Training Records
Records for personnel trained in spill response and/or emergency management are maintained by the Region.

4.5 Exercise Program

Introduction
Under the guidelines of the National Exercise Program (NEP), the Environmental Response Branch will implement a Regional Exercise Program. This program will be conducted over a three-year cycle. Coordination of the program will be the responsibility of the Regional Exercise Officer (RXO) of the Environmental Response Branch. Exercises will be designed and conducted in coordination with departmental staff, CCG base staff and CCG vessels on a regular basis. The purpose of the Regional Exercise Program is to validate environmental response training and regional emergency preparedness standards, policies and procedures.

Canadian Coast Guard will, through regional and area-specific exercising, ensure high priority initiatives such as exercising complex equipment (i.e. Lori Brush skimmers, sweep systems and command/communications facilities) are undertaken and will use industry and private sources of personnel where possible and/or appropriate.

Exercise Planning Matrix
The matrix below represents a typical three year exercising cycle followed by Canadian Coast Guard. The program cycle is designed to test all 17-response functions as outlined under NEP as well as including the different types of exercises. It includes internal, external (with other government departments as well as private sector organizations) and international exercises.

Table 4.1 *- Central & Arctic Region Exercise Matrix*

EXERCISE TYPE	YEAR1	YEAR2	YEAR3
Notification	**Quarterly**	**Quarterly**	**Quarterly**
Management	**2**	**2**	**2**
Operational drills	**3**	**3**	**3**
Combined Functional	**1**	**1**	**1**
Full Scale	**0**	**1**	**0**

Notification exercises will test the regional call-out system. Some of these exercises will be internal to the branch, some will be a full regional call-out to all CCG and DFO staff as well as to external resources (eg: freight contractors to check their availability to move Marine Emergency Response Trailers (MERTs) or First Response Units (FRUs).

Management exercises will focus on the development of the spill through the Response Management System (RMS).

Operational Drills will focus on equipment deployments in packages (i.e. a First Response Unit, NOFI V-Sweep).

Combined Functional exercises will be an equipment deployment (operational drill) with the goal of implementing a tactic designed in one of the Region's Area Plan Annexes.

A *Full Scale* exercise will incorporate a management-type exercise with the concurrent deployment of a spill countermeasure system (system = pollution containment, recovery, primary and secondary storage devices)

Exercising Partnership

Canadian Coast Guard will endeavor to participate, by request and on a situation by situation basis, in exercises lead by Oil Handling Facilities (OHFs), certified Response Organizations (ROs) and other government agencies throughout the Region.

Central and Arctic Region is a part of the Canadian Coast Guard response community and as such is also part of the International Response Community. Canadian Coast Guard's regional boundaries are in such close proximity with our United States neighboring response communities that joint exercising is a high priority. Specifically this region conducts joint exercises in the geographic areas of the Great Lakes and the Beaufort Sea with the United States Coast Guard's (USCG) (9^{th}) ninth (Great Lakes) and (17^{th}) seventeenth (Alaska) districts, respectively.

Exercise Evaluation and Shared Learnings

An important part of the National Exercise Program is the evaluation and use of subsequent findings. Four types of information can be learned from an exercise, all of which lead to improvement of overall response capability.

1) Contingency planning
2) Response techniques
3) Response training
4) Exercise program development

The primary sources of the information and learning will be the formal exercise evaluation report that is produced for every exercise by the evaluation team. This formal exercise report will follow the format laid out in Section 11 of the *Canadian Coast Guard National Exercise Program Planning and Evaluation Guide*.

4.6 Inventory Management, Maintenance and Infrastructure

Inventory Response Control Management System

To ensure that a nationally consistent and effective state of preparedness is maintained, an Inventory Response Control & Management System (IRCMS) has been implemented which utilizes The Management Authority database as its main tool. CCG HQ administers this system in concert with regional IRCMS Officers. In this region the program is administered by the Logistics and Statistics Officer in the Operations Section.

This system has been developed to:

- Maintain a real time record of the location and quantity of resources;
- Maintain a proper state of readiness through a pro-active approach using work orders and preventative maintenance;
- Assist in keeping response managers informed about Environmental Response's state of preparedness;
- Assist in the tracking of National Response Team personnel or equipment assigned to National or International incidents

Pre-positioned Equipment Caches and Depots

Central and Arctic Region covers an extremely large geographical and culturally diverse portion of Canada. There are, in essence, two zones of operation which are entrenched in the *Canada Shipping Act*. These are:

- the Arctic Zone, or all areas of Canadian jurisdiction north of 60^0 North Latitude; and
- the Central Zone, dominated in a marine transportation sense by the Great Lakes, but which include the southern portions of Hudson and James Bay, along with the major waterways and watersheds of Lake Winnipeg, Winnipegosis, Lake of the Woods, and Lake Athabasca.

The Environmental Response (ER) Branch has pre-positioned equipment to facilitate and maintain an effective response operation. Response strategies in each of the two zones (Central or Arctic) are based upon identification of local and regional response. This is means that the equipment generally required for such a spill size is contained within the Region. This capacity is supplemented by nationally available resources, which would be "cascaded" from/to other regions when and if required. Preparedness capacities in other regions are identified in their respective Regional Response Plans.

Arctic Zone

Arctic Community Packs (ACPs) are placed in northern communities for rapid (local) initial response. Canadian Coast Guard provides initial response training to members of the communities so that they may effectively deploy equipment in the ACPs in the event of a spill. Access (keys) for the ACPs have been given to an official in each community in most cases. The Senior Response Officer (ER-Hay River) maintains the current key holder listing.

The inventory for each Canadian Coast Guard Arctic Community Pack location is listed in Table 4-2. The program has received funding under the Health of the Oceans Initiative to proceed with placing Arctic Community Packs in additional sites. The equipment profiles at the existing Arctic Community Pack sites will be changed to reflect characteristics of the community. The inventory at all communities will be "site specific" and will coincide with response strategies designed by the ER planning group. The locations for the proposed additional Arctic Community Packs are: Baker Lake, Broughton Island (Qikiqtarjuaq), Chesterfield Inlet, Churchill, Hall Beach, Kimmirut, Iqaluit, Pangnirtung, Tuktoyaktuk and Yellowknife.

The main base of operations with Environmental Response dedicated personnel is located in Hay River, Northwest Territories. This base is home to a Rapid Air Transportable (RAT) cache of equipment known as the "RAT150". The RAT150T used in conjunction with the "Delta" (Δ) 1000T meets planning standards for a 1000 tonne (T) response. The selection of equipment for the RAT150 must meet pumping rates / capacities of 1000T thresholds and be complimentary[2] to the equipment held in the Δ1000T depots.

The response package, warehoused in Hay River, will be maintained in 100% readiness during the shipping season. The equipment will be broken down and be containerized such that it will fit through the smallest cargo door of any of the selected aircraft. Equipment will be TDG compliant, be palletized as appropriate, and labelled for ease of selection and loading.

[2] The logistics of moving large bulky items (ISO containers) in the arctic necessitates a LCM, deck barge, cargo vessel, icebreakers or any combination thereof. Consequently it is estimated that the 1000T design capacity would be available staged on-scene in 5 - 7 days. Following the doctrine *something sooner rather than everything later* having 150T of the 1000T equipment suite air-lifted within 48 hours is preferable to having nothing until the entire 1000T capacity arrives a week later.

Table 4-2 *- Canadian Coast Guard Arctic Community Pack Locations*

LOCATION	EQUIPMENT SUMMARY			
	Boom (24")	**Skimmers**	**Boats**	**Storage**
Arctic Bay (Ikpiarjuk)	3,650'	TDS-118	16' Aluminum	Open top Tank
Cambridge Bay (Ikaluktutiak)	1,350'	TDS-118	16' Aluminum	Open top Tank
Cape Dorset (Kinngait)	1500'	TDS-118	16' Aluminum	Open top Tank
Clyde River (Kangiqtugaapik)	4,500'	TDS-118	16' Aluminum	Open top Tank
Coppermine (Kugluktuk)	1,350'	TDS-118	16' Aluminum	Open top Tank
Coral Harbour (Salliq)	1,500'	TDS-118	16' Aluminum	Open top Tank
Gjoa Haven (Uqsuqtuuq)	1,350'	TDS-118	16' Aluminum	Open top Tank
Holman (Ulukhaktok)	1,500'	TDS-118	16' Aluminum	Open top Tank
Rankin Inlet (Kangiqsiniq)	2,200'	TDS-118	16' Aluminum	Open top Tank
Resolute (Qausuittuq)	1,350'	TDS-118	16' Aluminum	Open top Tank
Hay River FRU +	1,000'	-	37' Seatruck 42' Cutter	-

In combination with the RAT150T, equipment found in the ∆1000T depots will be at a 1000T capacity. Hence, the delta or "∆" is the difference between the RAT150T and a full 1000T. The ∆1000T depots will have containerized heavier equipment (not suitable for air transport to smaller communities) augmenting the RAT150T to a 1000T capacity, ready to be loaded on deck barge, Canadian Coast Guard icebreaker or freighter. While response personnel cascade in to the spill site pre-identified local, CCG base and available ER personnel will mobilize to the centres and load the equipment on suitable marine transport.

Three ∆1000T depots are strategically located in the northern communities of Tuktoyaktuk (NorthWest Territories), Iqaluit (Nunavut), and in Churchill (Manitoba). For the purposes of response in Central & Arctic Region, Churchill is included in the Arctic Zone of operations despite it being south of 60° North Latitude due to the similarities in response characteristics that it shares with locations north of 60° North Latitude.

Table 4-3 *- Canadian Coast Guard Arctic Design Inventory*[3]

PCM equipment	Description	Hay River RAT150T	Tuk Δ1000T	Iqaluit Δ1000T	Churchill Δ1000T
Skimmers	Light to medium product /disk type	3	1	1	1
	Heavy product /weir type	0	2	2	2
Boom	24" river type	0	10000'	10000'	10000'
	24" lay-flat type	5000'	0	0	0
Land storage	4T Open top tank	0	0	0	0
	8T Open top tank	7	3	3	3
	45T shore bladders	3	0	0	0
O/w storage	Total (in 5-25T Seaslugs)	50	250T	250T	250T
Pumps	2" low pres / volume style	4	1	1	1
	4" trash	5	1	1	1
	3" positive displacement	6	1	1	1
Vessels	"Car-topper" + 9.9hp	0	0	0	0
	Seatruck	0	2	2	2
	RAT RHI	2	0	0	0
Generators	5KW gas	7	2	2	2
Pressure washer	Larger hot water type	1	1	1	1
	Small cold water type	3	1	1	1
Incinerator	Sorbent	2	0	0	0
	Liquid waste	2	0	0	0

Central Zone

The Central zone is dominated by the Great Lakes and has well defined road transportation infrastructure.

Local / first response inventories have been established at all regional Canadian Coast Guard shore-side facilities that have fleet assets or a significant number of program vessels and that have operational personnel to deploy the equipment. Standardized inventory consists of a 20-24' trailer with a 1000' (nominal) of 24" boom and related accessories.

The 2500T Rapid Road Transportable cache is centred around the St. Mary's River and from time to time in major CCG facilities in Ontario. The response package warehoused in a series of 45' transport trailers will be maintained in 100% readiness during the shipping season. The primary purpose of the RRT 2500T system is significant containment of resources; shoreline, sheltered, and off-shore sweep and recovery ability; and staging and storage transfer area equipment.

[3] Inventories in Tuktoyaktuk and Iqaluit are at 95% completion. The Churchill Depot is at about 50% (pending the construction of a new and adequate facility) with the bulk of the inventory in storage at the Thundar Bay Coast Guard base. The RAT 150 needs an evaluation of the command and control component as well as storage for the second Saccke burner.

Table 4-4 *Canadian Coast Guard RRT 2500T Design Inventory*

PCM equipment	Description	BOOMERT #1-5 (each)	SKIMMERT #1 and #2[4]	Softside
Skimmers	Light to medium product/ disk type	-	3	
	Heavy product/ weir type	-	1	1
Boom	24" river type	4000'		
Sweep	36" Nofi V-sweep	-		1
Land storage	4T Open top tank	-	7	1
O/w storage	25T Towable bladders	-	4	4
Pumps	3" positive displacement	-	4	1
Generators	5KW gas	-	2	

Table 4-5 *Canadian Coast Guard locations for First Response Units (FRUs)*

Location	Relevant Area Plan(s)	Primary custodian	Secondary custodian
Amherstburg	Lake Erie/St. Clair-Detroit	SAR crew	ITS field services
Cobourg	Lake Ontario	SAR crew	
Gimli	Lake Winnipeg	SAR crew	
Goderich	Lake Huron	SAR crew	
Kenora	Lake of the Woods	ITS field services	
Kingston	Lake Ontario	SAR crew	
Meaford	Lake Huron	SAR crew	
Parry Sound	Lake Huron	ER personnel	ITS field services
Port Dover	Lake Erie	SAR crew	
Port Weller	Lake Ontario	SAR crew	
Prescott	St. Lawrence River	ER personnel	ITS field services
Selkirk	Lake Winnipeg	ITS field services	
Thunder Bay	Lake Superior	SAR crew	ITS field services
Tobermory	Lake Huron	SAR crew	
Hay River	Mackenzie River & Delta	ER personnel	ITS field services

[4] An additional SkimMERT is being added this year to accommodate additional hoses. The exact configuration of each SKIMMERT is not known yet so the inventories will remain listed together for this year.

Section 5 - RESPONSE OPERATIONS

5.1 Pattern of Response

Based upon the principles outlined in the *National Response Plan*, *(Sections 1.3, 1.5 & 4.4),* Central and Arctic Region assesses, notifies relevant parties, and initiates the tasking/deployment of necessary resources. This is based upon the determination of CCG's role as Lead or Resource Agency and the appropriate CCG Posture. The Duty Officer (DO) is tasked with this initial assessment, which is then verified by the Superintendent, Environmental Response. The appropriate response is activated by the Superintendent who in turn assigns an On-scene Commander (OSC) or Federal Monitoring Officer (FMO) and notifies Canadian Coast Guard (CCG) Management. Upon termination of the incident cost recovery actions are undertaken. To illustrate the generic process see Figure 5-1-Typical Sequence of Events and Table 5-1-Typical Functions Descriptions has been provided.

CCG Expectations of Ships for Response

In most instances when a spill occurs the initial report will trigger the mobilization of local response organizations. It is not normally practical for ship personnel to be directly involved in the clean up activities.

Small Spills

Ships are expected to take whatever actions listed in their Shipboard Oil Pollution Emergency Plan (SOPEP) that are reasonable and necessary to prevent the oil from escaping over the side and having done so, to take action to clean-up the oil contained on deck. Spilled oil should not be washed overboard, nor should degreasers or dispersants be used on spilled oil in the water. Once the oil is in the water, the ship's ability to respond in a practical manner is greatly reduced. It is Canadian Coast Guard's expectation that a response organization or other competent contractor be called upon to provide operational response capability at the discretion of the Polluter.

Where there is no availability of local response contractors or where there is a delay in response activation, the Master of the vessel should consider the use of available materials to contain and clean up the spilled oil by, for example, using ship-stocked absorbent material or utilizing mooring ropes or air filled hoses as makeshift booms.

Large Spills

The ship is restricted as to what action it can take to respond to a major spill. In the case of a casualty the safety of the ship and crew take priority. Therefore the ship's actions will be limited to reporting the incident details

to the appropriate authorities and to ensure that a response is initiated. In large spills it is Canadian Coast Guard's expectation that the Polluter appoint an On-Scene Commander (OSC) which may be a representative of the company that owns the ship or the ship's insurer.

Canadian Coast Guard needs to be kept informed as to the escalating response costs accrued by the Polluter during a response in order to prepare for the possibility that the Polluter will cease their response activities once their Limit of Liability is reached.

CCG expectations of Oil Handling Facilities (OHF) for Response

In most instances when a spill occurs, the initial report will trigger the mobilization of the facility response team. It is normal, in most cases, for the oil handling facility personnel to be the initial responders when a spill occurs.

Small Spills

For the purpose of this plan, a small spill will be defined based on the maximum oil transfer rate of the oil handling facility (i.e. what Level it is assigned under the *Canada Shipping Act, 2001),* which directly links to the minimum spill size to which it must be prepared to respond to within one hour. Oil handling facilities are required to have the resources on site to contain a spill of a minimum size within one hour and have the resources required to recover, or where the oil cannot be recovered the resources to control a spill of a minimum spill size within six hours. Response organizations may be called upon to provide additional operational response capability at the discretion of the Polluter.

Large Spills

For the purposes of this plan, any spill above the facility's minimum spill size will be characterized as a large spill. Oil handling facility personnel are still expected to deploy their on-site equipment. Response organizations will likely be called upon to provide additional operational response capability at the discretion of the Polluter.

***Figure 5-**1 - Pattern of Response – Typical Sequence of Events*

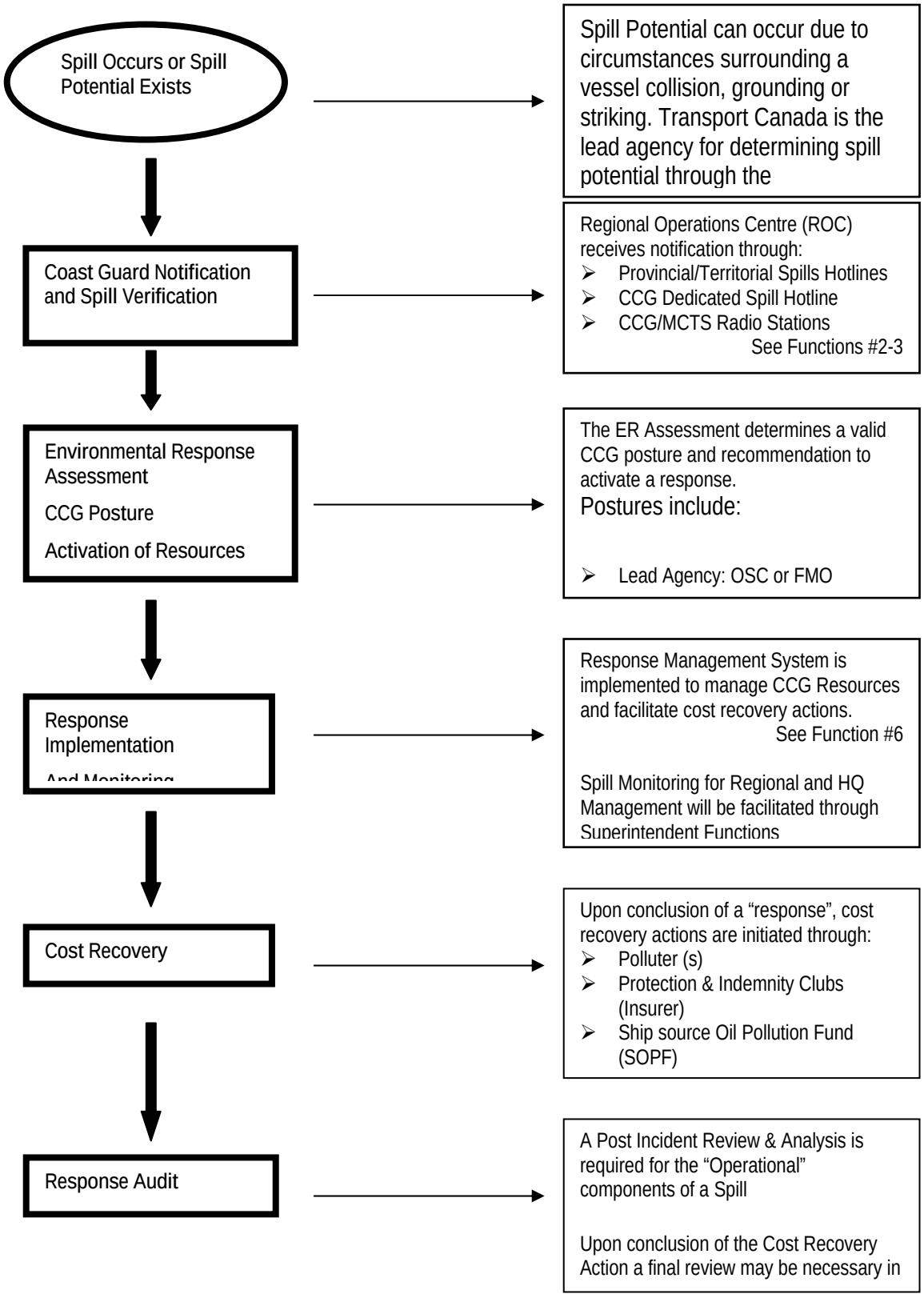


Table 5-1 *- Pattern of Response – Function Descriptions*

Function		***Description***
1	**Responsible Party/Third Party Functions** *(Spill occurs or sufficient potential risk exists)*	• Spill is sighted/reported. Spill reports originate from source (to regulatory body) or by third party (to various emergency or dedicated pollution hotlines) • Transport Canada is responsible for determining potential risk
2	**Spills Hotline Functions** *(Canadian Coast Guard Notification)*	• Assessment for dissemination • Dissemination (fan out according to applicable procedures) to relevant parties, calls from other spill hotlines are received by CCG-ROC.
3	**CCG-ROC Duty Officer Functions** *(Canadian Coast Guard Spill Verification)*	• Spill Assessment-pollution verification ➢ Mandate Confirmation ➢ Pollution Verification ➢ Source Credibility • Notification to ERDO • Dissemination • Initiation of MPIRS
4	**ER Duty Officer Functions** *(Environmental Response Assessment – CCG Posture)*	• Spill Assessment-response analysis • Source Control/Mitigation • Safety Issues • Tactical & Logistical Issues • Recommendation to Superintendent of likely Response Posture • Documentation – MPIRS
5	**Superintendent Functions** *(Environmental Response Assessment – Activation of CCG Resources)*	• Response Posture Evaluation ➢ Potential Risk to CCG Personnel and Equipment ➢ Propriety of request ➢ International Implications • Identification of OSC/FMO • Obtain an Order-In-Council (Arctic) • Obtain a Finance Code & Regional File Number • Notification of Senior Management and ongoing monitoring • MPIRS documentation • Obtain AC CCG sign off on MPIRS situation report
6	**OSC/FMO Functions** *(Response Implementation*	• Management or monitoring of response using the Response Management System (RMS). Escalation or de-escalation in accordance with needs of the incident. • Consolidation of all documentation upon conclusion of the response for Cost Recovery purposes. • Coordinate final debrief to facilitate future improvements to the systems and processes in place.
7	**Chief Financial Officer Function** *(Cost Recovery)*	• Utilizing CCG Ship-source and Marine Pollution Response Costing Principles and Documentation Standards (DFO 6332) compile pollution response costs recovery claim.

8.	**Internal** **Review Team Functions** *(Audit)*	• Utilizing the National Exercise Program Planning and Evaluation Guide, a Team is selected to complete the Post-Incident Review of an incident. • Improvements & corrective actions are to be documented

5.2 Spill Potential or Pollution Risk Assessment

Given an actual spill (i.e. pollutant in the water), the activities specified in this plan are rather obvious. However, in the event of vessel grounding, striking or collision that does not immediately result in a release, the responsibility for determining the risk of pollution rests with a Pollution Prevention Officer (PPO) within the Marine Safety (MS) branch of Transport Canada (TC). Should TC-MS be unable to make that determination, the Canadian Coast Guard (CCG), Environmental Response Duty Officer (ERDO) will complete that requirement. In some cases this may involve engaging a marine architect as no accredited expertise for vessel stability assessment resides within the ER section.

For all other areas where Canadian Coast Guard is the Lead Agency, this activity shall be considered the responsibility of the Canadian Coast Guard, Environmental Response Duty Officer.

5.3 Notification

To facilitate the notification of Canadian Coast Guard, and in addition to the existing Marine Communications system, a series of call-out or “Spill Hotline” agreements with the Province of Ontario, Nunavut and Northwest Territories and other Federal Departments within the Region have been implemented.

In addition, Central and Arctic Region, provides a 24 hr public access spills hotline:

24 hour toll free - Spills Hotline:
1-800-265-0237

Notification may occur through various mechanisms, depending upon the manner in which the spill (incident) occurs.

5.4 Verification

In all cases, spill information is initially processed and verified through the Regional Operations Centre (ROC) located in Sarnia, Ontario (See Section 3.3 – Organization). The ROC Officer on duty:

1. Determines whether the pollution is within Canadian Coast Guard’s mandate as Lead Agency or as a potential Resource Agency
2. Establishes the credibility of the source

3. Identifies the following:
    - Incident name (nature of incident)
    - Time of call (local / UTC)
    - Time of spill (local/UTC) *(if available)*
    - Reported by / call back particulars
    - Source determination
    - Incident background and description of clean-up activities (if any)
    - On-scene environmental/atmospheric conditions
    - Pollutant type and quantity
    - Verifying party contact information (as applicable)
4. Initiates an MPIRS entry for the following cases:
    - Originally pursuing verification as Canadian Coast Guard mandate but additional information about source changes lead to another agency
    - Canadian Coast Guard mandate and verified no pollution
    - Canadian Coast Guard mandate and verified pollution
    - Likely to impact on / impacting on foreign waters
    - Significant impact on region, though not falling under Canadian Coast Guard mandate.
    - Request for Canadian Coast Guard as a resource agency.
5. Enters information into MPIRS (indicated in #3 above) as well as name of paged ERDO.

This information is then relayed to the Environmental Response Duty Officer to determine Canadian Coast Guard posture. It should be noted that all spill incidents, irrespective of CCG's mandate, may require Canadian Coast Guard resources if requested (see Resource Agency Role in Section 1.5 of the *National Response Plan).*

By agreement, spill verification will be completed by the Regional Operations Centre (ROC) Duty Officer. The verification will be complete when the ER Duty Officer is advised where Canadian Coast Guard is Lead Agency. (see Figure 5.2 Pollution Verification Process and Figure 5.3 Response Analysis Process)

5.5 Spill Assessment – Environmental Response Duty Officer

To facilitate the requirement for efficient and rapid notification and assessment of incidents, Central and Arctic Region, in accordance with the *National Response Plan,* Section 4.4, has instituted a 24-hr year round monitoring regime integrated with the Regional Operations Centre (ROC). The following sections identify the context in which this activity is carried out.

Coordination

The coordination of the ER Duty Officer is the responsibility of the ER Regional Emergency Operations Officer (REOO). These duties include assigning shifts in an equitable manner, keeping records of the duty officer schedules, maintaining equipment required to perform ER Duty Officer functions, reviewing individual ER Duty Officer performance, reviewing ER Duty Officer procedures, and liaising with the ROC and National HQ.

Performance

The ER Duty Officer function shall be performed by the following positions provided sufficient experience, appropriate training, and at the discretion of the Superintendent ER:

- ✓ Senior Officers
- ✓ Those in capacity to act for Senior Officer.

Review

The ER Duty Officer procedures shall be reviewed in reaction to:

- Changes at the Regional Operations Centre (ROC) affecting the ER Duty Officer function
- Changes in Canadian Coast Guard (CCG) policy on the response to ship source pollution
- In consideration of accepted recommendations stemming from exercises and operational responses.

The individual officer performance shall be reviewed in context of their execution of a spill assessment.

Responsibilities

At the beginning of the ER Duty Officer's shift the following are required:

- Functioning communication equipment (pager, cell phone/Blackberry);
- The necessary analytical tools (e.g. spill assessment forms, Greenwood's Guide to Great Lakes Shipping, Area Plans, Oil Spill Response Field Guide, OSH reference tools, and the CANUTEC Emergency Response Guide book.)

During the ER Duty Officers shift the following are required to be complete:

- MPIRS cases for any spill reports that required ER Duty Officer analysis by noon of the next business day;
- Extra Duty Reports;
- Notification of the next ER Duty Officer and the ER Regional Emergency Operations Officer of any on-going cases.

Availability

The availability of the ER Duty Officer is 24 hours/7 days a week. Pages must be responded to within 10 minutes of notification. Should the ER Duty Officer (DO) be unable to fulfill their duties at any time during the shift, they are required to

notify the ER Regional Emergency Operations Officer (REOO) immediately who will notify the ROC of any changes immediately. The following activities conflict with the performance of the ER Duty Officer function:

- travel out of country / region / pager range;
- inability to respond immediately due to performance of other job functions (instructing a course, running an exercise, delivering a presentation, involved in a maintenance run that would be too difficult to reschedule, chairing a meeting, or participating in any activity that requires attendance or would be inappropriate to leave);
- inability to respond immediately due to personal reasons (vacation, sickness, etc.).

Should an individual become unavailable for a significant portion of the shift for reasons noted above, that shift may be assigned to another officer at the discretion of the ER Regional Emergency Operations Officer.

Function

The primary function of the ER Duty Officer is to complete an initial incident assessment and analysis, making a recommendation to the Superintendent of ER as to the appropriate course of action. **

The initial assessment will be complete for the following cases:

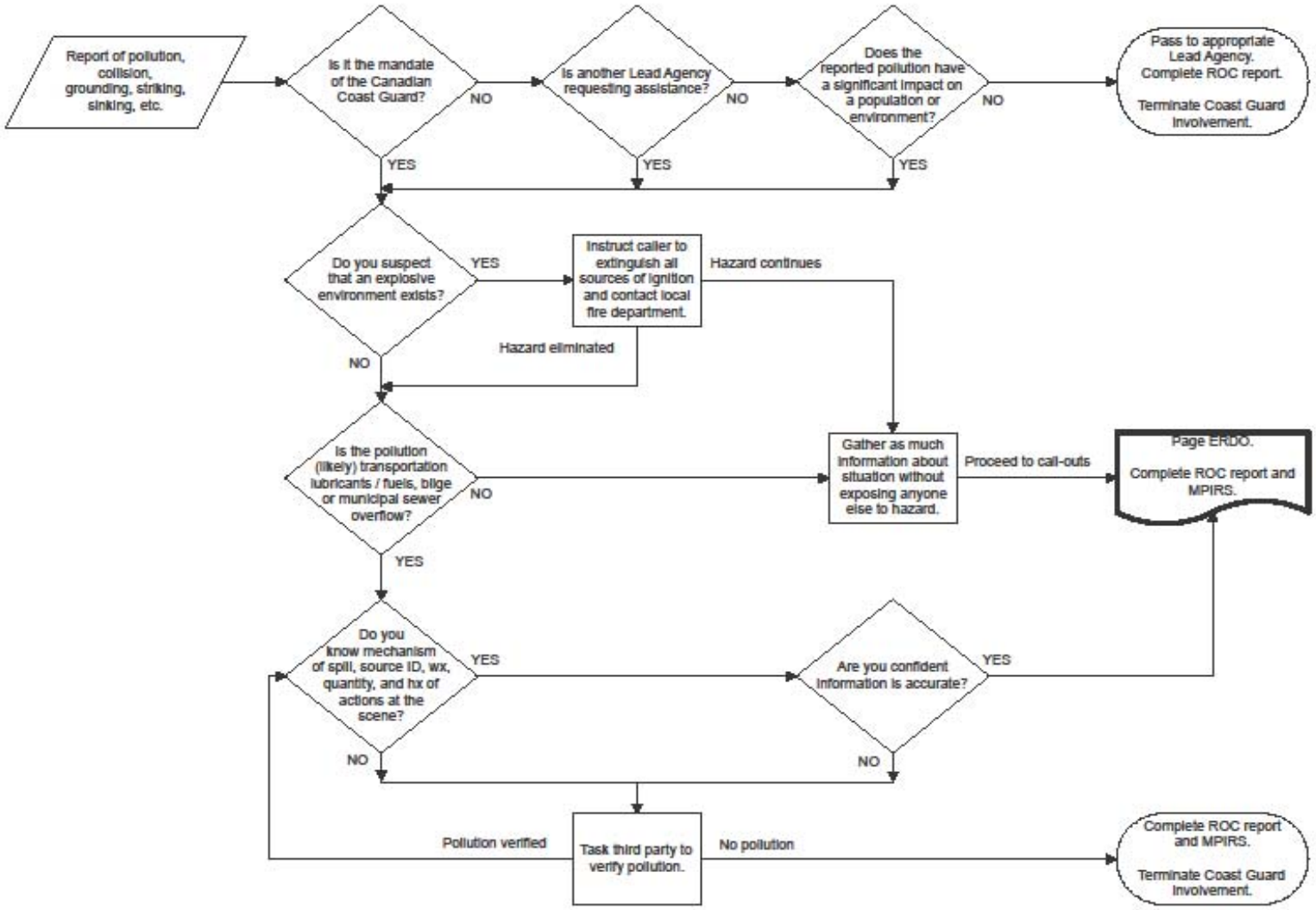
- Canadian Coast Guard mandate and verified pollution
- Likely to impact on / impacting on foreign waters
- Significant impact on region, though not falling under Canadian Coast Guard mandate.
- Request for Canadian Coast Guard as a resource agency.

The analysis function is complete when the Superintendent ER is informed and advised of the recommended course of action that will consider the following (see flow chart):

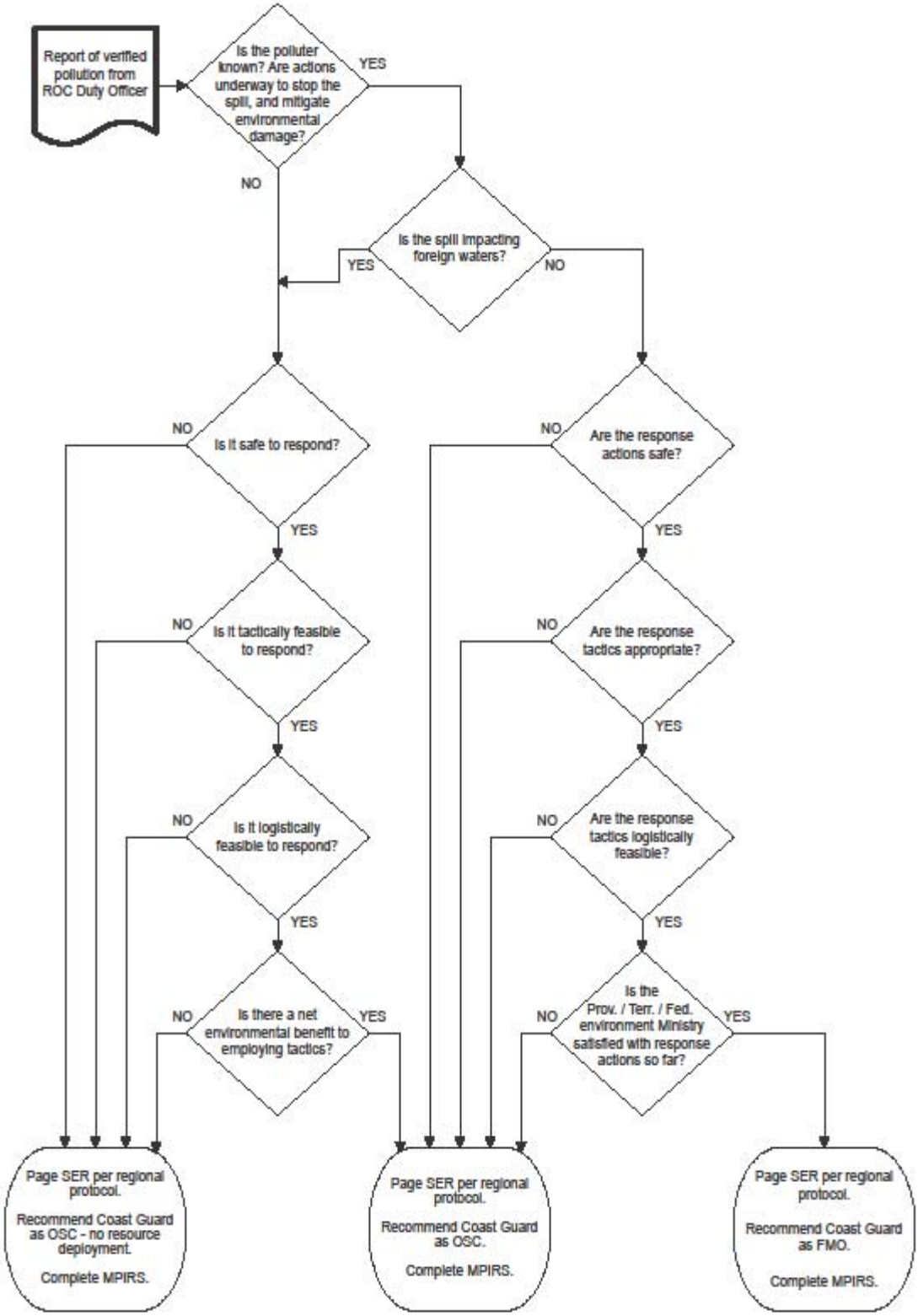
- polluter's actions and intentions (if applicable);
- safety concerns, tactical, logistical, and environmental feasibility of any response.

** The ER Duty Officer does not need to notify the Superintendent of any incidents that require "no activation" of CCG resources (assets/personnel) in monitoring/clean-up activity.

Spill assessment: *pollution verification process*



Spill assessment: *response analysis process*



5.6 Activation of Canadian Coast Guard Response Resources

In the event of small (0-150 T) to medium size (150-1000 T) spill incidents, the Superintendent, Environmental Response, acting upon the assessment provided by the Duty Officer, initiates/activates the appropriate response. This entails, but is not limited to, the following activities:

- Identification of overall health and safety risks to response personnel.
- Establishing the propriety of the recommended response posture. This includes the verification of international issues in border areas.
- Verification of Canadian Coast Guard capability to respond, impact on normal regional operations and, if necessary, the potential requirement for the notification and activation of the National Response Team.
- Assignment of the designated On-Scene Commander (OSC) or Federal Monitoring Officer (FMO). SROs are typically assigned as FMO/OSC for incidents occurring within their geographic area.
- Obtaining the necessary Order-in-Council, for spills in Arctic Waters
- Obtaining the financial project code, and forwarding it to the OSC/FMO.
- Signing a contract with the Response Organization (RO) in accordance with PWGSC contracting rules.
- Creation and dissemination of initial situation report to Regional and National management in accordance with the *Safety and Environmental Response Systems (SERS) – Incident Notification Guidelines*.
- Completion of MPIRS to document above activities.

For significantly larger spill incidents (1000T and above) the Superintendent, Environmental Response shall immediately assume the OSC/FMO role, notify Regional and National management of the situation and initiate the Response Management System (RMS) (and activation of the National Response Team, if necessary) in addition to the above activities. Upon stabilization of the immediate emergency, the Assistant Commissioner, Canadian Coast Guard, Central and Arctic Region and/or Director General, Canadian Coast Guard shall assess the requirement for assigning a new OSC/FMO.

5.7 Response Implementation

As stated previously (Section 4 - Preparedness), the Canadian Coast Guard will employ the Response Management System (RMS) as its primary management and operational tool. At the heart of this system is the development of clear obtainable objectives and the implementation of the supporting tactical deployment. This is achieved through the creation of incident action plans spanning specified operational time periods. For small spills these plans can be rather informal. As spill size and impacts increase, so to will the complexity of

operational assignments and hence a need for greater formalization of the Incident Action Plan.

All operations shall be carried out in accordance with the Guiding Principles set out in *Section 1.3* of the *National Response Plan* and the *Oil Spill Response Field Guide* (ISBN 0-660-16112-5).

Central and Arctic Region covers an extremely large geographical and culturally diverse portion of Canada. There are, in essence, two zones of operation which are entrenched in the *Canada Shipping Act*.
These are the:

- Arctic zone, or all areas of Canadian jurisdiction north of 60^0 N Latitude;
- Central zone, dominated in a marine transportation sense by the Great Lakes, but which include the southern portions of Hudson, James and Ungava Bay, along with the major waterways and watersheds of Lake Winnipeg, Winnipegosis, Lake of the Woods, and Lake Athabasca.

Arctic zone – first response
The highest risk of pollution in the arctic is during a ship fuel transfer to facilities in Canada's northern communities. Should pollution occur, the vessel and oil handling facility have responsibilities to implement their Oil Pollution Emergency Plans (OPEP) that deal with source control. The next step would be for the community to respond using its response plan, protecting the identified priority area(s) and employing the response equipment in an Arctic Community Pack, if so equipped.

Arctic zone – escalation
If the pollution is beyond the ship, facility, and community response then the Rapid Air Transportable (RAT)150T will be the first line Canadian Coast Guard ER response (Arctic icebreakers or Special River Nav-aid Tenders may have been on-scene first). Upon activation of the RAT150T, standing offers with aviation contractors will be called up. Closest ER personnel will be dispatched to the community to assess, plan, assemble (and train) responders, while preparing to stage the in-coming equipment. The Hay River base personnel will transport the pallets to the airport where they will be loaded into the awaiting airframe. Upon arrival the pallets will be unloaded and a trailer tongue and wheels affixed to the pallet to facilitate movement (by ATV if necessary) to a forward staging area and ultimately to a beach site. The timeframe for full forward staged capacity with personnel at any community with suitable runways is under 48 hours.

The hospitality industry of Arctic communities can be rapidly overwhelmed with the influx of as little as 10 people. Experience has shown that these communities could only support 10-15 additional personnel and only offer 10-15 community responders. Consequently, the RAT was designed considering the amount and type of equipment that is most easily handled by a combination of trained

Canadian Coast Guard personnel and community responders. The RAT150T response is predicated on an in-community response with the following positions identified in the table below:

Table 5-2 *Anticipated personnel usage for the RAT150T in an Arctic community*

Position	Canadian Coast Guard responder	Community responder
OSC	X	
OSC support		X
Chief Ops & Planning	X	
Logs – services	X	X
Logs – support	X	X
Ops skimming (A)	X	X
Ops skimming (B)	X	X
Ops shoreline (A)	X	X X X X
Ops shoreline (B)	X	X X X X
Ops booming vessel (A)	X	X
Ops booming vessel (B)	X	X
Transfer / disposal	X	X
Totals	**11**	**16**

Upon escalating beyond a RAT150T response, the Δ1000T will be stood up. Standing offers / arrangements with local contractors will be activated to move the containers / seatrucks to a location where they can be transferred to a ship / barge. If required, closest Canadian Coast Guard base personnel will be dispatched to the depot to assist. The closest suitable marine transportation asset will also be contracted to move the equipment to the spill site. The timeframe for full forward staged capacity with personnel is estimated at one week.

As the 150T response is predicated on an in-community response a larger spill would have to be supported by a Canadian Coast Guard icebreaker, rented camp barge, or flown in from surrounding communities.

Table 5-3 *Anticipated personnel usage for the 1000T in an Arctic community.*

Position	Canadian Coast Guard ER responder	CCG Fleet or professional contractor	Community responder
OSC	X		
OSC support		X	X
Chief of Planning	X		
Plan – response	X		
Plan – demobilization	X		
Chief of Logs	X		
Logs – services		X	X
Logs – support	X X	X X X	
Chief of Ops	X		
Air Ops		X	
Ops on-water	X X	X X X X	
Ops shoreline	X X		X X X X X X X X X
Ops booming	X X	X X X X	
Transfer / disposal	X	X	X
Totals	**14**	**13**	**13**

Central Zone – first response

The highest risk of pollution occurring in the region is found in the Great Lakes. Statistically the areas in the Great Lakes of highest risk are the connecting channels due to volumes, numbers of transits, and convergence factors (existing VTS / navigational aid systems recognize this). Areas with traditionally high pleasure craft and small commercial craft traffic experience frequent (though low in volume) pollution incidents.

If the pollution is in the local vicinity of a Canadian Coast Guard Search and Rescue (SAR) station or facility with operational staff, a First Response Unit (FRU) may be deployed as an initial attempt at containment. If more equipment sweeps systems or recovery units are required then the Rapid Road Transportable (RRT) 2500T will be activated.

Transfer of Lead Agency

Transfer of Lead from CCG

Should an incident initially appear to fall within the jurisdiction of the Canadian Coast Guard yet later is determined to be another government agency's

responsibility, the CCG-appointed OSC or FMO will verbally acknowledge the transfer of Lead Agency responsibility followed by written confirmation on the terms of the transfer (this may require time for termination of a response contract with CCG and the establishment of a response contract with the appropriate Lead Agency.) When the Lead is transferred from CCG to another Lead Agency, CCG will submit an invoice of its response costs to the Lead Agency for response activities undertaken up to the time of transfer recognition.
Should the Lead Agency wish to retain CCG as a Resource Agency, the criteria in Section 7 of the *National Response Plan* of the *CCG National Marine Spills Response Plan* will apply.

Transfer of Lead to CCG
When the Lead is transferred to Canadian Coast Guard from another agency, the Canadian Coast Guard will incorporate the appropriate costs borne by the other agency in the initial stages of the spill into its claim to the Polluter or to the Ship Source Oil Pollution Fund, (SOPF) as the case may be.

Safety Procedures and Considerations

All petroleum cargoes are considered hazardous substances. Canadian Coast Guard command, clean-up, monitoring and verification personnel have protective equipment and training available to them up to Level “D”. All Environmental Response branch staff have been issued with a variety of personal protective equipment (PPE) and are expected to deploy to a spill site (includes exercises and training) with all appropriate gear. Safety glasses and rain suits with rubber boots and gloves are appropriate for Canadian Coast Guard's traditional verification of and response to oil pollution.

Bulk chemical carriers, rail cars, road trailers, sour (H2S) petroleum products or BTX (benzene, toluene, xylene) carried on oil tankers are all sources of substances for which Canadian Coast Guard personnel are not readily equipped for. In most cases where the pollutant reported is suspected to be from one of these sources Canadian Coast Guard assets should not be tasked to verify. If it falls within Canadian Coast Guard mandate the ER program personnel will get directly involved in the verification, likely looking to other government departments or contractors to continue with the assessment and response.

When the pollution is reported to the ROC by a member of the public, or by a credible professional as a mystery spill, closer examination of the circumstances or probable cause of the pollution will occur as part of spill verification. During the conversation with the individual reporting the incident the ROC Duty Officer will want to find out what it is that they observed. These are:

- Colour [typical petroleum silvery to rainbow to dark purple / brown or is it frothy, green organic matter, rusty, etc.]
- Odour [does it smell like gas, diesel, rotten eggs, no odour]
- Proximity to any likely source [vessel, industrial outfall, municipal outfall, midlake, mid channel, washed up industrial storage drum]

- Volumes [football field sized, shopping mall parking lot big, or a thin ribbon]
- Other factors [heavy rainfall in last 12 hours; seasonal conditions / times / areas known for algae blooms; fish or animal kills].

By picking up on any "flags" during an assessment it can be reasonably determined whether the pollution should not/should be classified as a hazardous substance (for which CCG personnel are unable to respond to). The ER duty officer will consult with experts in Environment Canada (EC), Spills Action Centre (SAC), and CANUTEC, as appropriate to determine the safety for personnel.

Alternative countermeasures

Alternative countermeasures are those non-mechanical techniques utilized in oil spill response operations such as in-situ burning, dispersant application, and shoreline cleaner application.

Central Zone

The likelihood of approval of in-situ burning operations on the Great Lakes or in connecting channels or inland lakes is minimal. The use of dispersants in the Great Lakes, connecting channels or in inland waterways will not be considered. Shoreline cleaner agents approved by Environment Canada may be considered.

Arctic Zone

In view of the difficulties associated with mounting an effective response in the Arctic, the CCG has recommended that further research be done in the areas of in-situ burning, the use of dispersants (reference Quebec paper) and other oil in ice recovery methods. This research should be operational R&D and assume that the product spilled is Arctic diesel and that the spill occurs during the Arctic shipping season.

5.8 Summary Report and Post Incident Review

It is regional policy to provide a Summary Report and/or conduct a formal Post Incident Review for incidents deemed noteworthy or valuable by the OSC/FMO or Assistant Commissioner, Canadian Coast Guard.

Summary Report

The summary report shall contain at minimum the following, but can include any information deemed relevant by the OSC/FMO.

Summary Incident Report Format

(a) Overview of Crisis Event

- spill source (not cause), initial environmental conditions and assessment of situation

(b) Spill chronology
- spill response activities and climate/wind /sea condition data
- key response objectives (success and failures in implementation), major shifts in tactics, other agencies involvement

(c) Costs and cost recovery issues
- total estimated cost summary
- identification of Cost Recovery requirements and options

(d) References
- Situation Reports

Post Incident Review

The main objective of a Post Incident Review is the evaluation of the incident to ultimately improve Canadian Coast Guard's effectiveness at spill response. To that end, this requirement is essentially similar to the principles of exercise evaluation. Therefore, when required, the review shall be conducted in accordance with the principles contained in the *National Exercise Program – Evaluation guidelines, Chapter 11*.

This entails six distinct tasks:

1) Brief the Evaluation Team
2) Brief the Response Team
3) Evaluate the Incident
4) Prepare a Preliminary Summary of Key Observations
5) Hold an Incident Debriefing Session
6) Prepare an Official Post Incident Evaluation Report

Post Incident Evaluation Report Format

(a) Executive Summary -Summarizes overall findings and observations

(b) Overview of Incident Objectives -Briefly describes the key objectives, environmental conditions and initial situation assessment

(c) Evaluation Techniques and Criteria - Describes the technique(s) (i.e. self, peer or independent evaluation) and the major evaluation criteria used

(d) Assessment of Key Incident Objectives - This provides a critical appraisal of the incident objectives or major shifts in tactics. Each key objective assessment will include the following:

Findings – A summary statement describing key positive and negative findings.

Specific Observations - Observed decisions and tasks noted during the incident by responders, management and interested parties.

Conclusions - Assessment of the impact of the finding on overall achievement of the incident objective(s)

Recommendations – A description of potential corrective or follow-up action required to implement the findings to improve overall marine spill response preparedness.

(e) Appendices or Attachments - May or may not be required

Section 6 – CLAIMS & COST RECOVERY

6.1 Purpose

The purpose of this section of the *Regional Response Plan* is to outline the requirements and regional processes to assist in the creation of a claim to the relevant fund or directly to a polluter.

The ability of Canadian Coast Guard to recover or pursue recovery of response expenses or costs associated with monitoring activities is set out in the *Marine Liability Act, Part 6, "Liability and Compensation for Pollution"*. This ability to recover costs is seen as the embodiment of the polluter-pay-principle set out in the *National Response Plan, Guiding Principles, Section 1.3*.
Note: That at this time there is no mechanism to recover monitoring costs from an oil handling facility.

In addition to the above and recognizing the potential financial risks and impacts to Canada, Canadian legislation also provides for the creation and maintenance of a Ship-Source Oil Pollution Fund, (SOPF). This fund, in addition to the International Oil Pollution Compensation Fund (IOPCF) and the Protection & Indemnity (P&I) Clubs, provides for the assessment of claims/loss against member ships and/or shipping companies. Neither of these funds hinder nor otherwise limit Canadian Coast Guard's ability to lay claims directly against a Polluter. However, the Polluter is only required to reimburse a claim up to its Limit of Liability. This limit is calculated using the guidelines established in the *Convention on Limitation of Liability for Maritime Claims (LLMC), 1976*.

6.2 Policy Guidelines

The following points serve as regional guidelines for pursuing cost recovery activities:

- The decision to seek cost recovery should be made based on common sense and in consultation with other operational and finance team members.
- Cost recovery should be avoided in situations where the administrative costs of recovery action exceed the dollars expected to be recovered.
- Cost recovery embodies the "Polluter Pays" principle.
- Costs incurred while acting as a resource agency must be recovered from the lead agency.
- Costs incurred while acting as OSC/FMO are recoverable from either the polluter, its P&I Club, the Ship-Source Oil Pollution Fund or from the International Oil Pollution Compensation Fund.

6.3 Responsibilities

On-Scene Commander/Federal Monitoring Officer (OSC/FMO)
The OSC/FMO is responsible for ensuring that complete and accurate documentation is provided for a timely and effective cost recovery process. The OSC/FMO is responsible for preparing all documentation necessary to initiate cost recovery.

Regional Finance Staff
Response, monitoring and administrative costs must be calculated in accordance with national financial accounting and recording practices. Senior administrative officers within Maritime Services may be called upon to provide expert advice as required. It is recommended that a regional finance representative be on-scene as soon as possible to help establish procedures, to safeguard documentation, and to ensure the integrity of the costing process.

Environmental Response Headquarters
The Environmental Response Senior Advisor for Cost Recovery and Claims will submit those claims that are intended for the Ship-Source Oil Pollution Fund and to International Fund Conventions in accordance with the guidelines specified by each. The Advisor will also issue equipment charge-out rates periodically for use by all regions.

6.4 Process
The Response Management System (RMS) documentation (field notes, Incident Action Plans, Minutes and meeting records, time sheets and any and all expense records, invoices/requisitions etc.) shall form the basis of data for the Cost Recovery action.

The Region will initiate cost recovery actions against the Polluter. Should the Polluter be unable or unwilling to pay the costs, the Region will forward the claim to HQ Senior Advisor for Cost Recovery and Claims for submission to the Ship-Source Oil Pollution Fund. Should the costs of the response exceed the Limit of Liability of the Polluter, reimbursement of costs will be through the SOPF and then through the IOPCF. Claims associated with mystery spills will be submitted directly to HQ for a claim against the SOPF.

6.5 Documentation
Proper documentation alleviates the need to reconstruct the incident after the fact, reduces the volume of questions, and adds credence to the claim. The key source of information that enables various parties to determine the degree of reasonableness of the actions taken and the costs claimed is the part of the cost recovery summary known as a “narrative”. That justification is considered to be a critical component to successful and timely claims.

The regional guideline for producing cost summaries and documentation handling is as follows:

Incidents of minimum complexity and limited expenditures (under $15K)

- Expenditures may be summarized within the body of the Final Report, including any description of "calculated" values (i.e. administration costs)
- Original invoices shall be kept on the dedicated spill file.

Incidents of medium complexity and moderate expenditures (up to $50K)

- Expenditures will be summarized in a single table by Cost Element within the body of the Final Report.
- A supporting cost summary document or appendix shall be created to provide a detailed cost summary by date. Copies of the expenditure documentation will be included.
- Original invoices shall be kept on the dedicated spill file organized by date.

Incidents of high complexity and significant expenditures ($50K plus)

- Expenditures will be summarized in a single table by Cost Element within the body of the Final Report. (similar to medium complexity incidents)
- A supporting cost summary document will be created summarizing the daily expenditures by individual cost element, followed by a cumulative summary of each cost element (spreadsheet of all daily summaries). The sum total of all cost elements will then be summarized for use in the final report.
- Due to the volume of transactions, copies of the expenditure documents will not be provided in the supporting cost summary document.
- Original invoices will be kept in their original state, filed by date and archived when feasible to a dedicated file.

Table 6.1 Sample Cost Element Table

Cost Element	Description
Personnel	Includes hourly regular and overtime costs associated with CCG Staff (includes EBP)
Equipment	Includes cost of all CCG assets, based upon established charge out rates
Purchases/Expendables	Includes expendables such as office supplies and PPE
Travel	Includes meals and accommodation costs incurred by CCG staff accordance with TB travel directive.
Contractors	Includes the costs of all private sector contractor/goods and services.
Administration	Includes the cost of CCG administration.
Total Estimated Cost	

6.6 References

- CCG Ship Source and Marine Pollution Response Costing Principles and Documentation Standards DFO2004-6332
- Cost Recovery of Ship Source and Marine Pollution Response Directive # D-4010-2001-01
- Cost Recovery Related Policies, Memorandum dated October 26, 1998, File AWE 1001-5-2-1 (AWEA)

6.7 Third Party Claims

While monitoring or responding to an incident, Canadian Coast Guard will refer all inquiries regarding third party claims to the Polluter. In the case of a mystery spill, the Canadian Coast Guard will encourage claimants to submit a claim directly to the Ship Source Oil Pollution Fund.

Section 7 - PLAN MAINTENANCE AND CUSTODIANS

7.1 *Maintenance Process*

Responsibility
The *Regional Response Plan* of the *Canadian Coast Guard Marine Spills Response Plan* for Central & Arctic Region is the responsibility of:

Assistant Commissioner, Canadian Coast Guard
Central & Arctic Region
520 Exmouth Street
Sarnia, Ontario
N7T 8B1
fax (519) 383-1991

Revision Requests
All requests or suggestions for revision to this plan should be forwarded, in writing, to the above noted address and should include the following information:

- Originator (including return address and telephone number)
- Date
- Subject (i.e. request for revision)
- Suggested change (including section and page number references)
- Reason for revision

All formally received requests will be acknowledged in writing and assessed for inclusion into the plan. Upon approval the revision will be distributed accordingly.

Revision Record
Upon receiving a revision transmittal, recipients are requested to ensure that its number is next in sequence to the previous issue, process the amendments according to the transmittal instructions and complete the revision record in this section.

Should there be any discrepancies or questions, the recipient should contact the Canadian Coast Guard, Assistant Commissioner, Central & Arctic Region at the above address.

The onus is on the plan holder to maintain a current plan.

7.2 *Canadian Coast Guard Custodians*

This document is structured to reflect the fundamental phases of Environmental Response (ER) activities and hence reflects the co-operative nature of each

aspect of the Central and Arctic Region Environmental Response organization. In conjunction with this, each component has been assigned to a specific section within the branch (e.g. training is the responsibility of the Training Officer). The Assistant Commissioner – Canadian Coast Guard, Central and Arctic Region retains the overall responsibility for the document's implementation. The Emergency Plan Development Officer (EPDO) facilitates the physical management and co-ordination of this document.

These custodial relationships herein are designed to facilitate the annual review and maintenance of the *Regional Response Plan*.

Letter of Promulgation	Emergency Plan Development Officer
Record of Revision	Plan Holders
Section 1 – Introduction	Emergency Plan Development Officer
Section 2 - Agreements & Memoranda of Understanding	Emergency Plan Development Officer
Section 3 – Organization	Emergency Plan Development Officer
Section 4 – Preparedness 4.2 RMS	 Regional Training Officer
4.3 Planning	Emergency Plan Development Officer
4.4 Training	Regional Training Officer
4.5 Exercising	Regional Exercise Officer
4.6 Inventory Maintenance & Management	Regional Emergency Operations Officer
Section 5 – Response Operations	Regional Emergency Operations Officer
Section 6 – Claims & Cost Recovery	TBD
Section 7 - Plan Maintenance & Custodians	Emergency Plan Development Officer
Section 8 – Contacts	Emergency Plan Development Officer
Section 9 – References & Annexes	Responsibility for each annex is assigned in each Annex.

All unassigned sections shall be considered the responsibility of the Emergency Plan Development Officer unless otherwise indicated.

7.3 Plan Distribution

The *Regional Response Plan* shall be distributed to all holders of the *Canadian Coast Guard Marine Spills Response Plan*, in accordance with the Area of Responsibility set in Section 1 - Introduction. This includes the relevant Federal and Provincial Lead Agencies as described in the National Response Plan Section 1, sub-section 1.5; all Canadian Coast Guard Management; Facilities and Vessels; all Oil Handling Facilities and relevant certified Response Organizations by request and in accordance with Transport Canada-Marine

Safety, Compliance and Enforcement division. All subsequent revisions will be automatically distributed to these plan holders.

Any member of the general public wishing to obtain a copy may do so through the Fisheries and Oceans, Canadian Coast Guard, National Headquarters. These plan holders will not be advised of revisions.

Section 8 – CONTACTS

8.1 Pollution Reports for Canadian Coast Guard, Central & Arctic Region

To report a pollution emergency anywhere within Central & Arctic Region telephone the Canadian Coast Guard, Regional Operations Centre (ROC) toll free at:

1-800-265-0237

or report via

Marine Radio on VHF, Channel 16.

8.2 Other Lead Agencies that Maintain Spill Report Lines

- Ontario Ministry of the Environment - Spills Action Centre: 1-800-268-6060
- Territorial Spills Line – Arctic Alarm: 1-867-920-8130
- Manitoba Conservation: 1-204-944-4888
- Saskatchewan Environment - Saskatchewan Spill Centre: 1-800-667-7525
- Alberta Environment: 1-800-222-6514

8.3 Canadian Coast Guard, Environmental Response Branch (CCG/ER) Phone List – Regular Office Hours

Regional Office, Canadian Coast Guard **520 Exmouth Street** **Sarnia, ON N7T 8B1**	
Title	**Telephone**
Superintendent, Environmental Response	519-383-1954
Emergency Plan Development Officer	519-464-5126
Assistant Contingency Planning Officer	519-383-1953
Regional Exercise Officer	519-383-1978
Regional Emergency Operations Officer	519-383-1956
Environmental Training Officer	519-383-1957
Administrative Assistant	519-383-1951

Canadian Coast Guard Base **42037 McKenzie Highway** **Hay River, NT X0E 0R9**	
Title	**Telephone**
Senior Response Officer	867-874-5557
Response Specialist	867-874-5558
Response Specialist	867-874-5559

Canadian Coast Guard Base **PO Box 1000, 401 King Street** **Prescott, ON K0E 1T0**	
Title	**Telephone**
Senior Response Officer	613-925-2865 x 157
Response Specialist (2)	613-925-2865 x 262
Logistics and Statistics Officer	613-925-2865 x 126

Canadian Coast Guard Base **28 Waubeek Street** **Parry Sound, ON P2A 1B9**	
Title	**Telephone**
Senior Response Officer	705-746-2196 x 228
Response Specialist	705-746-2196 x 270
Response Specialist	705-746-2196 x 201

Section 9 – REFERENCES & ANNEXES

9.1 References

The following list includes those documents which supplement the Regional Response Plan.

Supplement	Custodian
Environmental Response Manual – Standard Operating Procedures and Directives	Canadian Coast Guard, Environmental Response, Headquarters
Response Management System User's Guide, version 3.0 (May 2006)	Canadian Coast Guard, Environmental Response, Headquarters
Environmental Response Superintendent's Manual	Superintendent, Environmental Response, Regional Office
Environmental Response Regional Health & Safety Plan	Environmental Response, Regional Emergency Operations Officer
National Exercise Program (NEP) Manual	Canadian Coast Guard, Environmental Response Headquarters
Inventory Control and Response Management System – TMA database	Regional Logistics and Statistics Officer, Environmental Response
DFO Crisis Communications Plan	DFO Corporate Services, Communications Branch

9.2 Annexes

The following Area Plans make up the Annexes to the Regional Chapter:

1) St. Lawrence River and Lake Francis
2) Lake Ontario
3) Lake Erie
4) St. Clair and Detroit River
5) Lake Huron, Georgian Bay and North Channel
6) St. Mary's River
7) Lake Superior
8) Lake of the Woods
9) Inland waters (South of 60°N Latitude)
10) Hudson and James Bay
11) Baffin Region
12) Keewatin Region
13) Kitikmeot Region
14) Great Slave Lake Region
15) Mackenzie River and Delta
16) Beaufort Sea and Amundsen Gulf

APPENDIX C - MSDS Jet-A and Diesel

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	DIESEL FUEL
Synonyms	:	Seasonal Diesel, #1 Diesel, #2 Heating Oil, #1 Heating Oil, D50, Arctic Diesel, Farm Diesel, Marine Diesel, Low Sulphur Diesel, LSD, Ultra Low Sulphur Diesel, ULSD, Mining Diesel, Naval Distillate, Dyed Diesel, Marked Diesel, Coloured Diesel, Furnace special, Biodiesel blend, B1, B2, B5, Diesel Low Cloud (LC). Marine Gas Oil
Product code	:	101802, 100107, 100668, 100658, 100911, 100663, 100652, 100460, 100065, 101796, 101793, 101795, 101792, 101794, 101791, 100768, 100643, 100642, 100103, 101798, 101800, 101797, 101788, 101789, 101787, 102531, 100734, 100733, 100640, 100997, 100995, 100732, 100731, 100994
Manufacturer or supplier's details		Petro-Canada P.O. Box 2844, 150 - 6th Avenue South-West Calgary Alberta T2P 3E3 Canada
Emergency telephone number		Suncor Energy: +1 403-296-3000; Poison Control Centre: Consult local telephone directory for emergency number(s).

Recommended use of the chemical and restrictions on use

Recommended use	:	Diesel fuels are distillate fuels suitable for use in high and medium speed internal combustion engines of the compression ignition type. Mining diesels, marine diesels, MDO and naval distillates may have a higher flash point requirement.
Prepared by	:	Product Safety: +1 905-804-4752

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

Appearance	Bright oily liquid.
Colour	Clear to yellow (This product may be dyed red for taxation purposes).
Odour	Mild petroleum oil like.

GHS Classification

Flammable liquids	:	Category 3
Acute toxicity (Inhalation)	:	Category 4

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

Skin irritation	:	Category 2
Carcinogenicity	:	Category 2
Specific target organ toxicity - single exposure	:	Category 3 (Central nervous system)
Specific target organ toxicity - repeated exposure	:	Category 2 (Liver, thymus, Bone)
Aspiration hazard	:	Category 1

GHS Label element

Hazard pictograms :



Signal word : Danger

Hazard statements :
H226 Flammable liquid and vapour.
H304 May be fatal if swallowed and enters airways.
H315 Causes skin irritation.
H332 Harmful if inhaled.
H336 May cause drowsiness or dizziness.
H351 Suspected of causing cancer.
H373 May cause damage to organs (Liver, thymus, Bone) through prolonged or repeated exposure.

Precautionary statements :
Prevention:
P201 Obtain special instructions before use.
P202 Do not handle until all safety precautions have been read and understood.
P210 Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P233 Keep container tightly closed.
P240 Ground/bond container and receiving equipment.
P241 Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242 Use only non-sparking tools.
P243 Take precautionary measures against static discharge.
P260 Do not breathe dust/ fume/ gas/ mist/ vapours/ spray.
P264 Wash skin thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves/ eye protection/ face protection.
P281 Use personal protective equipment as required.
Response:
P301 + P310 IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician.
P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P304 + P340 + P312 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or doctor/ physician if you feel unwell.

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

P308 + P313 IF exposed or concerned: Get medical advice/ attention.
P331 Do NOT induce vomiting.
P332 + P313 If skin irritation occurs: Get medical advice/ attention.
P362 Take off contaminated clothing and wash before reuse.
P370 + P378 In case of fire: Use dry sand, dry chemical or alcohol-resistant foam for extinction.
Storage:
P403 + P233 Store in a well-ventilated place. Keep container tightly closed.
P403 + P235 Store in a well-ventilated place. Keep cool.
P405 Store locked up.
Disposal:
P501 Dispose of contents/ container to an approved waste disposal plant.

Potential Health Effects

Primary Routes of Entry	:	Eye contact Ingestion Inhalation Skin contact Skin Absorption
Target Organs	:	Skin Eyes Respiratory Tract
Inhalation	:	May cause respiratory tract irritation. Inhalation may cause central nervous system effects. Symptoms and signs include headache, dizziness, fatigue, muscular weakness, drowsiness and in extreme cases, loss of consciousness.
Skin	:	Causes skin irritation.
Eyes	:	Causes eye irritation.
Ingestion	:	Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhoea. Aspiration hazard if swallowed - can enter lungs and cause damage.
Aggravated Medical Condition	:	None known.

Carcinogenicity:

IARC	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
OSHA	No component of this product present at levels greater than or

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

NTP No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Pure substance/mixture : Mixture

Hazardous components

Chemical Name	CAS-No.	Concentration (%)
kerosine (petroleum), hydrodesulfurized	64742-81-0	70 - 100 %
kerosine (petroleum)	8008-20-6	
fuels, diesel	68334-30-5	
fuel oil no. 2	68476-30-2	
Alkanes, C10-20-branched and linear	928771-01-1	0 - 25 %
Soybean oil, Methyl ester	67784-80-9	0 - 5 %
Rape oil, Methyl ester	73891-99-3	
Fatty acids, tallow, Methyl esters	61788-61-2	

SECTION 4. FIRST AID MEASURES

If inhaled : Move to fresh air.
Artificial respiration and/or oxygen may be necessary.
Seek medical advice.

In case of skin contact : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Wash skin thoroughly with soap and water or use recognized skin cleanser.
Wash clothing before reuse.
Seek medical advice.

In case of eye contact : Remove contact lenses.
Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes.
Obtain medical attention.

If swallowed : Rinse mouth with water.
DO NOT induce vomiting unless directed to do so by a physician or poison control center.
Never give anything by mouth to an unconscious person.
Seek medical advice.

Most important symptoms : First aider needs to protect himself.

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

and effects, both acute and delayed

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media	:	Dry chemical Carbon dioxide (CO2) Water fog. Foam
Unsuitable extinguishing media	:	Do NOT use water jet.
Specific hazards during firefighting	:	Cool closed containers exposed to fire with water spray.
Hazardous combustion products	:	Carbon oxides (CO, CO2), nitrogen oxides (NOx), sulphur oxides (SOx), sulphur compounds (H2S), smoke and irritating vapours as products of incomplete combustion.
Further information	:	Prevent fire extinguishing water from contaminating surface water or the ground water system.
Special protective equipment for firefighters	:	Wear self-contained breathing apparatus for firefighting if necessary.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	:	Use personal protective equipment. Ensure adequate ventilation. Evacuate personnel to safe areas. Material can create slippery conditions.
Environmental precautions	:	If the product contaminates rivers and lakes or drains inform respective authorities.
Methods and materials for containment and cleaning up	:	Prevent further leakage or spillage if safe to do so. Remove all sources of ignition. Soak up with inert absorbent material. Non-sparking tools should be used. Ensure adequate ventilation. Contact the proper local authorities.

SECTION 7. HANDLING AND STORAGE

Advice on safe handling	:	For personal protection see section 8. Smoking, eating and drinking should be prohibited in the application area. Use only with adequate ventilation. In case of insufficient ventilation, wear suitable respiratory equipment. Avoid spark promoters. Ground/bond container and

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

equipment. These alone may be insufficient to remove static electricity.
Avoid contact with skin, eyes and clothing.
Do not ingest.
Keep away from heat and sources of ignition.
Keep container closed when not in use.

Conditions for safe storage : Store in original container.
Containers which are opened must be carefully resealed and kept upright to prevent leakage.
Keep in a dry, cool and well-ventilated place.
Keep in properly labelled containers.
To maintain product quality, do not store in heat or direct sunlight.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value type (Form of exposure)	Control parameters / Permissible concentration	Basis
kerosine (petroleum), hydrodesulfurized	64742-81-0	TWA	200 mg/m3	ACGIH
kerosine (petroleum)	8008-20-6	TWA	100 mg/m3	NIOSH REL

Engineering measures : Use only in well-ventilated areas.
Ensure that eyewash station and safety shower are proximal to the work-station location.

Personal protective equipment

Respiratory protection : Use respiratory protection unless adequate local exhaust ventilation is provided or exposure assessment demonstrates that exposures are within recommended exposure guidelines. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Filter type : organic vapour cartridge or canister may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits. Protection provided by air-purifying respirators is limited. Use a positive-pressure, air-supplied respirator if there is any potential for uncontrolled release, exposure levels are unknown, or any other circumstances where air-purifying respirators may not provide adequate protection.

Hand protection
Material : neoprene, nitrile, polyvinyl alcohol (PVA), Viton(R). Consult your PPE provider for breakthrough times and the specific glove that is best for you based on your use patterns. It should be realized that eventually any material regardless of their imperviousness, will get permeated by chemicals. Therefore, protective gloves should be regularly checked for

Petro-Canada is a Suncor Energy business. TM Trademark of Suncor Energy Inc. Used under licence.

wear and tear. At the first signs of hardening and cracks, they should be changed.

Remarks	:	Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Eye protection	:	Wear face-shield and protective suit for abnormal processing problems.
Skin and body protection	:	Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place.
Protective measures	:	Wash contaminated clothing before re-use.
Hygiene measures	:	Remove and wash contaminated clothing and gloves, including the inside, before re-use. Wash face, hands and any exposed skin thoroughly after handling.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Bright oily liquid.
Colour	:	Clear to yellow (This product may be dyed red for taxation purposes).
Odour	:	Mild petroleum oil like.
Odour Threshold	:	No data available
pH	:	No data available
Pour point	:	No data available
Boiling point/boiling range	:	150 - 371 °C (302 - 700 °F)
Flash point	:	> 40 °C (104 °F) Method: closed cup
Auto-Ignition Temperature	:	225 °C (437 °F)
Evaporation rate	:	No data available
Flammability	:	Flammable in presence of open flames, sparks and heat. Vapours are heavier than air and may travel considerable distance to sources of ignition and flash back. This product can accumulate static charge and ignite.
Upper explosion limit	:	6 %(V)
Lower explosion limit	:	0.7 %(V)
Vapour pressure	:	7.5 mmHg (20 °C / 68 °F)

™ Trademark of Suncor Energy Inc. Used under licence.

Relative vapour density	:	4.5
Relative density	:	0.8 - 0.88
Solubility(ies)		
Water solubility	:	insoluble
Partition coefficient: n-octanol/water	:	No data available
Viscosity		
Viscosity, kinematic	:	1.3 - 4.1 cSt (40 °C / 104 °F)
Explosive properties	:	Do not pressurise, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Runoff to sewer may create fire or explosion hazard.

SECTION 10. STABILITY AND REACTIVITY

Possibility of hazardous reactions	:	Hazardous polymerisation does not occur. Stable under normal conditions.
Conditions to avoid	:	Extremes of temperature and direct sunlight.
Incompatible materials	:	Reactive with oxidising agents and acids.
Hazardous decomposition products	:	May release COx, NOx, SOx, H2S, smoke and irritating vapours when heated to decomposition.

SECTION 11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure: Eye contact, Ingestion, Inhalation, Skin contact, Skin Absorption

Acute toxicity

Product:

Acute oral toxicity	Remarks: No data available
Acute inhalation toxicity	Remarks: No data available
Acute dermal toxicity	Remarks: No data available

Components:

kerosine (petroleum), hydrodesulfurized:

Acute oral toxicity	LD50 (Rat): > 5,000 mg/kg

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

Acute inhalation toxicity	LC50 (Rat): > 5.2 mg/l Exposure time: 4 hrs Test atmosphere: dust/mist
Acute dermal toxicity	LD50 (Rabbit): > 2,000 mg/kg

kerosine (petroleum):

Acute oral toxicity	LD50 (Rat): > 5,000 mg/kg
Acute inhalation toxicity	LC50 (Rat): > 5 mg/l Exposure time: 4 h Test atmosphere: dust/mist
Acute dermal toxicity	LD50 (Rabbit): > 2,000 mg/kg

fuels, diesel:

Acute oral toxicity	LD50 (Rat): 7,500 mg/kg
Acute dermal toxicity	LD50 (Mouse): 24,500 mg/kg

fuel oil no. 2:

Acute oral toxicity	LD50 (Rat): 12,000 mg/kg
Acute inhalation toxicity	LC50 (Rat): 4.1 mg/l Exposure time: 4 h Test atmosphere: dust/mist

Skin corrosion/irritation

Product:

Remarks: No data available

Serious eye damage/eye irritation

Product:

Remarks: No data available

Respiratory or skin sensitisation

No data available

Germ cell mutagenicity

No data available

Carcinogenicity

No data available

Reproductive toxicity

No data available

STOT - single exposure

No data available

STOT - repeated exposure

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

No data available

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

Product:

Toxicity to fish	:	Remarks: No data available
Toxicity to daphnia and other aquatic invertebrates	:	Remarks: No data available
Toxicity to algae	:	Remarks: No data available
Toxicity to bacteria	:	Remarks: No data available

Persistence and degradability

Product:

Biodegradability	:	Remarks: No data available

Bioaccumulative potential

No data available

Mobility in soil

No data available

Other adverse effects

No data available

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods

Waste from residues	:	The product should not be allowed to enter drains, water courses or the soil. Offer surplus and non-recyclable solutions to a licensed disposal company. Waste must be classified and labelled prior to recycling or disposal. Send to a licensed waste management company. Dispose of as hazardous waste in compliance with local and national regulations. Dispose of product residue in accordance with the instructions of the person responsible for waste disposal.
Contaminated packaging	:	Do not re-use empty containers.

SECTION 14. TRANSPORT INFORMATION

International Regulation

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

IATA-DGR

UN/ID No.	:	1202
Proper shipping name	:	Diesel fuel
Class	:	3
Packing group	:	III
Labels	:	3
Packing instruction (cargo aircraft)	:	366

IMDG-Code

UN number	:	1202
Proper shipping name	:	DIESEL FUEL
Class	:	3
Packing group	:	III
Labels	:	3
EmS Code	:	F-E, S-E
Marine pollutant	:	no

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

Not applicable for product as supplied.

49 CFR

UN/ID/NA number	:	1202
Proper shipping name	:	Diesel fuel
Class	:	3
Packing group	:	III
Labels	:	3
ERG Code	:	128
Marine pollutant	:	no

Special precautions for user

Not applicable

SECTION 15. REGULATORY INFORMATION

The components of this product are reported in the following inventories:

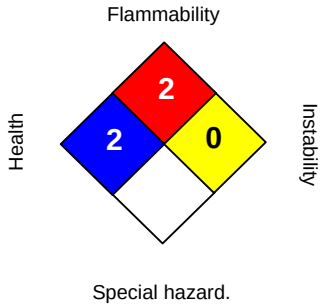
DSL	On the inventory, or in compliance with the inventory
TSCA	All chemical substances in this product are either listed on the TSCA Inventory or are in compliance with a TSCA Inventory exemption.
EINECS	On the inventory, or in compliance with the inventory

SECTION 16. OTHER INFORMATION

Petro-Canada is a Suncor Energy business.
TM Trademark of Suncor Energy Inc. Used under licence.

Further information

NFPA:



HMIS III:

HEALTH	**2**
FLAMMABILITY	**2**
PHYSICAL HAZARD	**0**
PERSONAL PROTECTION	**H**

0 = not significant, 1 =Slight,
2 = Moderate, 3 = High
4 = Extreme, * = Chronic

For Copy of (M)SDS : Internet: www.petro-canada.ca/msds
Canada-wide: telephone: 1-800-668-0220; fax: 1-800-837-1228
For Product Safety Information: 1 905-804-4752

Prepared by : Product Safety: +1 905-804-4752

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

TM Trademark of Suncor Energy Inc. Used under licence.

APPENDIX D 1.1– Agnico Pre-discharge and Spill Response Sea Can checklists

Agnico Eagle Mines: Meadowbank Division
Environment Department

AGNICO EAGLE MEADOWBANK

Pre-discharge Checklist for AEM's Oil Handling Facility in Baker Lake

Date: _____ **Inspected By:** _____

Time: _____ **Vessel Unloading:** _____

Pre-Discharge Check List	Conform	Non-Conform	Comments
Is there two way communications between the OHF and the off-loading Vessel?			
Has a review of response material checklist been completed?			
Current Copy of OPEP and Declaration at the OHF.			
Prior to discharge have the certification of the transfer conduits been received?			
Has there been secondary containment placed underneath each connection of Conduit?			
Is lighting in place at the transfer flange to provide illumination during any transfers taking place during the low to no light hours.			
Prior to discharge has the Vessels Ship/Shore checklist been reviewed and a completed copy received by AEM.			
Prior to discharge inform H&S and Environment Departments that fuel transfer will commence.			
Has the emergency response equipment been reviewed with all personnel and contractors on shore.			

Comments/Recommendations:_____

_____

_____

_____

_____

_____

_____

Signature : _____

Agnico Eagle Mines: Meadowbank Division
Environment Department

AGNICO EAGLE MEADOWBANK

Inventory report for Spill Response Sea Can at AEM's Oil Handling Facility in Baker Lake

Date: _____ **Inspected By:** _____

Time: _____ **Vessel Unloading:** _____

Subject	Conform	Non-conform	Comments
Is the material and PPE stored in a manner that is organized and accessible in order to easily respond to spill?			
Are the sea cans in physically good shape? Easy to open?			
Are the sea cans identified as "Environmental Emergency Sea Can"?			
Is all the spill material in place? Nothing Missing?			
3 x Empty drums (sealed)			
2 x Mini Berm 36"x 36"			
2 x 4 Drums Berm 4'x 8'			
4 x Tarp 20'x 30'			
4 x Tarp 30'x 50'			
10 x Oil Spill Absorbent Pads			
5 x Universal Absorbent Boom 5"x 10' (For Hydro-soluble Chemical)			
5 x Universal Absorbent Boom 8"x 10' (For Hydro-soluble Chemical)			
5 x Petroleum base Absorbent Boom 5"x 10' (for Petroleum product)			
4 x Maritime Barrier (Baffle)			
5 x ABS pipe: 10' long x 4" diameter			
2 x Cell-U-Sorb (Absorbent)			
2 x Amerisorb Peat moss (Absorbent)			

1

Agnico Eagle Mines: Meadowbank Division
Environment Department

2 x Oil Gator Absorbent			
1 x Plug Patties			
4 x Quatrex bags			
2 x Fork Lift Crate			
4 x Hand Shovel			
1 x Cro Bar Chisel			
1 x Ice Breaker Chisel			
1 x Sledge hammer			
15 x Rod bar 4'			
1x ½ drum containment			
100 feet of rope			
Knife to cut rope			
Emergency Boat			
18ft Lund boat			
20 HP motor			
Fresh gasoline in jerry can			
Boat Safety Kit			
2 Mustang Suits			
2 Paddles			
Anchor with 30 feet of rope			
Additional 20 feet of rope			
Is all the PPE material in its place?			
3 x Rain gear -- Pants and Top (L & 2-XL)			
3 x Rubber boots (size 8, 10,12)			
6 x Rubber gloves			
3 x Goggles			
3 x Tyvex suits (L & 2 XL)			

3 x Safety glasses			
3 x Leather gloves			

Comments/Recommendations:_____
_____
_____
_____
_____
_____
_____
_____

Signature : _____

APPENDIX D 1.2 – OHF Ship to Shore Fuel Discharge Procedure

OHF / Ship to Shore Fuel Discharge

		PROCEDURE NUMBER:	**MBK-ENV-0013 Rev. 2**
People concerned	• **Environment** • **Site Services** • **Procurement and Logistics** • **Health and Safety**	**Prepared by**	**Environment Department**
		Authorized by	**Jeffrey Pratt – Environment Coordinator**
Effective :	**July 8, 2015**	***"Safety First, Safety Last … Safety Always!"*** ***"No Repeats" – Our Stepping Stone to ZERO HARM***	
This procedure corresponds to the required minimum standard. Each and every one also have to comply with the rules and regulations of the Nunavut Government in terms of health and safety at work.			

Objective:

- To ensure that prior to the discharge of any fuel into the Agnico Eagle Baker Lake Tank Farm or Agnico Eagle Baker Lake Oil Handling Facility (OHF) that all proper steps are in place to ensure compliance with Canadian Shipping Act, as well as Nunavut Water Board License and Nunavut Impact Review Board Certificate.

Concerned departments:

Environment | Health & Safety | Site Services | Procurement and Logistics

Risks/ Impacts Legend

Health & Safety | Process/quality | Legal Requirement | Environment

Prior to the beginning of the annual fuel discharge the following must be completed.

Procedure	Risks/ Impacts
1. The Oil Pollution Emergency Plan (OPEP) must be reviewed on an annual basis and updated prior to the first annual discharge. This will include but not limited to: a) Reviewing the Phone numbers for emergency's b) Updating maps c) Review and if necessary update equipment lists d) Review roles and responsibilities e) Update Declaration This is the responsibility of the Environment department.	
2. Contact Canadian Coast Guard and Transport Canada Pollution Prevention and make them aware of plans for transferring of fuel into our OHF for that season. This is the responsibility of the Environment department.	
3. Complete *Inventory report for Spill Response Sea Can at AEM's Oil Handling Facility in Baker Lake*. (*Inventory Checklist found on Page 6) This is the responsibility of the Environment department.	
4. Ensure Woodward (Shipping Company) has provided Transfer Conduit Annual certification. This is the responsibility of Environment Department.	
5. All personnel who will be a part of the fuel transfer (including Baker Lake Supervisor and third part contractor Intertek) must review the OPEP and be familiar with preventive measures to take and with the steps to take in the case of a spill event while fueling. This is the responsibility of Procurement and Logistics	
6. Install secondary containment underneath each connection of conduit on land. This is the responsibility of Environment Department	

7. Monitor secondary containment underneath each connection of conduit on land. This is the responsibility of Procurement and Logistics	
8. Ensure there is two way functional communications between the OHF and the off-loading Vessel. This is the responsibility of Procurement and Logistics	
9. Ensure there is lighting in place at the transfer flange to provide illumination during any transfers taking place during the low to no light hours. This is the responsibility of Procurement and Logistics	
10. Prior to any discharge AEM must receive a copy of the Ship/Shore checklist completed by Woodward. And should verify this has been completed (as much as realistically possibly without boarding the ship). This is the responsibility of Procurement and Logistics	
11. Contact must be made with both the H&S and Environmental Departments prior to the discharge of fuels. Meadowbank Health & Safety meadowbank.healthandsafety@agnicoeagle.com Meadowbank Environment meadowbank.environment@agnicoeagle.com This is the responsibility of Procurement and Logistics	
12. The *Pre-discharge Checklist for AEM's Oil Handling Facility in Baker Lake* must be completed, signed and provided to the Environment department prior to discharge. (*Checklist found on Page 5) This must be done for each fuel tanker for each campaign. This is the responsibility of Procurement and Logistics	
Transfer	
1. Once the above points are completed, the ship to shore transfer can commence.	
2. Photos of the complete fuel transfer process should be taken, visually proving that all above procedures have been reached. This is the responsibility of Environment department and Procurement and Logistics.	

3. During the ship-to-shore transfer, AEM will have competent personnel on location at all times to monitor the fuel transfer and maintain contact with the tanker's crew. This is the responsibility of Procurement and Logistics.	
4. Monitor the fuel transfer at the beginning of each transfer and after that on an hourly basis checking the manifold, conduit, tank, and any connection points on land for spills and/or leaks. Communication between shore and ship should take place on an hourly basis. This is the responsibility of Procurement and Logistics.	
5. We are required by law to have a fuel spill scenario every two years. However, since we have shift work at Meadowbank, to ensure adequate training annually we will do mock spill/training and switch shifts each year. This way each shift completes every second year. This is the responsibility of Environment Department in conjunction with ERT to plan and execute.	

APPENDIX D 1.3 – 2016 Meeting Minutes of Fuel Transfer Procedure Revision Meeting

Environmental, P&L and E&I Departments
Ship to Shore Fuel Discharge Meeting Agenda
Agnico-Eagle Mines Limited
Meadowbank Project

Date:	April 19, 2016
Prepared By:	Environment Department
Meeting Lead By:	Robin Allard and Erika Voyer
Attendees:	Monique Cossette (P&L), Christian Soucy (E&I), Alex Arcand (E&I), Robin Allard (ENV), Erika Voyer (ENV)
Distribution:	Meadowbank Environment, Meadowbank Procurement and Logistic, Meadowbank Energy and Infrastructure

E&I – Energy and Infrastructures, P&L – Procurement and Logistics, ENV - Environment

	Procedure MBK-ENV-0013 Review	Task Owner	Due Date
1	**OPEP Review**	ENV	May 9th (+60 days prior to transfer)
2	**Contact Canadian Coast Guard and Transport Canada Pollution Prevention**	ENV	May-June
3	**Complete Inventory report for spill response c-can**	ENV	May-June
4	**Ensure that Woodward provide Transfer Conduit Annual certification (Hose Cert.)**	ENV	Prior to first transfer – in OPEP
5	**All personal to review the OPEP and be familiar with preventive measures.** (OPEP will be provided by Env.)	All	Prior to first transfer – July 1st
6	**Install secondary containment underneath each connection of conduit on the land** - *For Jet A hose installation – collaboration between P&L and E&I*	ENV	Prior to first transfer
7	**Monitor secondary containment underneath each connection of conduit on land.**	P&L (Intertek)	Before and during transfer
8	**Ensure there is two way functional communications between the OHF and the off-loading Vessel**	P&L	Before and during transfer
9	**Ensure there is lighting in place at the transfer flange to provide illumination during any transfers taking place during the low to no light hours**	P&L/ E&I (if repairs is required)	Before and during transfer
10	**Prior to any discharge AEM must receive a copy of the **Ship/Shore checklist completed by Woodward. And should verify this has been completed (as much as realistically possibly without boarding the ship).**	P&L	Prior to each transfer

11	**Contact must be made with both the H&S and Environmental Departments prior to the discharge of fuels (generally by email)**	P&L	Prior to each transfer
12	**The Pre-discharge Checklist for AEM's Oil Handling Facility in Baker Lake must be completed, signed and provided to the Environment department prior to discharge.** **This must be done for each fuel tanker for each campaign.**	P&L (Intertek)	Prior to each transfer
During Transfer Procedure review			
1	**Once the above points are completed, the ship to shore transfer can commence** - *Valve opening and sequence for tank filling will be completed by E&I*		
2	**Photos of the complete fuel transfer process should be taken, visually proving that all above procedures have been reached**	ENV. and P&L	Prior and during transfer
3	**During the ship-to-shore transfer, AEM will have competent personnel on location at all times to monitor the fuel transfer and maintain contact with the tanker's crew.**	P&L (Intertek)	During transfer
4	**Monitor the fuel transfer at the beginning of each transfer and after that on an hourly basis checking the manifold, conduit, tank, and any connection points on land for spills and/or leaks. Communication between shore and ship should take place on an hourly basis**	P&L (Intertek)	During transfer
5	**We are required by law to have a fuel spill scenario every two years. However, since we have shift work at Meadowbank, to ensure adequate training annually we will do mock spill/training and switch shifts each year. This way each shift completes every second year.**	ENV and ERT	Summer, during period of transfer
Miscellaneous			
1	**Document required prior to fuel transfer** - Hose certifications (Hydrostatic test) – Woodwards (will be included in OPEP) - **Notice of readiness, Floating hose Ship/Shore Cargo checklist , Cargo preparation checklist - Woodwards - OHF Ship to Shore Fuel Discharge AEM Checklist prior to transfer - AEM	P&L	

2	**Intertek role and responsibility** Intertek is the contractor under the responsibility of P&L hired for the fuel transfer. Intertek must be aware of the required procedure for the fuel transfer and have received the proper documents (OPEP, OHF / Ship to Shore Fuel Discharge AEM procedure). Intertek will complete some tasks related to P&L responsibilities during transfer.	P&L	
3	**Management of the wildlife monitors to be on the barge** - ENV will contact Woodwards for lodging on the boat - ENV will contact Comm. Affairs in BL for management of the monitors this summer	ENV/Comm. Affairs	
4	**Inspection by Environment**	ENV	Prior and during transfer

APPENDIX D 1.4 – 2016 Mock Spill Minutes

AGNICO EAGLE

On October 3rd, 2016 AEM Sr. Environment Technician Tom Thomson and Environment Technician Randy Schwandt met with Intertek personal in Baker Lake to conduct a mock spill at the Baker Lake transfer valve.

AEM Sr. ENV Tech Tom Thomson took photographs and documented the spill actions as well as acted as the "Control Room" responder. AEM ENV Tech Randy Schwandt acted as the BL Dispatch and the ENV Technician on the scene.

The scenario was a leaking flange at the transfer valve. The secondary containment under the transfer valve had overflowed and was now leaking diesel fuel into the tundra and towards the shoreline. Below is the timeline of the scenario.

13:30 – Spill occurs (45g drum w/water and dye is tipped over outside the secondary containment pool)



13:34 – Intertek crew do visual inspection of transfer valve and pipeline. Overflow of secondary containment pool and leaking flange at the transfer valve is observed by Intertek crew.



AGNICO EAGLE

13:36 – Intertek crew calls the vessel to stop transfer of fuel and relays the message of leaking flange at transfer valve to the Captain.



13:40 – Intertek crew has receive confirmation from captain of vessel that fuel transfer has stopped. Intertek calls Code 1 to Baker Lake dispatch. BL dispatch confirms the spill and advises Intertek that they will relay information to Environment department.

13:45 – Intertek crew goes to Emergency Sea-Can to pull out spill response equipment



13:50 – Spill response equipment is deployed by Intertek crew and containment of the spill commences. ENV Tech arrives on site to assess the spill and advise crew of containment and clean up actions

AGNICO EAGLE

13:52 – AEM ENV Tech relays status of the spill and clean up/containment actions to AEM Control room.





13:55 – AEM ENV Tech asks Site Service for vacuum truck and ENV team for Emergency spill trailer with pump to be brought down to Baker Lake to empty secondary containment pool.

14:00 – AEM ENV Tech asks Intertek crew if the spill is contained. Intertek confirms and ENV tech relays status of spill to MBK control room and MBK environment team.

AGNICO EAGLE

AEM Comments/Recommendations: Intertek crew communicated and confirmed with the vessel the stopping of fuel transfer. The Baker Lake dispatch was also notified of the spill. After identifying the source of the spill and assuring the safety of the crew - Intertek commenced preparing spill response equipment for containment and clean up.

AEM stressed the importance of taking all necessary precautions to ensure that a spill does not enter Baker Lake. Containment booms, diversion booms, or maritime booms are all available in the Emergency Sea Cans. Be sure to use all available resources to contain spill. AEM also mentioned that any heavy equipment such as backhoes, excavators, dump truck is available at any time in the event of a spill. Intertek should not hesitate to ask for AEM assistance.

AEM mentioned the importance of the making the facility safe by installing barricades or a "No Entry" perimeter around the spill area. Intertek should not hesitate to ask for AEM assistance.

AEM mentioned to Intertek/ENV Tech to follow chain of command. Use people/resources as necessary – i.e. send 1 or 2 people to get spill response gear, another person to barricade area, another person to call dispatch or control, etc.

AEM mentioned the OPEP and Spill Contingency plan located in the spud barge office. If Intertek crew is unsure of what to do or what procedures to follow – they can refer to the plans listed above or call Environment department. Again – Intertek should not hesitate to ask for AEM assistance.

Intertek Comments/Recommendations: Intertek asked AEM to provide a radio with BL Dispatch, Vessel, and Spud Barge radio frequencies to allow for quicker communication with the Spud Barge and BL dispatch in the event of a spill.

Intertek asked AEM to provide more "spill" drums (at each connection) or move one of the emergency spill Sea-cans closer to the transfer valve to allow for faster deployment of spill recovery equipment in the event of a spill.

Intertek asked AEM for a solid berm or a solid secondary containment pool around the transfer valve. The current secondary containment pool walls are pushed down by the pipes and would not fully contain a spill or leak if it occurred. Intertek suggested a small genset, pump, and empty tote be accessible to empty the containment pool in the event of a spill.

Intertek suggested to AEM an upgrade of spill response equipment, including more equipment to respond a spill that entered Baker Lake.

Intertek asked for additional tower lights along the pipeline to assist in the inspection process.

APPENDIX E 1.1– COASTAL SHIPPING LTD. SHIP GENERAL CHECKLIST

ARCTIC WATERS OIL TRANSFER

TRANSFER PARTICULARS

VESSEL / STATION INFORMATION			Location:	
	Supplier	Recipient	Start Date	
Vessel / Station Name			Start Time	
Officer in Charge			Finish Date	
Title			Finish Time	

OPERATIONS	
Transfer Type:	Connection Type (eg 2/4 bands):
Total Length of Hose (m):	Number of Hose Sections:
Diameter (m):	Test Pressure (kPa):
Purge Method: Nitrogen / Air	Pig Used: Yes / No
Boom deployed before transfer: Yes / No	If yes, type:
Work Boat used: Yes / No	
Hose Strain Relief System used: Yes / No	

PRODUCT INFORMATION				WEATHER CONDITIONS
Type	Quantity	Start Time	Finish time	Ice:
				Wind Force (knots):
				Wind Direction:
				Sea State:
				Visibility:
				Light Conditions:

COMMUNICATIONS	
Primary Method:	(VHF/UHF CHAN/FREQ)
Backup Method:	(PHONE, RADIO, ETC)
Language Used:	

ARCTIC WATERS OIL TRANSFER **GENERAL CHECKLIST FOR ALL TRANSFERS**

GENERAL PROCEEDURE	CHECK	SUPPLIER		RECIPIENT		COMMENTS
	YES	INITIAL	DATE	INITIAL	DATE	
1. Pre-transfer P.A. Announcement made?						
2. All personnel involved are informed & adequately trained? A designated person in charge on duty at all times during the transfer operation?						
3. Language agreed to?						
4. All communications including Backup System tested?						
5. Is fire fighting equipment tested, available & are fire screens in place?						
6. Are all regulations for transfer unders tood and observed and "NO SMOKING, NAKED LIGHTS or FLAMES" signs posted?						
7. Are flashlights "intrinsically safe" and approved?						
8. Are window type A.C. units switched off?						
9. Are exterior doors and ports leading to main deck closed?						
10. Is equipment, tools & material required for transfer available at hand?						
11. Is containment equipment and absorbent material available?						
12. Has Transfer Emergency Shutdown been tested?						
13. Hoses to be used have been checked for:						
a) correct diameter & length to reach other station,						
b) chafing, cracks or other deformation,						
c) damaged fittings,						
d) blanking of hoses,						
e) continuity.						
14. All repair work at either station stopped. (if dangerous for transfer)						
15. Inert gas system is fully operational (if fitted).						

16. Main transmitting aerials and radar scanners are used with due care .

GENERAL PROCEEDURE	CHECK	SUPPLIER		RECIPIENT		COMMENTS
	YES	INITIAL	DATE	INITIAL	DATE	
17. All craft alongside are authorised and following hazard warnings, etc.						
18. Is hose test certificate or records available for inspection?						
19. Have weather and ice report s been determined?						
20. Are gas concentration accumulations in still air conditions monitored?						
21. Are all scuppers plugs in place?						
22. Are main decks free of standing water?						
23. Were manifolds drained before removing blanks?						
24. Are pressure gauges ready and in place?						
25. All sea valves on cargo systems closed?						
26. Are drip cans and trays in place, and empty?						
27. Is lighting adequate for all transfer requirements?						
28. Is mooring watch being monitored?						
29. Are spill reporting procedures understood?						
30. Are all tank vents free of blockage?						
31. Have Pressure/Vacuum Relief (PVR) valves been checked?						
32. Has a post-transfer PA announcement been made?						
33. Are International signals being displayed? (if required)						
34. Has a written procedure and the sequence of the transfer been agreed upon?						
35. Is there a clear understanding of the watch and shift arrangement?						
36. Will there be sufficient personnel a vailable at all times to monitor the transfer operation, tend cargo hose and mooring lines and take appropriate action in an emergency?						

APPENDIX E 1.2– COASTAL SHIPPING LTD. SHIP TO SHORE CHECKLIST

ARCTIC WATERS OIL TRANSFER **CHECKLIST FOR SHIP TO SHORE TRANSFERS**

	SHIP to SHORE - PROCEEDURE	CHECK	SUPPLIER		RECIPIENT		COMMENTS
		YES	INITIAL	DATE	INITIAL	DATE	
1.	Has the General Checklist for All Transfers complete?						
2.	Are all vehicles outside the agreed safe distance?						
3.	Are the emergency towing wires in place?						
4.	Is the vessel ready to move under its own power immediately?						
5.	Has a hose drainage plan been agreed upon?						
6.	Has the hose string been checked to working pressure?						
7.	Is a work boat deployed to check the hose frequently for leaks during transfer?						
8.	Are all transfer associated valves and tanks closed after transfer?						
9.	Have hoses been purged prior to their return to the vessel?						
10.	Are hoses and other transfer equipment properly stowed?						

APPENDIX E 1.3– COASTAL SHIPPING LTD. CARGO PRE ARRIVAL

ARCTIC WATERS OIL TRANSFER **CHECKLIST FOR BARGE TRANSFERS**

	BARGE - PROCEEDURE	CHECK	SUPPLIER		RECIPIENT		COMMENTS
		YES	INITIAL	DATE	INITIAL	DATE	
1.	Has the General Checklist for All Transfers been completed?						
2.	Is the dis charge pump as close as possible to suction pipe of the discharge tank?						
3.	Check hard line hose between pump and tank (if fitted)?						
4.	Check couplings on discharge between pump and recipient?						
5.	Do not exceed the following: a) maximum list (P & S) b) maximum trim (FWD & AFT)						
6.	Are barge tank diagrams and pipe schematics available?						
7.	Are fenders between the barge and other vessel?						
8.	Is barge equipment bonded to barge structure?						
9.	Are fire screens installed in ullage openings?						
10.	Are all valves closed and hoses stowed after completion of transfer?						

APPENDIX F – Agnico Internal Spill Report Form

Agnico Eagle Mines Meadowbank Project:
Internal Spill Reporting Form

(Spills greater than the *Reportable Volume*, see Spill Contingency Plan, require the completion and submission of the *Nunavut Spill Report Form*)

AGNICO EAGLE	Meadowbank Project	Spill report #.
Date and time of spill :		
Location of spill :		
First responder name :		
Company Name:		
AEM Contact:		
Nature of contaminant :		
Volume/quantity of the container / tank (L)		
Quantity spilled (L) :		
Cause of the spill :		
Contaminant collected by :		
Follow-up done by :		
Actions taken :		
Report completed by:	Date :	
Incident investigation recommended :	YES ☐	NO ☐
Government agency notified :	YES ☐	NO ☐
Date of notification to government agency :		
Date of report : _____	Signature of environmental personnel : _____	

Landfarm Design and Management Plan, Version 4

MEADOWBANK GOLD PROJECT

Landfarm Design and Management Plan

In Accordance with Water License 2AM-MEA1525

Prepared by:
Agnico Eagle Mines Limited – Meadowbank Division

Version 4
March, 2017

EXECUTIVE SUMMARY

General Information

The Landfarm Design and Management Plan (LDMP) describe the design features and operational procedures for the landfarm constructed at the Meadowbank Gold Project site for the storage and treatment of petroleum hydrocarbon contaminated soil.

Annual Review

The LDMP will be reviewed and updated if necessary. Completion of the review of the LDMP will be documented through signatures of the personnel responsible for reviewing, updating and approving the LDMP.

Record of Changes

A record will document all significant changes that have been incorporated in the LDMP subsequent to the latest review. The record will include the names of the persons who made and approved the change, as well as the date of the approval.

Distribution List

Agnico Eagle Mines Limited will maintain a distribution list for the LDMP providing information about all parties that receive the plan including mine personnel, departments, and outside agencies.

IMPLEMENTATION SCHEDULE

As required by Water License 2AM-MEA1525, Part B, Item 11, the proposed implementation schedule for this Plan is effective immediately (February 2017) subject to any modifications proposed by the NWB as a result of the review and approval process.

DISTRIBUTION LIST

Agnico Eagle – Environmental Superintendent
Agnico Eagle – Environmental Senior Coordinator
Agnico Eagle – General Mine Manager
Agnico Eagle – Energy and Infrastructure Superintendent
Agnico Eagle – Field Services Supervisor
Agnico Eagle – Engineering Superintendent

DOCUMENT CONTROL

Version	Date	Section	Page	Revision
1	08/10/08	2		Remediation guidelines used and the parameters measured
		7		Details on storage and treatment options for metals, solvents, glycol and heavy oils; Measures to prevent damage to the liner during mechanical operation
		4		Contingency plans for exceedances in the amounts of contaminated soil and/or snow/ice
		5		Details describing the design components/specifications of the spillway
		8		Contingency planning and monitoring of sump volumes during the snowmelt period
2	12/10/22	All	All	Comprehensive revision to original plan
3	13/02/28	All	All	Further detail and rationale provided
4	17/02/20	All	All	Comprehensive review. Add detail regarding the Landfarm #2

Prepared By: Meadowbank Environment Department

Approved By: Jamie Quesnel
Environmental Superintendent

TABLE OF CONTENTS

1 Introduction 6
1.1 Background 6
1.2 Objectives 6
2 Spill Prevention 7
2.1 Spill Management Documentation 7
2.2 Spill Severity 7
3 Landfarm Design 8
3.1 Background 8
3.2 Location 8
3.2.1 Proximity of Surface Water 12
3.2.2 Proximity of Groundwater 12
3.3 Design 12
3.3.1 Soil Volume Requirements Landfarm 2 12
3.3.2 Design Specifications 12
4 Landfarm Operation and Maintenance 14
4.1 Management Responsibility 14
4.2 Acceptable Materials 14
4.2.1 Contaminants 14
4.2.2 Grain Size 15
4.3 Contaminated Soil Additions 15
4.3.1 Spill Excavation 15
4.3.2 Placement in the Landfarm 15
4.4 Contaminated Snow 15
4.5 Remediation 15
4.5.1 Absorbent Materials 16
4.5.2 Aeration 16
4.5.3 Soil Moisture 16
4.5.4 Nutrient Amendment 16
4.6 Removal of Soil from the Landfarm 17
4.6.1 Remediation Guidelines 17
4.6.2 Sampling and Analysis 18
4.6.3 Soil Removal 18

4.7 Water and Snow Management 19
4.7.1 Snow Management 19
4.7.2 Water Management 19
4.8 Landfarm Abandonment 19
4.9 Summary of Activities 20
5 Contingency Options 22
5.1 Large Spill Event 22
5.2 Alternate Treatment Options 22
5.2.1 Soil Amendment 22
5.2.2 Tier 2 – Modified Criteria Approach 22
5.2.3 Thermal Desorption 23
5.2.4 Direct Placement in the TSF or PRSF 23
6 Plan Review and Continual Improvement 24

LIST OF TABLES

Table 1 - Summary of relevant Government of Nunavut Tier 1 soil remediation criteria for surface soil for industrial land uses. 18
Table 2 - Summary of landfarm activities and records to be kept. 21

LIST OF FIGURES

Figure 1. General location of Landfarm 1 and Landfarm 2. 9
Figure 2. Landfarm 1 as-built design 10
Figure 3. Landfarm 2 as-built design 11

1 INTRODUCTION

1.1 Background

In 2008 the Landfarm Design and Management Plan was developed by Agnico Eagle in accordance with Water License 2AM- MEA0815 to describe the handling and remediation of petroleum hydrocarbon (PHC)-contaminated soil at the Meadowbank site. During construction and initial operations (2008-2011, prior to construction of the landfarm facility), soil potentially contaminated with PHCs, as a result of spills was deposited in two quarries (Q5 and Q22) along the All Weather Access Road (AWAR). The majority of this soil was from a transport tanker spill in 2010 and from the contractor camp used for roadway construction in 2007 and 2008. In 2012 the transport of this soil back to the minesite for treatment/storage at the onsite landfarm began. Subsequent landfarm design and management plan modifications (Version 2 and 3) focused on minimizing the waste footprint onsite, and maximizing remediation potential through implementation of a pilot bioremediation project, as well as spill prevention and contingency planning. The current version (Version 4) has been updated to describe construction of an extension to the original landfarm, and construction of a new landfarm facility in 2016.

1.2 Objectives

Onsite storage and remediation has been established as the preferred method for treatment of petroleum hydrocarbon-contaminated soil that may be generated on the Meadowbank site, Exploration Camp and Amaruq Road. Specifically, remediation through landfarming has been identified as the primary treatment option and, as such, is the focus of this contaminated soil management plan. A pilot project to enhance rates of bioremediation through addition of a nutrient source is also described. Alternate contingency options in the event that landfarming is not successful or as efficient as planned are also discussed.

This plan is a component of the Meadowbank Environmental Management System. The objectives of this plan are:

- To provide an overview of contaminated soil management at Meadowbank
- To describe the physical setting, location and design criteria of the landfarm
- To define acceptable types of contaminated soils to be placed in the landfarm and conditions for removal of treated soil
- To define operating procedures and monitoring requirements for the landfarm, including the pilot bioremediation project
- To describe contingency options for alternate treatment/storage of PHC contaminated soil

2 SPILL PREVENTION

2.1 Spill Management Documentation

Spill prevention is the first stage in contaminated soil management at the Meadowbank site. Three documents describe spill prevention, management and response at this facility: the Spill Contingency Plan, the Emergency Response Plan, and the Oil Pollution Emergency Plan. Specifically, Section 2.1 of the Spill Contingency Plan describes spill prevention measures and can be referred to for further detail. All are updated regularly. General spill prevention methods include:

- Regular inspections of fuel/chemical storage areas for leaks
- Training in safe handling procedures
- Keep containers sealed
- Use methods of secondary containment
- Keep over pack drums nearby to contain leaking drums
- Keep storage area secure from unauthorized access, and protected from weathering and damage
- Segregate incompatible materials
- Regular meetings with site departments

2.2 Spill Severity

In 2011, spills of landfarmable materials (fuel and hydraulic oil) at Meadowbank totaled 5,338 liters. In 2012, Meadowbank Division Environment Department increased delivery of spill prevention programing. This included more departmental information sessions to maintain awareness about spill prevention methods and reporting procedures. In 2012, spills of fuel and hydraulic oil have been reduced to 3,012 liters. In 2013, the Environment Department incorporated a site wide training session for every employee on site. In addition, the Emergency Response Team as well as Environment and Road Maintenance staff had extensive training in spill response by a consultant specializing in spill training (January, 2013). Training pertains to spill response on the tundra as well as surface water. In addition, Agnico has begun use of a new hydraulic fluid (Hydrex^{TM} Extreme; Petro-Canada) that contains no heavy metals and is 40% biodegradable in 28 days. It is therefore estimated that any soil contaminated with the new fluid will be more rapidly remediated in the landfarm than soil contaminated with the previously used fluid. A significant increase of reported spills was noted in 2016 comparing to previous years. The overall changes are a result of different factors, focus on proper spill reporting, equipment wear and increased mining production. An action plan was initiated to address the increase and identify proper improvement channels.

3 LANDFARM DESIGN

3.1 Background

When spills do occur, onsite storage and remediation is the most practical and efficient method of handling contaminated soil, particularly in an isolated location like Meadowbank. For PHC contamination, bioremediation through landfarming has been identified as a viable remedial technique. This method involves spreading, mechanical mixing, and placing the contaminated soil in windrows within a containment area and promoting conditions favorable for the volatilization and aerobic microbial degradation of hydrocarbons. A number of environmental factors and physical properties of the soil affect microbial growth and rates of biodegradation, including temperature, soil moisture, nutrient content, salinity and soil particle size.

Previously, a landfarm options analysis prepared for Agnico by Golder (2007a) identified some of these factors, and presented the following information from the literature on landfarming in the north. Although rates of biodegradation decline with temperature, landfarming is still a feasible technique in arctic climates (Reimer et al. 2005). Microbial activity stops between 0 – -5°C (although volatilization continues at this temperature), so degradation in the north is typically restricted to the months of June – September. Nevertheless, degradation was reported at 70% after one year in a study in Alert, NU (Greer et al. 2007), and 90% over two summers on Resolution Island (Paudyn et al. 2005).

3.2 Location

The overall site plan for the Meadowbank Gold Project and the location of the landfarm facilities are shown in Figure 1. This central location was chosen to minimize the waste footprint on site and the transport distance of contaminated material from spill locations. All of the waste generated at Meadowbank in the form of tailings, wasterock and the site landfill is in close proximity. The location of the original landfarm facility (Landfarm 1) is directly north of the South Cell Tailings Facility. In 2016, Landfarm 1 was extended due to operational work required at the buttress of the Stormwater Dike. The Landfarm 1 extension as-built drawing is presented in Figure 2.

In 2016, a second landfarm facility (Landfarm 2) was constructed in the same general location within the South Cell Tailings impoundment, since the Landfarm 1 facility is planned to be flooded by reclaim water in mid-2017. Landfarm 2 is located on the north east side of the South Tailing Cell, north of the Central Dike. Specifications of the Landfarm 2 design are presented in the as-built drawing, Figure 3. As with the original landfarm, the Landfarm 2 facility is designed with one soil remediation/storage cell.

Landfarm 1 may continue to be used until mid-2017. At that point, any un-remediated soil will be moved to Landfarm 2 as necessary.

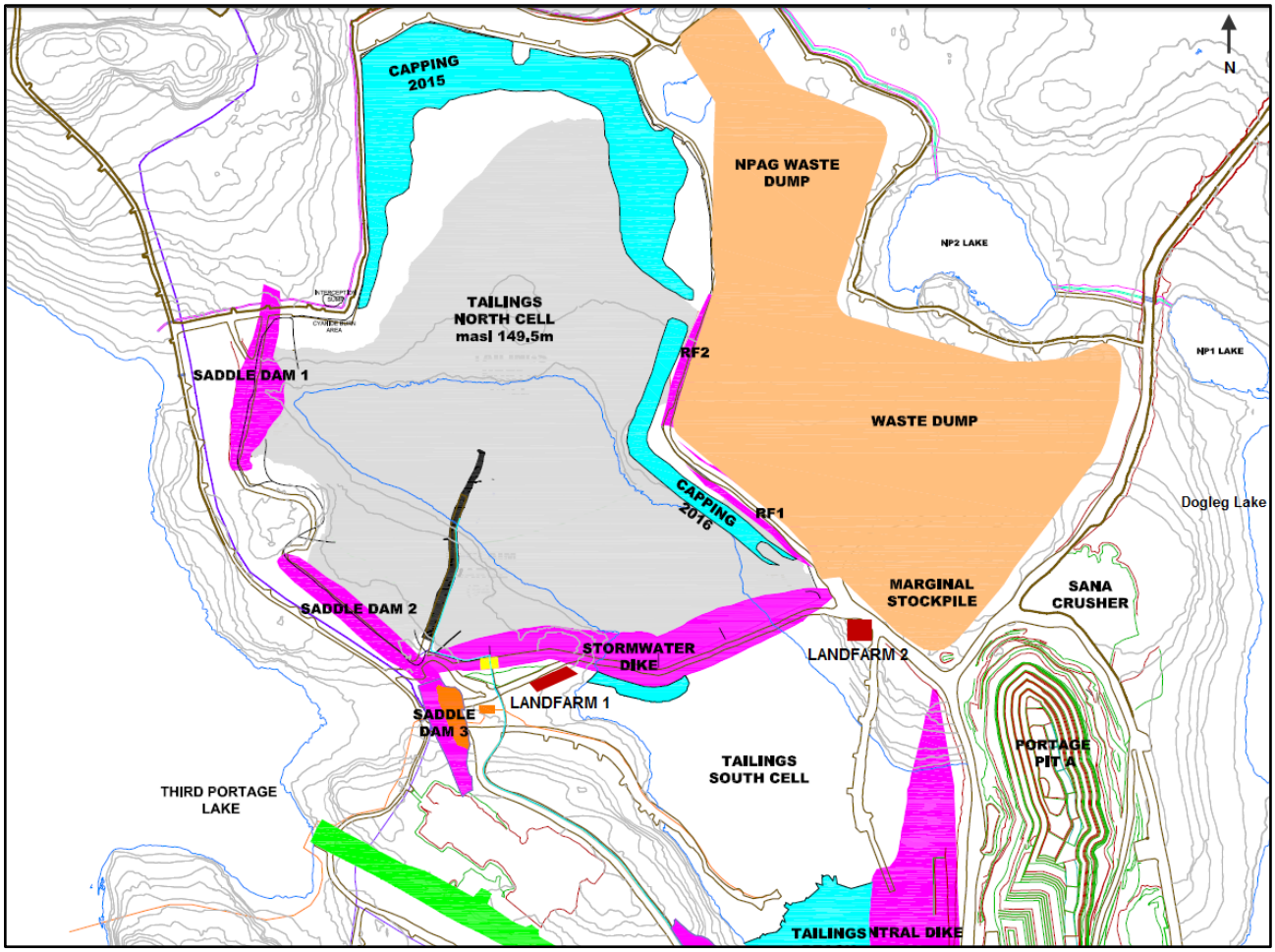


Figure 1. General location of Landfarm 1 and Landfarm 2.

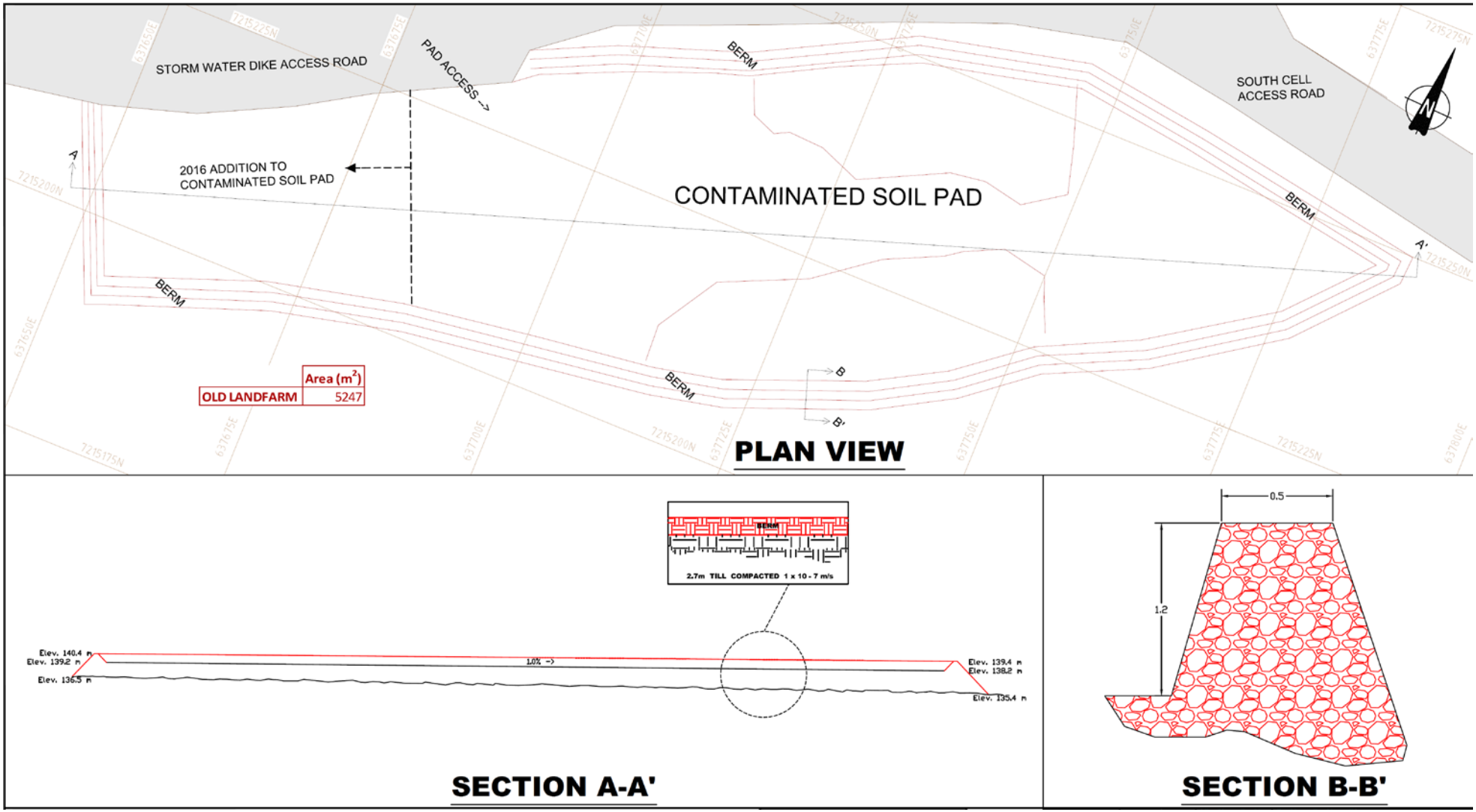


Figure 2. Landfarm 1 as-built design

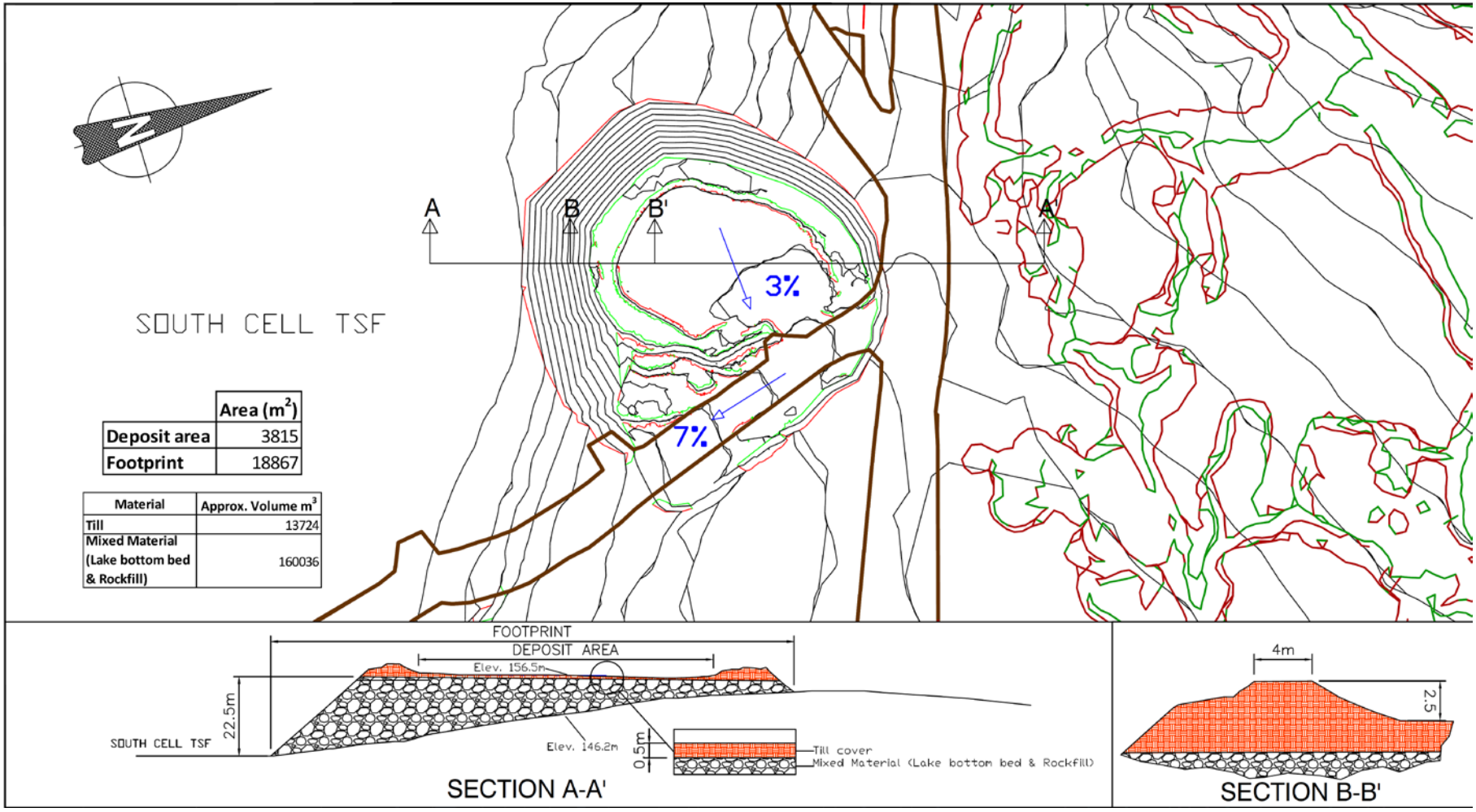


Figure 3. Landfarm 2 as-built design

3.2.1 Proximity of Surface Water

Landfarm 1 is located 300 m from the nearest water body, Third Portage Lake (TPL) and immediately adjacent to the North Cell Tailings Storage Facility (TSF). Surface drainage in this area is easterly, towards the TSF and away from TPL.

Landfarm 2 is 900 m west of the nearest water body (Dogleg Lake). Surface drainage in the area of Landfarm 2 is westerly, towards the South Tailings Cell and away from surface watercourses.

3.2.2 Proximity of Groundwater

In the Meadowbank area, the shallow groundwater is estimated to be 1.5 m below surface (active layer July – October), at the average depth of thaw. In order to prevent movement of contaminants from the landfarm facility into groundwater, Environment Canada (SAIC, 2006) recommends implementation of a barrier with 10^{-7} m/s hydraulic conductivity at a thickness of 0.6 m. The Meadowbank Landfarm 1 facility pad is constructed of 2.7 m of compacted till with a hydraulic conductivity of 10^{-7} m/s. The Landfarm 2 cell is constructed with a 0.5 m thick layer of compacted till base with hydraulic conductivity estimated of 10^{-7} m/s, over a constructed pad which varies between 6 m and 22.5 m in thickness. Therefore, no impacts to groundwater are anticipated.

3.3 Design

The landfarm facilities are designed with one soil remediation/storage cell. The design volumes of the cells are based on allowances for the materials to be treated. This calculation is described in the following section.

3.3.1 Soil Volume Requirements Landfarm 2

In September 2016, Landfarm 1 held a total of 1,258 m^3 of contaminated soil, based on survey results. Currently production will continue through 2018 for an expected additional required landfarm capacity of 692 m^3 (2 years x 346 m^3/year; average yearly amount of contaminated soil, from LDMP (Agnico, 2013)). With an additional 30% for contingency, and conservatively assuming that no soil will be remediated in Landfarm 1 in 2017 and before closure, the total estimated required capacity for landfarm 2 is 2,535 m^3.

3.3.2 Design Specifications

Specifications of the landfarm designs are shown in Figure 2 and 3. Landfarm 1 is constructed with a 1.5 m high berm and a 2.7 m deep compacted till base with hydraulic conductivity of $1x10^{-7}$ m/s. The slope of the base is 1.5%.

Landfarm 2 is constructed with a 2.5 m high berm and a 0.5 m thick compacted till base with hydraulic conductivity estimated of 10^{-7} m/s. The slope of the base is 3% towards the east side, and 7% towards the South Tailings Cell. The pad under the till layer on top of the tundra

varies from 6 – 22.5 m thick.

For Landfarm 1, the useful landfarm area is 5,247 m^2, with the extension. The area of Landfarm 2 is 3,815 m^2. Based on landfarm specifications of other northern mines (Ekati Diamond Mine – in Golder, 2007a), contaminated material can be stockpiled up to 4 m high. Accounting for a 25% loss of area due to sloping at that windrow height, the landfarm area will allow for the storage of a maximum of 11,445 m^3. This will readily accommodate the estimated total of 2,535 m^3 of contaminated soil, should all of it need to be stored until closure. In addition, ample room will be available to accommodate a designated area for spreading of contaminated coarse-grained material that cannot be bioremediated (see Section 4.2.2).

Based on the available area, maximum windrow size will be 15 m wide at base x 4 m high x 50 m long, but smaller piles will be used as space allows maximizing rates of biodegradation and volatilization.

4 LANDFARM OPERATION AND MAINTENANCE

The following presents the operational procedures that apply to each landfarm facility.

4.1 Management Responsibility

Agnico Eagle will be responsible for managing and implementing the operation plan. Operation and monitoring of the facility will come under the responsibility of the Environment Superintendent. Designation of training requirements is the responsibility of Meadowbank Environment Department.

4.2 Acceptable Materials

4.2.1 Contaminants

The landfarm facility will only treat and/or store petroleum hydrocarbon contaminated soils that have been generated through mine-related activities at the Meadowbank Gold, Project Meadowbank exploration camp and the Amaruq Road. Material from other sites will not be accepted without approval from the Nunavut Water Board, AANDC Water Resources Officers and the Kivalliq Inuit Association.

The following products may be treated in the landfarm if used onsite and spilled on soil:

- Diesel fuel
- Gasoline
- Aviation fuel (Jet A)
- Hydraulic oil
- Other light oil e.g. engine oil, lubricating oil

In the event that the contaminant source is unknown, soil samples will be analyzed for petroleum hydrocarbons and possibly additional contaminants prior to placement in the landfarm. These additional parameters could include total metals, oil and grease, and volatile organic compounds. Analysis for additional compounds will be determined by the Environment Department on a case-by-case basis. Concentrations of contaminants will be compared to the site background values (for metals) and/or criteria in the GN Guidelines for Contaminated Site Remediation (March, 2009). If this analysis indicates soil contamination above background or GN guidelines with any substances not described in Section 4.2.1 (i.e. non-PHC contaminants), it will not be placed in the landfarm facility. This is to ensure PHC contaminated soil is not contaminated with other products.

Spills of > 100 L of non-PHC material (e.g. solvents, glycol) will be placed in drums and stored in the site Hazmat area for shipment south to approved facilities during barge season. Spills of non-PHC material < 100 L will be placed in the TSF.

4.2.2 Grain Size

While very coarse-grained larger soil material does not readily retain moisture and nutrients, inhibiting bioremediation, volatilization will occur more rapidly (SAIC, 2006). It has been noted that this material likely contains lower concentrations of contaminants due to a lower volume:surface area ratio, and can typically be screened out prior to landfarming (SAIC, 2006). A 2010 study at Meadowbank (Qikiqtaaluk Environmental, 2010) indicated increasing concentrations of PHC with decreasing grain size in one group of samples with soil fractions of 0.5, 0.5-1 and >1" (two other groups sampled were below detection at all grain sizes) (see Section 4.3.1).

4.3 Contaminated Soil Additions

4.3.1 Spill Excavation

Soil contaminated with the above-described petroleum hydrocarbon materials will be excavated from the source and transported to the landfarm facility in dump trucks or by roll- off containers. Care will be exercised to ensure that the entire spill is excavated (verified by visual assessment, by using a PID meter or sampling if necessary) and that none of the contaminated material is lost during transport.

4.3.2 Placement in the Landfarm

All material collected (coarse and fine) from spill locations will be deposited at the landfarm to be remediated.

A mechanical screener, used to separate coarse and fine material, will be operated to segregate material once in landfarm when conditions permit it.

4.4 Contaminated Snow

For spills < 100 L, PHC-contaminated snow will be placed in a designated area of the landfarm and treated as contact water after snowmelt.

For spills > 100 L, PHC-contaminated snow will be excavated and stored in labeled drums. After snow melt, the contaminated water will be pumped through the site's oil-water separator (carbon filter) to remove PHC residue. The treated water will be sampled per Part F, Item 7 of the Water License, and discharged to the Stormwater Management Pond if criteria are met. If criteria are not met, water will be treated as hazardous material and shipped south. Also, after snowmelt, visible product will be cleaned up with absorbent pads or booms.

4.5 Remediation

Remediation of fine-grained PHC-contaminated soil in landfarms occurs naturally through volatilization and aerobic microbial degradation. Soil aeration and nutrient amendment are recognized as methods of improving rates of remediation. To this end, remedial operations at

the Meadowbank site include soil mixing (aeration) and a pilot project utilizing onsite nutrient additions. While it is recognized that pH, salinity, moisture content and microbial population density also contribute to rates of degradation, these factors will not be explicitly investigated or managed unless remediation rates are too slow to meet the site closure time period (see Section 5.2).

4.5.1 Absorbent Materials

Coarse-grained soils are not readily bio-remediated, but concentrations of PHC contaminants may still be reduced through volatilization. Oil absorbent pads will be used to help remove visible product from coarse-grained material. Used absorbent materials will be incinerated.

4.5.2 Aeration

In order to promote aerobic conditions throughout the windrows, soil will be mixed mechanically with earth-moving equipment. This turnover of soil piles will occur at least once per year, during the summer months. The presence of coarse material also helps creating gaps within the piles which will increase aeration and help degradation of PHC.

4.5.3 Soil Moisture

Prior to turning, site personnel will ensure that soil is not so dry as to generate significant dust, nor overly saturated. If soil is dry, water from within the landfarm containment area will be used as a moisture source and sprayed on the piles. If no accumulated water is available, a freshwater supply will be used. If the windrows are saturated, aeration will be conducted at a later date.

4.5.4 Nutrient Amendment

A number of studies have indicated that amendment with nutrients may increase rates of biodegradation in PHC contaminated soils, but the effectiveness of this practice is not well defined in northern climates. For example, in a Resolution Island study by Paudyn et al. (2008), aeration alone reduced concentrations of diesel fuel by 80% over three summers, almost entirely due to volatilization (not biodegradation). One-time amendment with nutrients (C:N:P of 100:7.5:0.5) in combination with aeration resulted in 90% reduction of TPH concentrations over this time, with significant (but undefined) contributions from microbial degradation.

In 2012, three pilot piles in the landfarm facility were treated with 400 gallons of sewage sludge as a nutrient source. Sewage sludge was mixed into the pilot piles on October 8th 2012. Each pile consisted of approximately 140 m^3 of soil. Samples of the nutrient-treated piles were taken in July 2013 (CSP-STP-1, 2, 3) in attempts to determine if this method of nutrient amendment significantly affects rates of PHC degradation

Representative composite samples of two non-treated piles (CSP-WDP-1, 2) were taken from two locations (0.5 m depth) in October 2012 and again in July 2013 to assess degradation of TPH over this time period without sewage sludge amendment. Samples were sent to an

accredited analytical laboratory and analyzed for humidity, BTEX and F1-F4 hydrocarbons. Attempts to sample all piles again in the fall of 2013 were unsuccessful because of frozen ground.

Overall, rates of PHC degradation were found to be sufficiently rapid to warrant continued use of the landfarm as a viable treatment for spills of the designated materials. Nutrient treatment appeared to generally increase degradation rates, particularly for the F3 fraction. Use of the landfarm with application of sewage sludge as a nutrient treatment will be continued. Based on these results, the pilot project (comparison of treated and untreated piles) was completed and the addition of sewage sludge as a nutrient source to enhance bioremediation was implemented as an operational practice in 2014. Sewage sludge was incorporated into all contaminated soil since 2014.

The use of sewage sludge as a nutrient amendment has precedent in the north. This method has been used at Diavik Diamond Mine, as reported in the BSc thesis of Brenda Lee Bailey, Carleton University (in Golder, 2007). It was found in this study that with sewage sludge amendment (12.6 gallons on a 6 m^3 soil pile), aeration by perforated pipe and clear polyethylene covers to retain heat and moisture, TPH concentrations declined from 15,000 mg/kg to less than 2,000 mg/kg in 88 days. Sewage sludge as a nutrient source has also been proposed for the Milne Inlet Mary River Project (EBA, 2010). This material not only provides the benefit of nutrients, but adds organic matter to help retain moisture, and is a source of microorganisms. Furthermore, the re-use of this material produced onsite helps to reduce the waste footprint of the mine by re-directing this material from disposal facilities and avoiding the import of chemical fertilizer.

4.6 Removal of Soil from the Landfarm

When PHC vapors are no longer detected, coarse-grained material will be removed to the site waste rock disposal area and disposed of as potentially acid generating (PAG) material. PAG will be covered with a minimum of 2 m of non-potentially acid generating (NPAG) material to closure, such that freeze-back occurs and any potentially remaining contaminants are not mobile in the environment.

Prior to removal of the finer grained soil from the landfarm, soil samples will be analyzed to ensure they meet Government of Nunavut guidelines, as described below.

4.6.1 Remediation Guidelines

In assessing the remediation success of PHC contaminated soils being treated in the landfarm facility, Agnico Eagle will use the Government of Nunavut (GN) Department of Environment, Environmental Guidelines for Site Remediation (March, 2009) to determine if the soil has been suitably treated.

The following parameters will be measured and compared with the GN industrial remediation criteria in order to determine whether PHC contaminated soil has been adequately remediated:

- Benzene, toluene, ethylbenzene and xylene (BTEX)
- Petroleum hydrocarbon fractions 1 - 4

GN remediation criteria are characterized for agricultural/wildland, residential/parkland, commercial and industrial land uses. At the Meadowbank site, remediation to agricultural/wildland criteria is targeted. However, if these criteria cannot be met efficiently, industrial criteria will be followed and soil disposed of accordingly (see Section 4.6.3). Remediation criteria for coarse-grained (>75 um) soils will be applied. Table 1 presents the applicable Tier 1 criteria for coarse-grained soil, assuming agricultural/wildland or industrial land uses. For contaminated sites, a Tier 1 analysis involves the most conservative criteria, and may be applied when the proponent does not wish to establish site-specific criteria.

Table 1 - Summary of relevant Government of Nunavut Tier 1 soil remediation criteria for surface soil for industrial land uses.

Parameter	Criteria (mg/kg)
Benzene	0.03
Toluene	0.37
Ethylbenzene	0.082
Xylene	11
PHC Fraction 1	320
PHC Fraction 2	260
PHC Fraction 3	1700
PHC Fraction 4	3300

4.6.2 Sampling and Analysis

Landfarm windrows will be sampled annually to determine if remediation objectives have been met. Representative composite samples will be taken of each windrow to estimate remaining PHC concentrations. For each 10 m of windrow length, one composite sample will be collected, each consisting of three surface sub-samples and three sub-samples at 1 m depth. Sub-samples will be taken approximately 3.3 m apart, and will be taken from both sides of the windrow.

Degradation rates are assessed regularly to estimate the total remediation time required for PHC-contaminated soil under these conditions. If remediation to GN guidelines is feasible within the timeframe, landfarm operations will continue, with aeration and nutrient amendments as described above. If rates of TPH degradation are not sufficient through this method, alternate options will be further investigated (see Section 5).

4.6.3 Soil Removal

Coarse-grained material will be assessed after segregation from mechanical screening has been started, by Environment Department technicians for PHC product and odors. A PID monitor may be employed to assist in petroleum-hydrocarbon based vapor detection. When PHC vapors are no longer detected, this material will be removed to the Portage Rock Storage Facility (PRSF) and disposed of as PAG material.

When sample analysis of fine-grained material indicates that concentrations of contaminants are below Government of Nunavut guidelines, a soil pile or the appropriate section of a pile will be deemed acceptable for removal from the facility. Interim monitoring may be conducted through measurements of head-space with a portable instrument (e.g. flame ionization detector), but samples will be confirmed by an accredited laboratory prior to soil removal.

Soil remediated to agricultural/wildland criteria will be appropriately delineated by Environment Department staff, and stockpiled outside the landfarm for use in site works or reclamation activities.

Soil remediated to industrial-use criteria will be removed from the landfarm and placed in the (PRSF) as PAG material. This material will be capped with a minimum of 2 m of NPAG at closure, allowing freeze-back and permanent encapsulation to occur.

4.7 Water and Snow Management

Since the landfarm facility is uncovered to facilitate natural weathering, water accumulating inside the bermed area may come into contact with contaminated material. The management plan for handling this potentially contaminated water is described below.

4.7.1 Snow Management

Snow will be removed as much as possible during winter to minimize the quantity of spring melt water inside the berm. Care will be taken to ensure contaminated snow/soil is not disturbed by leaving a base layer of snow (no less than 10 cm) in place. After snowmelt any contaminated product left from winter spill clean-up operations will be padded up. The base soil in these areas will be excavated and added to existing remediation windrows as soon as possible after snow melt to minimize migration into the facility substrate.

4.7.2 Water Management

Monitoring will be conducted for seepage of contact water through the perimeter berm, or accumulation of water within the containment berm through visual inspection by the Environment Department. This will be conducted on a weekly basis, after freshet, from July through October when water is likely to be present. In the event of water accumulation or seepage, the ponded water will be analyzed for Group 4 monitoring parameters, as described in Table 2 – Monitoring programs of the Water License prior to discharge to the adjacent Tailings Storage Facility (monitoring stations ST-14 and ST-14b). Alternatively, ponded water will be sprayed on the windrows to increase moisture content, as required. Water accumulating in the landfarm will not be discharged to the environment as per Part F, Item 18 of the water license.

4.8 Landfarm Abandonment

After removal of all remediated soil and prior to abandonment/closure of the landfarm, the

berm and base will be sampled on a 10 m grid, including at a depth of 1 m in representative locations, to determine if these soils are free from PHC contamination. Results of this analysis will be compared to GN criteria. Since this area will form part of the TSF at closure, no excavation is necessary if industrial criteria are not met. Agnico Eagle's Closure Plan notes that the tailings facilities will be capped with at least 2 m of NPAG to ensure freeze-back encapsulation. Monitoring of tailings freeze-back is ongoing at the site, and to date the results indicate that tailings are already freezing as planned.

4.9 Summary of Activities

A summary of landfarm activities including monitoring of the physical condition and potential environmental impacts of the landfarm facility is provided in Table 2. A report will be prepared annually, indicating the volume of material added to the facility, amount of material removed and disposal or reuse location, all analysis results, volume and type of nutrient addition, visual inspection results and volume of contact water pumped. This information will be appended to Agnico Eagle's Annual Report to the NWB.

Table 2 - Summary of landfarm activities and records to be kept.

Activity	Analysis	Frequency	Record
Excavation of spill and transport of contaminated material	If unsure of full excavation - F1-F4, BTEX	As needed	Date and time of excavation; estimated quantity of excavated soil; storage/disposal location of excavated soil, if applicable; any evidence of remaining product
Contaminated soil additions to landfarm	If contaminant source unknown, F1-F4, BTEX, metals, oil and grease, VOCs (at discretion of Environment Department)	Prior to soil addition at facility	Date and time; quantity of soil; original location; landfarm location; spill/excavation record # or storage container label
Soil aeration	N/A	Min. once during summer	Date and time; location; soil condition (moisture, odour, etc.)
Soil treatment with sewage sludge as nutrient supplement	Visual inspection to ensure proper incorporation	At least once during summer on selected windrows	Date and time; location in landfarm
Ponded contact water	BTEX, oil and grease, lead – as per Part F, Item 6 of Water License	Prior to any dewatering; if re-used in landfarm, no sampling necessary	Date and time, location, laboratory report, Annual Report
Sampling for progress of remediation	Hydrocarbon vapour in headspace (by PID); F1-F4, BTEX (laboratory)	Vapour – as needed; Laboratory - annually	Date and time; location; odour; laboratory report;
Soil removal from landfarm	Removal subject to meeting GN criteria	N/A	Date and time; location; quantity of soil removed; final location
Identification of maintenance requirements	Visual inspection of facility	Twice annually during summer	Inspected areas; condition of berm and base; previously unidentified safety concerns

5 CONTINGENCY OPTIONS

The following sections describe the contaminated soil management plan, should a large spill event occur, and if landfarm treatment is not successful.

5.1 Large Spill Event

Considering that the landfarm is built to hold nearly 5x as much contaminated soil as is expected to be produced, a large spill event producing a quantity of soil that cannot be contained in the landfarm is unlikely. Nevertheless, in this event, soils will be placed in a temporary storage area. A temporary stockpile area would be set up in the PRSF or at another location as approved by the NWB and AANDC. The soil would then be placed in the landfarm as soon as practical. Through extensive spill prevention measures discussed earlier in this Plan Agnico Eagle is minimizing the probability of this scenario occurring.

5.2 Alternate Treatment Options

Should landfarm treatment not perform as anticipated and it is evident that rates of degradation are not sufficient to meet GN Tier 1 criteria within the life-of-mine and the anticipated closure period (to 2025) the following alternative treatment options will be considered. Implementation will be after development of a more detailed protocol and approval of a revised plan by the NWB.

5.2.1 Soil Amendment

Since pH, salinity, moisture content and microbial population density all affect rates of biodegradation by microbes, these factors may be monitored and adjusted through soil amendments if they are not found to be optimal (see SAIC, 2006). In addition, the height of soil windrows could be reduced to maximize air exposure if space in the facility allows.

5.2.2 Tier 2 – Modified Criteria Approach

According to the Government of Nunavut Environmental Guideline for Contaminated Site Remediation (Appendix A), in cases where site conditions, land uses, receptors or exposure pathways are different from those assumed in the development of the Tier 1 criteria, modified criteria may be permitted. This process requires the collection of site-specific information on exposure and risk estimates, and is subject to GN approval. In the case of the Meadowbank site, landfarmed soils are to be encapsulated in the PRSF rather than used in surface applications, as assumed in Tier 1, reducing the likelihood of exposure to any remaining contamination. Therefore, the Tier 2 approach could be warranted if Tier 1 criteria cannot be met. Any consideration for this approach would be based on soil sampling results and science based information.

5.2.3 Thermal Desorption

In the thermal desorption process, excavated soils are heated in a chamber to rapidly volatilize PHCs. Gases produced are consumed in an oxidation unit, and particulate matter removed (baghouse). Soil, free of any contamination, can then be replaced, or used in site reclamation or construction processes. The other advantage of this approach is that this equipment is mobile and could be brought to any spill site for remediation activities (e.g. spills along the AWAR). This method is described by Environment Canada (2002). The purchase or rental of a portable thermal desorber unit is under consideration by Agnico Eagle as a contingency option.

5.2.4 Direct Placement in the TSF or PRSF

Another option for management of contaminated soil would be the direct placement of this material in the Tailings Storage Facility or Waste Rock Storage Facility, if bioremediation is not effective or for operational reasons. Although the consumption of space in these storage areas is not optimal, the quantity of PHC-contaminated soil created onsite is small in comparison to the quantity of tailings or waste rock. While this method would not result in the treatment of soil, it is a viable contingency option because it would allow for the safe disposal of the contaminated material. The final cover with NPAG will be a minimum of 2 m deep (current closure plan is 4 m of NPAG cover). Total encapsulation and freeze-back would occur, eliminating any movement of contaminants. Over time, this material would undergo natural degradation. Consideration of this option would also include a suitable monitoring program for PHCs, which would be incorporated into the Meadowbank Closure Plan.

6 PLAN REVIEW AND CONTINUAL IMPROVEMENT

The Landfarm Design and Management Plan will be reviewed regularly by the Meadowbank Environmental Superintendent, and updated, when needed.

REFERENCES

EBA. 2010. Hydrocarbon Impacted Soils Storage and Landfarm Facility Operations, Maintenance and Monitoring Plan, Milne Inlet, Mary River Project, Nunavut. Prepared for: Baffinland Iron Mines Corporation. Issued for Review. December 2010.

Environment Canada. 2002. Technical Assistance Bulletin 13: Soil Remediation: Low Temperature Thermal Desorption Available at: http://www.on.ec.gc.ca/pollution/ecnpd/tabs/tab13-e.html

Environment Canada. 2007. Part 4 screening for Land Farm, Hamlet of Pond Inlet – NIRB 07UN061. Technical advice. Available at: http://ftp.nirb.ca/01-SCREENINGS/COMPLETED%20SCREENINGS/2007/07UN061-GN-CGS%20-%20Pond%20Inlet%20Quarry/02-DISTRIBUTION/COMMENTS/070829-07UN061-EC%20Comment-IEAE.pdf

Golder (Golder Associates Ltd). 2007a. Technical Memorandum: Landfarm Option Analysis, Meadowbank Gold Project, Nunavut. Prepared for: Agnico-Eagle Mines Ltd. August 23, 2007.

Golder (Golder Associates Ltd.), 2007b. Final Report on Pit Slope Design Criteria for Portage and Goose Island Deposits, Meadowbank Gold Project Nunavut, Project 06-1413-089/5000, Doc. No. 449, Revision 0, submitted to Meadowbank Mining Corporation, dated April 5, 2007.

MMC (Meadowbank Mining Corporation), 2007. Meadowbank Gold Project Mine Waste and Water Management. August 2007.

SAIC (Science Applications International Corporation), 2006. Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils. Final report presented to: Contaminated Sites Division and Emergencies Engineering Technologies Office (EETO), Environmental Technology Centre, Environment Canada. SAIC Canada Project #: 11953.B.S08. CM #:

WHALE TAIL PROJECT

Core Receiving Environment Monitoring Program (CREMP): 2015 Plan Update – Whale Tail Pit Addendum

FINAL

Core Receiving Environment Monitoring Program (CREMP): 2015 Plan Update – Whale Tail Pit Addendum

Prepared for:

Agnico Eagle Mines Ltd.

Meadowbank Division
Baker Lake, NU
X0C 0A0

May 2018

Azimuth Consulting Group Partnership

218-2902 West Broadway
Vancouver, BC
V6K 2G8

Project No. AEM-15-03

TABLE OF CONTENTS

1. INTRODUCTION 1
2. WHALE TAIL PIT CREMP ROUTINE MONITORING 1
2.1. Introduction 1
2.2. Study Design 1
2.2.1. Approach 2
2.2.2. Sampling Areas 3
2.2.3. Sampling Components 4
2.2.4. Sampling Effort and Frequency 4
2.3. Sampling Methods 10
2.4. Quality Assurance/Quality Control 12
2.5. Data Evaluation Criteria 12
3. REFERENCES 12

LIST OF TABLES

Table 2–1. Status of Whale Tail Pit and Meadowbank CREMP areas. 2
Table 2–2. CREMP monitoring component sampling summary for Whale Tail Pit Project. 11

LIST OF FIGURES

Figure 2–1. Meadowbank – Whale Tail Pit Study Area Overview. 5
Figure 2–2. CREMP – Whale Tail Pit Sampling Areas. 6
Figure 2–3. Whale Tail Lake Sampling Areas. 7
Figure 2–4. Mammoth and A20 Lake Sampling Areas. 8
Figure 2–5. Nemo Lake Sampling Areas. 9

1. INTRODUCTION

In accordance with the terms of the Nunavut Impact Review Board (NIRB) Project Certificate No .008 and the associated Nunavut Water Board (NWB) Type A Water Licence (2AM-WTP ----), Azimuth Consulting Group Partnership (Azimuth) was retained by Agnico Eagle Mines Limited (Agnico Eagle) to complete an update of the core receiving environment monitoring program (CREMP) plan (Azimuth, 2015a). This report is an addendum to the 2015 CREMP plan update, and addresses how receiving environment monitoring for the Whale Tail Pit Project fits into the Meadowbank/Baker Lake CREMP program. Note that this addendum only highlights differences and does not repeat what is already stated in the CREMP 2015 plan update (see Azimuth, 2015a).

Baseline sampling was conducted in 2014 to 2017 (Azimuth, 2017) to support the final environmental impact statement (FEIS) as well as to characterize pre-mining "before" conditions for the development of a long-term receiving environment monitoring program consistent with the Meadowbank CREMP (Azimuth, 2016). Additional baseline sampling for the CREMP is planned, prior to the onset of activities with potential to impact to the aquatic receiving environment.

2. WHALE TAIL PIT CREMP ROUTINE MONITORING

2.1. Introduction

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) has been approved to develop Whale Tail Pit (Project), a satellite deposit on the Amaruq property, to continue mine operations and milling at Meadowbank Mine according to the terms and conditions outlined in Nunavut Impact Review Board (NIRB) Project Certificate No .008, specifically condition 19 and 23 and the associated Nunavut Water Board (NWB) Type A Water Licence (2AM-WTP ----). .

The Amaruq property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of Meadowbank Mine in the Kivalliq Region of Nunavut (**Figure 2–1**). The deposit will be mined as an open pit (i.e., Whale Tail Pit), and ore will be hauled to the approved infrastructure at Meadowbank Mine for milling.

The proposed open pit mine, mined by truck-and-shovel operation, will produce 8.3 million tonnes (Mt) of ore, 46.1 Mt of waste rock, and 5.6 Mt of overburden waste. There are four phases to the development: 1 year of construction, 3 years of mine operation, 8 years of closure, and the post-closure period.

2.2. Study Design

The study design is based on a before-after-control-impact (BACI) approach, but has also incorporated the concept of gradients in exposure; the study design mirrors the approved Meadowbank Mine CREMP. Tracking spatial and temporal differences related to mining activities relied on categorizing areas using two factors:

- *Area Type* – this concept relates to an area's spatial proximity to the planned mine development (i.e., whether built or not); categories include near-field, mid-field, far-field, and reference (see **Section 2.2.2**).
- *Area Status* – this concept is temporal and has two levels: control (not exposed to mine-related activity) or impact (exposed to mine-related activity). The term "impact" is taken from the BACI statistical study design approach and does not mean that an actual impact has taken place;

rather, it designates a time period when potential mine-related impacts may occur for an area (i.e., that an area has been exposed to one or more mining activities).

Together, area categorization by type and status provide a logical framework to facilitate the identification of real mining-related changes to the aquatic receiving environment (as opposed to natural regional changes due to climate or other factors). According to NIRB Project Certificate No .008, the objective of the CREMP is to monitor the freshwater environment, evaluate against FEIS predictions and inform mitigation measures specifically outlined in Condition 19 and 23. The CREMP is designed to include sufficient sampling and monitoring determine the short and long-term effects on the aquatic environment related to the site and to assess the impact predictions made in the Environmental Impact Statement for the Whale Tail Pit Project.

The onset of construction activities in proximity to a CREMP monitoring area formally ends the baseline phase and changes the status of that area from "control" to "impact". Status changes are also important for any statistical analyses, as they dictate how data are grouped when assessing potential trends. The status of the Amaruq CREMP areas starting in 2017 is provided in **Table 2–1**.

Table 2–1. Status of Whale Tail Pit and Meadowbank CREMP areas.

	Meadowbank Reference Areas		Whale Tail Pit Areas					
	REF	REF	NF	NF	NF	MF	MF	FF
Year	INUG	PDL	WTS	MAM	NEM	A20	A76	DS1
2015	C	C	C	C	C			
2016	C	C	C	C	C	C	C	C
2017	C	C	C	C	C	C	C	C

Notes: Area designations: C=Control; I=Impact; REF=reference (in grey shading); NF=near-field (in blue shading); MF=mid-field (in pink shading); FF=far-field (in teal shading); Blank denotes that the area was not part of the monitoring program that year. Area IDs: INUG=Inuggugayualik Lake; PDL=Pipedream Lake; WTS=Whale Tail Lake South; MAM=Mammoth Lake; NEM=Nemo Lake.

2.2.1. Approach

The 2015 AEMP describes a two-tiered approach for decision criteria based on 'trigger' and 'threshold' level concentrations (Azimuth, 2015b). These are defined as:

- *Triggers* are early warning criteria that may lead to action. Exceedance of a trigger value does not necessarily imply that an adverse effect may be expected. The triggers may be based on absolute numbers (e.g., an increases half-way from baseline to an identified effects-based threshold) or statistical criteria (e.g., statistically significant difference from baseline-reference conditions; these are used in the absence of an effects-based threshold for a substance and may be very conservative).
- *Thresholds* are legal requirements, regulatory guidelines (e.g., CCME), or other discrete benchmarks, below which unacceptable adverse effects are not expected and above which adverse effects may occur. If effects-based thresholds do not exist or are not warranted for a particular variable, then early warning triggers (based on statistical criteria) will be developed without thresholds. In such cases, if triggers are exceeded then the implications of such

exceedances can only be understood through the integration of results from other AEMP monitoring programs, or, if important information gaps still exist, through prescribed EEM studies or targeted studies.

Thus, comparison of the data to the early warning trigger values is the initial analytical focus; only if trigger values are exceeded are data then compared to the applicable thresholds (if available). Similar to what was done for the Meadowbank CREMP (Azimuth, 2012), area-specific trigger/threshold (as appropriate) values may need to be developed after the baseline period to support management of the Whale Tail Pit Study Area.

2.2.2. Sampling Areas

The core monitoring program is intended to detect changes at a basin or lake scale of inference and to help define the extent (both spatially and temporally) of any adverse effects identified and designed to meet NIRB Project Certificate No. 008 conditions 19 and 23. The CREMP for the Whale Tail Pit program will be comprised of 8 sampling areas (6 new monitoring areas and continued use of the two existing reference areas), each categorized into one of the four main types of areas described below. An overview of the Whale Tail Pit sampling areas is shown in **Figure 2–2**.

- Near-field (NF) areas – Near-field locations provide the first line of early-warning for introductions of stressors into the receiving environment. These areas are situated in close proximity to the development, in particular near dikes, dewatering discharge, and proposed effluent sources. As per NIRB PC No.008 condition 23, Agnico Eagle will conduct analysis to evaluate the potential impacts to freshwater ecosystem productivity and have designed NF stations in Mammoth Lake (**Figure 2–4**). As determined by academic researchers and DFO, further studies will leverage the CREMP data and as needed, collect additional biological data to evaluate productivity and change in trophic status in Mammoth Lake as outlined in the complementary measures (Agnico Eagle, 2018). The NF areas in the Whale Tail Pit Study Area include Whale Tail Lake South (**Figure 2–3**) and Mammoth Lake (**Figure 2–4**), due to their placement in relation to the planned development and in the watershed[1]. Nemo Lake (**Figure 2–5**) is also considered a NF area due to its proximity to Whale Tail and Mammoth Lakes even though it is located in an adjacent watershed. Nemo Lake is the source of drinking water for the exploration camp, and routine water quality monitoring is scheduled for this location. Additional CREMP sampling at Nemo Lake is proposed only in the event that increased parameter concentrations are observed in the routine drinking water quality monitoring samples.
- Mid-field (MF) areas – This area designation includes two lakes: Lake A20 and Lake A76. Sampling at Lake A20 and A76 will be undertaken according to the strategy outlined in the CREMP 2015 plan update for MF areas (Azimuth, 2015a). In the case of Lake A20, the start of the "impact" monitoring period would coincide with back-flooding of Whale Tail Lake into Lake A20, and the diversion of water towards Mammoth Lake through the Northwest Channel. Lake A76 is situated at the junction of the two flow paths leading to Lake DS1. Given its morphology and location, it represents an ideal mid-field exposure area for both flow paths.
- Far-field (FF) area – The intent of this area (Lake DS1) is to monitor water and sediment quality downstream of project infrastructure to provide insights into the spatial extent of any effects observed at the near-field areas. Lake DS1 will be the key location that will ultimately determine whether or not contaminants are detectable downstream of the entire mine development

[1] The north basin of Whale Tail Lake (WTN) was sampled in 2014 and 2015 to support the FEIS, but will not be part of the routine CREMP sampling plan as it lies within the pit footprint.

(**Figure 2–2**)[2]. Beyond the baseline period, the sampling strategy for Lake DS1 will follow the same approach for FF stations outlined in the CREMP 2015 plan update (Azimuth, 2015a).

- Reference (Ref) areas – By definition, reference areas are sufficiently removed from mine activities that they are presumed to be unaffected by any infrastructure and point sources (e.g. aerial deposition and effluent) associated with mine development and activities. Inuggugayualik Lake (INUG) and Pipedream Lake (PDL) are external reference areas chosen for the purposes of making comparisons with the Meadowbank project lakes (EVS, 1999; BAER, 2005). INUG has been the core reference area since formal monitoring began in 2006. PDL was added to the Meadowbank CREMP in 2009. In relation to the Whale Tail Pit Study Area, INUG is located about 41 km southeast of the Whale Tail Pit Study Area, while PDL is located 40 km to the southeast (**Figure 2–1**). Pipedream Lake is located northeast of INUG, and the exploration access road runs along the northeast shore of this lake. INUG and PDL satisfied the requirements of an external reference lake for the Meadowbank CREMP from a physical/chemical perspective because they are at similar latitude, have similar geology, relief and climate, do not have any significant inflows and has generally similar limnology, water chemistry and aquatic biological community structure to the project lakes (BAER, 2005). It should be noted that their proximity to the proposed access road may lead to dust deposition into each of the lakes under certain conditions. However, both lakes are quite large and the sampling locations for each are away from the road (i.e., approximately 2 km for PDL and 10 km for INUG), so while road-related trends will be tracked they are not anticipated.

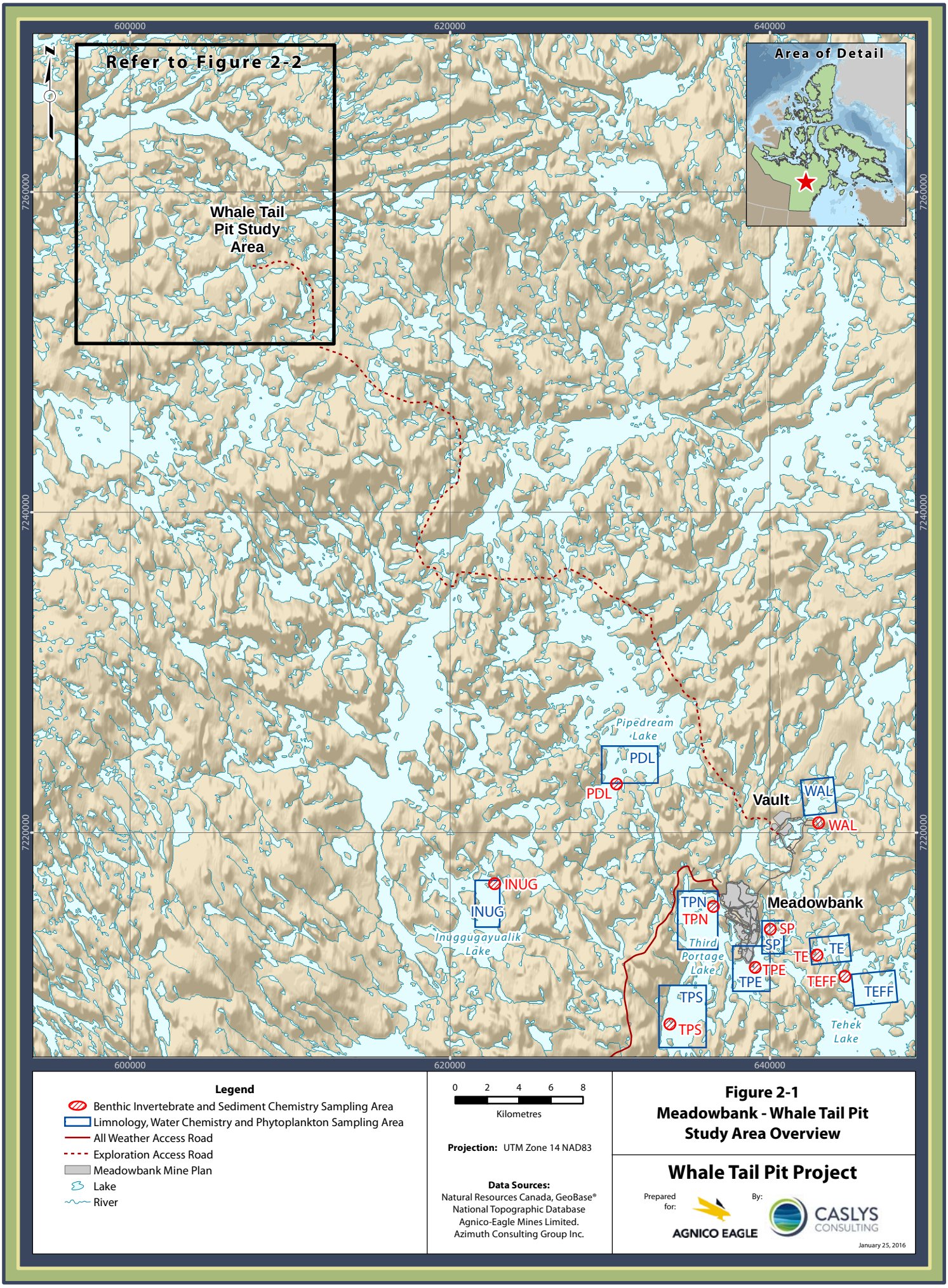
2.2.3. Sampling Components

As described in the CREMP 2015 plan update (Azimuth, 2015a), CREMP monitoring includes the following components, which apply to Whale Tail Pit Study Area lakes: limnology, water chemistry, sediment chemistry, phytoplankton, and benthic invertebrates.

2.2.4. Sampling Effort and Frequency

As described in the 2015 CREMP plan update (Azimuth, 2015a), CREMP sampling effort (i.e., number of replicates per event) and frequency (i.e., number of events per year) follows the recommendations from the CREMP Design Document 2012 (Azimuth, 2012). NWB interveners were consulted over several years during the re-design of the CREMP that was resubmitted following the Type A renewal in 2015 and subsequently approved by regulators. CREMP sampling at Whale Tail Pit Study Area will follow the same level of effort and frequency by area type; refer to Azimuth (2015a) for details on the decision making strategy for initiating sampling at the MF and FF stations.

[2] According to Golder (2016), the downstream flow of water splits into two paths. Downstream path 1 follows Lake A12 (immediately south of Lake A76) to Lake A76 and then flows west to the southern tip of Lake DS1. Downstream path 2 flows north from Lake A76 and A11 (east of Lake 76) through a series of small lakes and eventually enters Lake DS1 along the east shore (approximately 2/3 of the way up the bounded area shown on **Figure 2–2**). At present, Lake DS1 is shown as a single station; however, the area may be split into two stations to monitor the contribution of each flow paths.



Legend

- Benthic Invertebrate and Sediment Chemistry Sampling Area
- Limnology, Water Chemistry and Phytoplankton Sampling Area
- All Weather Access Road
- Exploration Access Road
- Meadowbank Mine Plan
- Lake
- River

0 2 4 6 8

Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

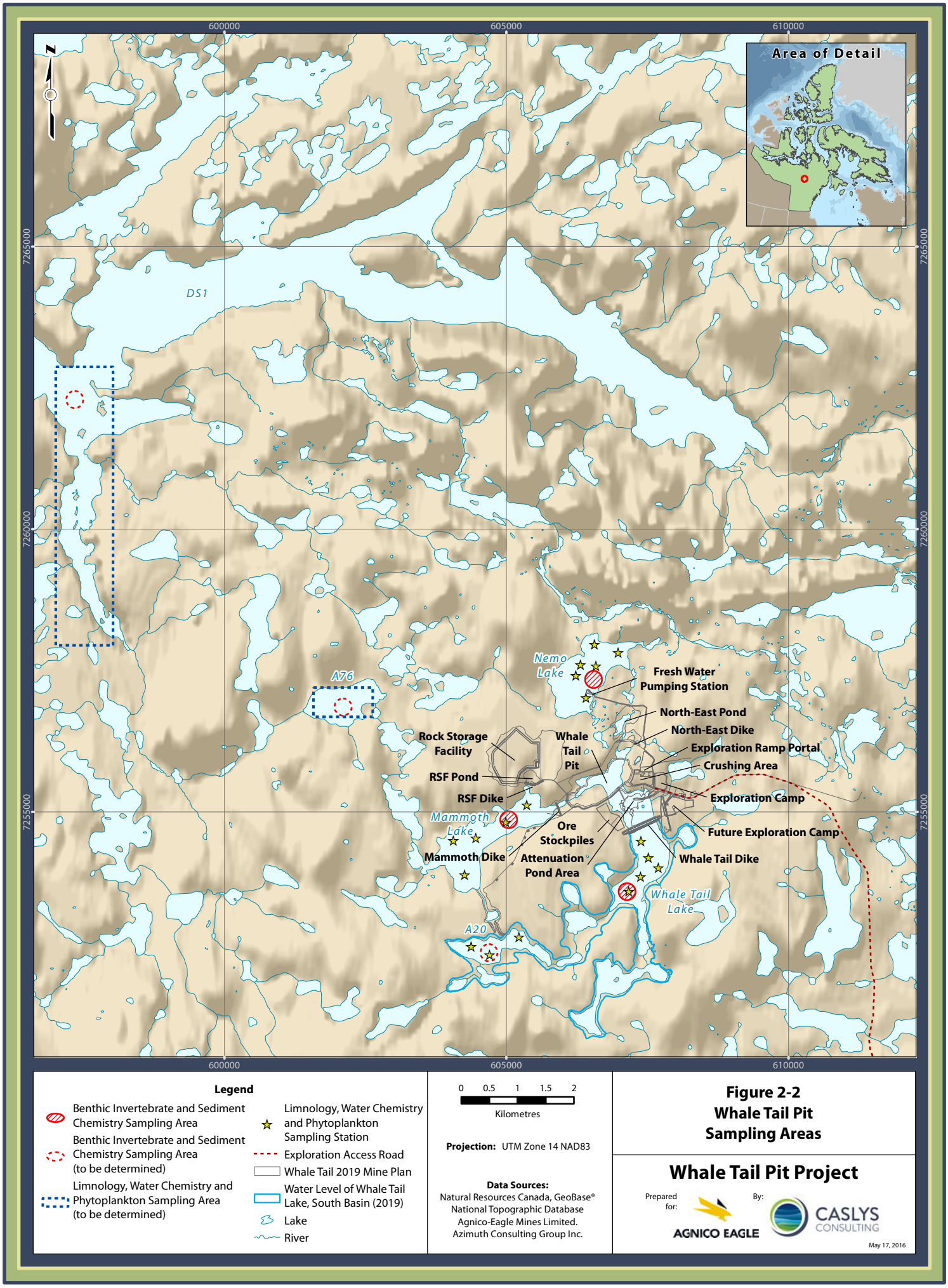
Figure 2-1
Meadowbank - Whale Tail Pit
Study Area Overview

Whale Tail Pit Project

Prepared for: AGNICO EAGLE

By: CASLYS CONSULTING

January 25, 2016



Legend

- Benthic Invertebrate and Sediment Chemistry Sampling Area
- Benthic Invertebrate and Sediment Chemistry Sampling Area (to be determined)
- Limnology, Water Chemistry and Phytoplankton Sampling Area (to be determined)
- Limnology, Water Chemistry and Phytoplankton Sampling Station
- Exploration Access Road
- Whale Tail 2019 Mine Plan
- Water Level of Whale Tail Lake, South Basin (2019)
- Lake
- River

0 0.5 1 1.5 2

Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

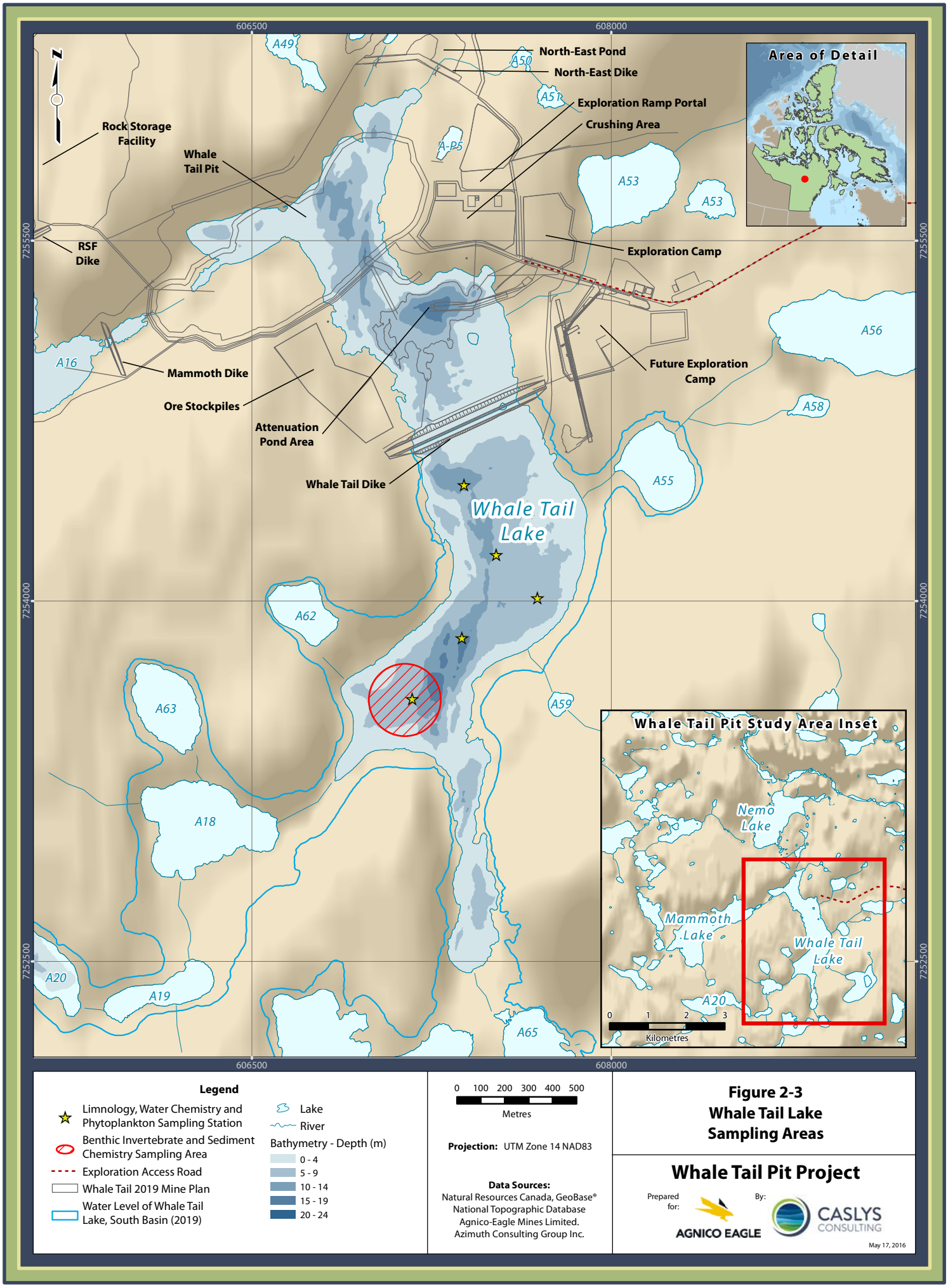
Figure 2-2
Whale Tail Pit
Sampling Areas

Whale Tail Pit Project

Prepared for: AGNICO EAGLE

By: CASLYS CONSULTING

May 17, 2016



Legend

- Limnology, Water Chemistry and Phytoplankton Sampling Station
- Benthic Invertebrate and Sediment Chemistry Sampling Area
- Exploration Access Road
- Whale Tail 2019 Mine Plan
- Water Level of Whale Tail Lake, South Basin (2019)
- Lake
- River

Bathymetry - Depth (m)

- 0 - 4
- 5 - 9
- 10 - 14
- 15 - 19
- 20 - 24

0 100 200 300 400 500
Metres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Figure 2-3
Whale Tail Lake Sampling Areas

Whale Tail Pit Project

Prepared for: AGNICO EAGLE

By: CASLYS CONSULTING

May 17, 2016

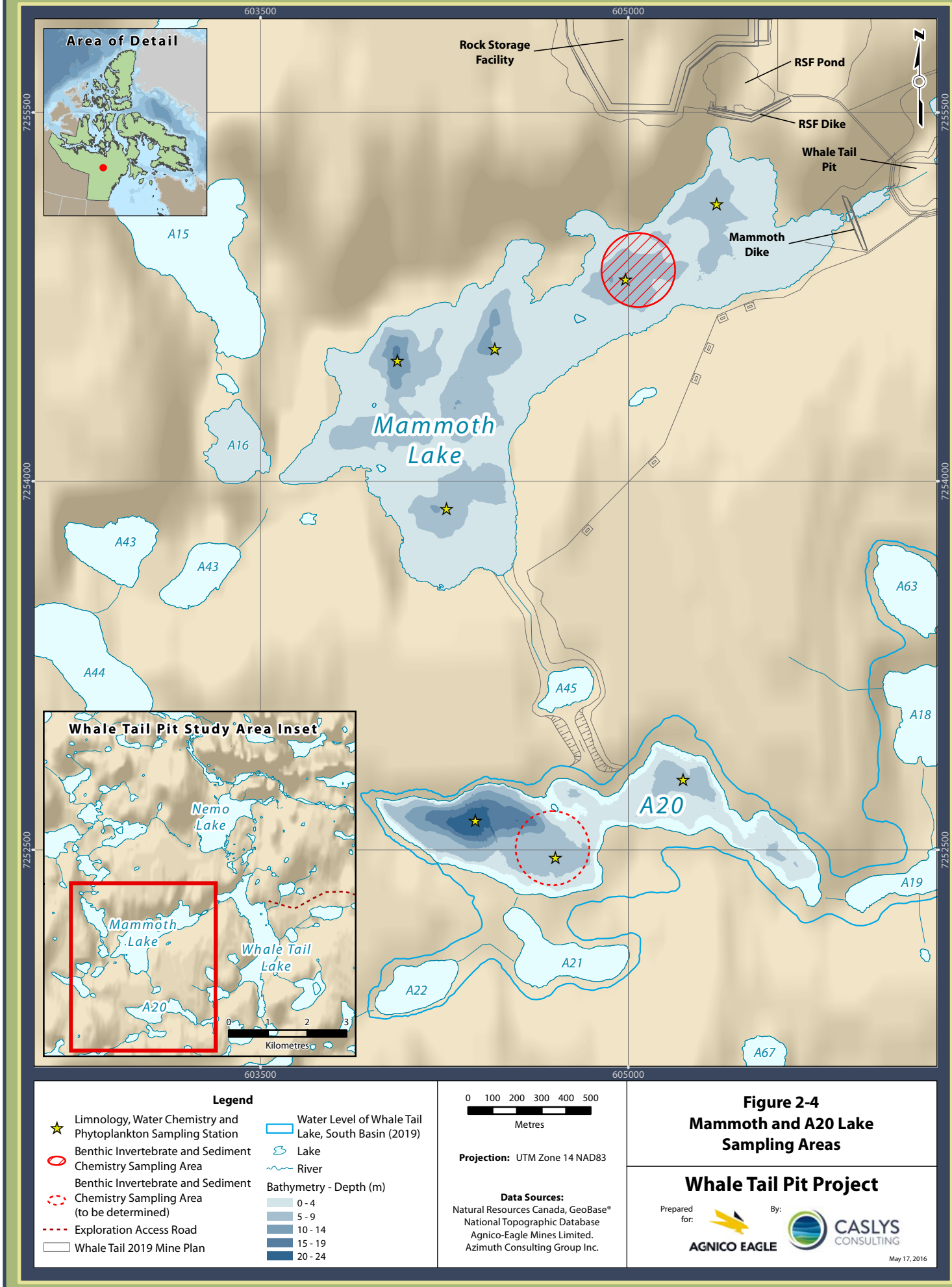


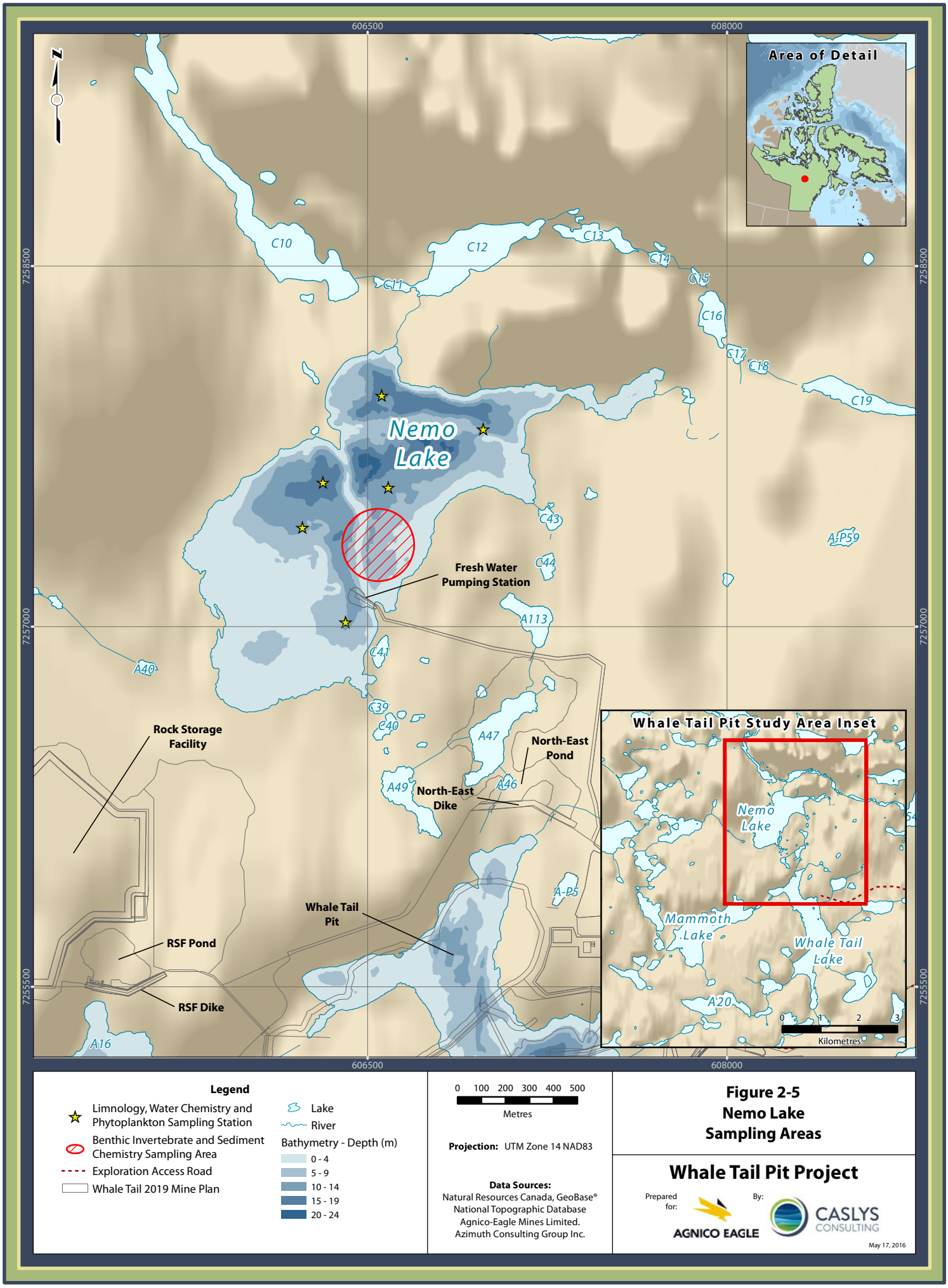
Figure 2-4
Mammoth and A20 Lake Sampling Areas

Whale Tail Pit Project

Prepared for: AGNICO EAGLE

By: CASLYS CONSULTING

May 17, 2016



Legend

- Limnology, Water Chemistry and Phytoplankton Sampling Station
- Benthic Invertebrate and Sediment Chemistry Sampling Area
- Exploration Access Road
- Whale Tail 2019 Mine Plan
- Lake
- River

Bathymetry - Depth (m)

- 0 - 4
- 5 - 9
- 10 - 14
- 15 - 19
- 20 - 24

0 100 200 300 400 500
Metres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Figure 2-5
Nemo Lake
Sampling Areas

Whale Tail Pit Project

Prepared for: AGNICO EAGLE

By: CASLYS CONSULTING

May 17, 2016

2.3. Sampling Methods

A summary of timing and frequency of sampling for each of the CREMP monitoring components for the Whale Tail Pit area is shown in **Table 2–2** by sampling season and month. Important to note is that the sampling frequency by area shown in the table is representative of the full study design, and not necessarily what would need to be conducted in a given year (e.g., for MF and FF areas if no changes are detected at NF areas the previous year; see **Section 2.2.4** for more information).

Sampling for the CREMP program follows the Standard Operating Procedures (SOPs) for each of the monitoring components. The SOPs include general information on field collections, pre-trip planning, field collection materials, field quality assurance / quality control protocols, step-by-step instructions on sample collection, bottle requirements and list of parameters, sample preservation, and sample handling and transportation. The SOPs are appended to the CREMP 2015 plan update (Azimuth, 2015a):

- Water chemistry, limnology, and phytoplankton sampling methods are outlined in Appendix A
- Benthic invertebrate and sediment grab chemistry methods are outlined in Appendix B
- Sediment coring is outlined in Appendix C.

The small size of the Whale Tail Pit Project lakes and comparably shallower depths relative to the Meadowbank Lakes was not amenable to using the bounded area method of generating random water quality sampling stations (see SOP and blue rectangles in **Figure 2–1**). Instead, a number of "fixed" sampling locations for limnology, water chemistry and phytoplankton were established for the Whale Tail Pit lakes[3] in areas where the water depth is greater than 5 m (**Figure 2–2**). Prior to going in the field for each sampling event, two of the locations are randomly selected for sampling. Coordinates are recorded in MapSource and in the hand-held GPS units (NAD 83).

The specific sampling locations for benthic invertebrates and sediment chemistry are selected each year from within established depositional zones in each lake (see red circles on maps) with a target water depth of 8 m ± 1.5 m. Areas in Whale Tail Lake (WTS), Nemo Lake (NEM), and Mammoth Lake (MAM) were established during the August 2015 field program. Lakes A20, A76 and DS1 were not sampled as part of the 2015 baseline program; suitable sampling locations will be selected prior to construction.

[3] Bathymetry is currently not available for Lake DS1 and Lake A76. Sampling stations will be chosen when in the field until bathymetry data is available to establish either fixed sampling locations or bounded areas of sampling.

Table 2–2. CREMP monitoring component sampling summary for Whale Tail Pit Project.

Sampling Season	Sampling Month	Monitoring Conditions	Monitoring Components[1]	INUG	PDL	WTS	MAM	NEM*	A20*	A76*	DS1*
				REF	REF	NF	NF	NF	MF	MF	FF
Winter	January	Ice	L			✓	✓				
	February	Ice	L			✓	✓				
	March	Ice	L			✓	✓				
Spring	April/May	Ice	L,W,P	✓	✓	✓	✓	✓	✓	✓	✓
	June	***Ice not safe***									
Summer	July	Open-water	L,W,P	✓	✓	✓	✓	✓	✓	✓	✓
	August	Open-water	L,W,P	✓	✓	✓	✓	✓	✓	✓	✓
			B,S,C**	✓	✓	✓	✓	✓	✓	✓	✓
	September	Open-water	L,W,P	✓	✓	✓	✓	✓	✓	✓	✓
Autumn/ Winter	***October***	***Ice not safe***									
	November/December	Ice	L,W,P	✓	✓	✓	✓	✓	✓	✓	✓

Notes:

1. The monitoring components shown for each month are an example of how the annual monitoring program could be completed on an annual basis. The summary table shows three open water events and 2 through-ice events where the full CREMP surface water program (L,W,P) is completed. The timing of the two winter water sample and limnology data may be completed prior to the open water season in July depending on logistical considerations for the annual monitoring cycle.

Area IDs: INUG=Inuggugayualik Lake; PDL=Pipedream Lake; WTS=Whale Tail Lake South; MAM=Mammoth Lake; NEM=Nemo Lake.

Area types: REF=reference (in grey shading); NF=near-field (in blue shading); MF=mid-field (in pink shading); FF=far-field (in teal shading).

***** Sampling at NEM and the MF and FF stations during the operation phase will be conducted according to the sampling strategy outlined in the CREMP 2015 plan update (Azimuth, 2015a). NEM is the source of drinking water for the exploration camp and water quality will be monitored monthly.

Components: L=Limnology; W=Water chemistry; P=Phytoplankton; B=Benthic invertebrates; S=Sediment grab chemistry; C=Sediment coring chemistry.

✓ indicates that monitoring components are conducted at the area/month given.

** Sediment coring is conducted every three years and synchronized to the EEM field program.

2.4. Quality Assurance/Quality Control

There are no Whale Tail Pit-specific differences in QA/QC methodology and reporting. See the 2015 CREMP plan update (Azimuth, 2015a) for details.

2.5. Data Evaluation Criteria

There are no Whale Tail Pit-specific differences in data evaluation methodology and reporting. See the 2015 CREMP plan update (Azimuth, 2015a) for details.

3. REFERENCES

Agnico Eagle Mines. 2018. Whale Tail Pit Fish Habitat Offsetting Plan, Appendix C – Complementary Measures. May 2018.

Azimuth Consulting Group (Azimuth). 2016. Whale Tail Pit Core Receiving Environment Monitoring Program (CREMP): 2014-2015 Baseline Studies. Report prepared by Azimuth Consulting Group for Agnico Eagle Mines Ltd., Baker Lake, NU. January 2016.

Azimuth. 2015a. Core Receiving Environment Monitoring Program (CREMP): 2015 Plan Update. Report prepared by Azimuth Consulting Group, Vancouver, BC for Agnico Eagle Mines Ltd., Baker Lake, NU. November, 2015.

Azimuth. 2015b. Aquatic Effects Management Program (AEMP), Meadowbank Mine. Report prepared by Azimuth Consulting Group, Vancouver, BC for Agnico Eagle Mines Ltd., Baker Lake, NU. November, 2015.

Azimuth. 2012. Core Receiving Environment Monitoring Program (CREMP): Design Document 2012, Meadowbank Mine. Report prepared by Azimuth Consulting Group, Vancouver, BC for Agnico Eagle Mines Ltd., Baker Lake, NU. December, 2012. Available at: Link

Baseline Aquatic Ecosystem Report (BAER). 2005. A report prepared by Azimuth Consulting Group, Vancouver for Cumberland Resources Ltd. October, 2005.

EVS Environment Consultants (EVS). 1999. Fisheries evaluation of candidate reference lakes, Meadowbank Gold Project Nunavut, 1998. A report prepared for Cumberland Resources Ltd., Vancouver BC by EVS Environment Consultants, North Vancouver, April 1999. 60 pp.

Golder Associates Limited (Golder). 2016. Draft Report on Mine Site and Downstream Receiving Water Quality Predictions Whale Tail Project, Meadowbank Division. Report Number 1520817. May 2016.

CREMP Addendum - Appendix A: Mercury Monitoring Plan for Whale Tail South Area, Version 2

Erosion Management Plan, Version 1

AGNICO EAGLE

Meadowbank Division

Whale Tail Project - Erosion Management Plan

JUNE 2018
VERSION 1

EXECUTIVE SUMMARY

This document presents the proposed erosion management plan (the Plan) at the Amaruq property for the development of the Whale Tail Project. The purpose of this Plan is to provide consolidated information on the management and monitoring of potential areas subjected to erosion, by presenting first a review of the potential effects of total suspended solids (TSS) and turbidity, the Federal guidelines and the license requirements, followed by the periods and type of activities subjected to erosion, the specific monitoring and mitigating measures.

General findings on the effects of TSS on fish and fish habitat have been listed, such as sublethal and lethal effects on fish and their eggs. Federal TSS Guidelines have been cited, distinguishing the short-term and long-term exposure thresholds. Turbidity guidelines are also discussed in the present document.

The Plan presents the monitoring and mitigating actions related to three (3) specific periods of activity for the Whale Tail Pit: the period of construction and dewatering (during construction and operation), the period of freshet (during construction, operation and closure) and the period of rise in water level in the South Basin of Whale Tail Lake (during operation). The proposed monitoring and mitigating measures are discussed for those periods of activity.

DOCUMENT CONTROL

Version	Date (YM)	Section	Page	Revision
1	June 2018	ALL	-	Comprehensive plan for Whale Tail Project

TABLE OF CONTENTS

Executive Summary ..... **i**

Table of Contents ..... **iii**

Acronyms ..... **iv**

Units ..... **iv**

Section 1 • INTRODUCTION **1**

Section 2 • TOTAL SUSPENDED SOLIDS/TURBIDITY EFFECTS, FEDERAL GUIDELINES AND LICENSE REQUIREMENTS **3**

2.1 Effects of Total Suspended Sediments on Fish Habitat 3

2.2 Federal Guidelines 3

2.2.1 TSS Guidelines 3

2.2.2 Turbidity Guidelines 4

2.3 License Requirements for the Protection of Fish and Fish Habitat at Whale Tail 5

Section 3 • EROSION MONITORING AND MITIGATION **6**

3.1 Erosion During Construction and Dewatering 6

3.2 Erosion During Freshet 6

3.2.1 Proposed Monitoring 7

3.2.2 Mitigating Measures 7

3.3 Erosion Due to the Rise of Water Level 7

3.3.1 Proposed Monitoring 8

3.3.2 Mitigating Measures 8

Section 4 • REFERENCES **9**

List of Tables in Text

Table 1.1 Overview of Timeline and General Activities 1

Table 2.1 Existing Federal TSS Guidelines (after Agnico Eagle, 2016) 4

ACRONYMS

Agnico Eagle	Agnico Eagle Mines Limited – Meadowbank Division
CCME	Canadian Council of Ministers of the Environment
DFO	Fisheries and Oceans Canada
MMM	Maximum Monthly Mean
NIRB	Nunavut Impact Review Board
NTU	Nephelometric Turbidity Units
NWB	Nunavut Water Board
Plan	Erosion Management Plan
STM	Short Term Maximum
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
WTD	Whale Tail Dike

UNITS

h	hour
km	kilometre
km^2	square kilometre
mg/L	milligram per litre

SECTION 1 • INTRODUCTION

Agnico Eagle is seeking to extend the life of the Meadowbank Mine by constructing and operating the Whale Tail Pit (Whale Tail), which is a satellite deposit on the Amaruq property, and will be a continuation of mine operations and milling at the Meadowbank Mine.

The Amaruq property is a 408 km^2 site located on Inuit Owned Land approximately 150 km north of the Hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq Region of Nunavut. The deposit will be mined as an open pit (i.e., Whale Tail Pit), and ore will be hauled on the Whale Tail haul road to the approved infrastructure at the Meadowbank Mine for milling.

As presented in Table 1.1, there are four main phases to the development: 1 year of construction, 4 years of mine operations (2019 to Q1 2022), 8 years of closure, followed by the post-closure period. Pending regulatory approvals, the construction phase is anticipated to start at the beginning of the third quarter of Year -1 (2018) and focus on site preparation and construction of infrastructure to support mine development, along with commencement of open pit development.

Table 1.1 Overview of Timeline and General Activities

Phase	Year	General Activities
Construction	Year -1	• Construct site infrastructure • Develop open pit mine • Stockpile ore
Operations	Year 1 to 3	• Open pit operations • Transport ore to Meadowbank Mine • Stockpile ore • Discharge Tailings in Meadowbank TSF
	Year 4	• Complete transportation of ore to Meadowbank Mine • Complete discharge tailings in Meadowbank TSF
Closure	Year 4 to 11	• Remove non-essential site infrastructure • Flood mined-out open pit • Re-establish natural Whale Tail Lake level
Post-Closure	Year 11 forwards	• Site and surrounding environment monitoring

This document presents the Erosion Management Plan (the Plan). The purpose of this Plan is to provide consolidated information on the management and monitoring of potential areas subjected to erosion, by presenting first a review of the potential effects of total suspended solids (TSS) and turbidity, the Federal guidelines and the license requirements, followed by the periods and type of activities subjected to erosion, the specific monitoring and mitigating measures.

As per Nunavut Impact Review Board (NIRB) Whale Tail Project Certificate No.008 Condition 11, the Erosion Management Plan should be developed to prevent or minimize erosion and its resulting effects from project-related land disturbance. The Plan should be submitted to the NIRB at least 30

days prior to the start of construction, with updates submitted annually thereafter or as may otherwise be required by the NIRB.

This Plan should be consulted in association with the the Water Quality Monitoring and Management Plan for Dike Construction and Dewatering (Agnico Eagle, 2016) and the future Whale Tail Freshet Action Plan.

SECTION 2 • TOTAL SUSPENDED SOLIDS/TURBIDITY EFFECTS, FEDERAL GUIDELINES AND LICENSE REQUIREMENTS

2.1 Effects of Total Suspended Sediments on Fish Habitat

Suspended sediments, and associated effects on water clarity, have the potential to affect fish and fish habitat in a variety of ways, including but not limited to:

- Smothering of deposited eggs or siltation spawning habitats;
- Smothering of benthic invertebrate communities;
- Decreased primary productivity caused by reduced light penetration;
- Reduced visibility, which may decrease feeding efficiency and/or increase predator avoidance; and
- Clogging and abrasion of gills.

Moreover, the general findings for effects of TSS on fish and fish habitat indicate the following:

- Effects of TSS depend on both the concentration of TSS and duration of exposure;
- Effects of TSS can also be influenced by the size and shape of suspended particles;
- Lethal concentration of TSS to fish over acute exposure range from hundreds to hundreds of thousands of mg/L;
- Sublethal effects on fish (reduced growth, changes in blood chemistry, histological changes) associated with chronic exposures tend to be exhibited at TSS concentrations ranging from the tens to hundreds of mg/L;
- There is considerable uncertainty about potential effects of low TSS concentrations over long time periods;
- Overall, the most sensitive group of aquatic organisms to TSS appears to be salmonids, and guidelines are developed to protect this group;
- Adult salmonids are generally more sensitive to short duration, high concentration of suspended sediments than juvenile salmonids; and
- Low suspended sediment levels are known to cause egg mortality (40 %) to rainbow trout at long durations (7 mg/L at 48 days). Guidelines for long-term exposure reflect these findings.

More details can be found in the report from Fisheries and Oceans Canada (DFO) on the effects of sediments on fish and their habitat (Fisheries and Oceans Canada, 1999).

2.2 Federal Guidelines

2.2.1 TSS Guidelines

The Canadian Council of Ministers of the Environment (CCME) specifies separate guidelines for TSS for clear flow and high flow periods. The guidelines are derived primarily from Caux *et al*. (1997), with application intended mainly for British Columbia streams. In the case of application to the Amaruq Project lakes, the clear flow guidelines would be most relevant; even during freshet, one would not expect to see large natural fluctuations in TSS expect in localized areas for short periods.

The guidelines put forth by the CCME recognize that the severity of effects of suspended sediments is a function of both the concentration of suspended sediments and the duration of exposure. Guidelines are intended to protect the most sensitive taxonomic group and the most sensitive life history stages. **Erreur ! Source du renvoi introuvable.** summarizes the available guidelines applicable to clear water (CCME) and to mine-related effluent discharges (MMER).

Table 2.1 Existing Federal TSS Guidelines (after Agnico Eagle, 2016)

Source	Short-Term Exposure	Long-Term Exposure
CCME (1999)	Anthropogenic activities should not increase suspended sediment concentrations by more than 25 mg/L over background levels during any short-term exposure period (e.g., 24-h).	For longer term exposure (e.g., 30 days or more), average suspended sediment concentrations should not be increased by more than 5 mg/L over background levels.
MMER (2002)	Maximum authorized concentration in a composite effluent sample = 22.5 mg/L. Maximum authorized concentration in a grab sample of effluent = 30 mg/L.	Maximum authorized monthly mean effluent concentration = 15 mg/L.

The guidelines mentioned in **Erreur ! Source du renvoi introuvable.** are based on hundreds of studies in different environments (see Caux *et al*., 1997). Some of the studies may not be particularly relevant to the case of suspended sediment associated with dike construction and dewatering in a lake environment. Consequently, it is worth considering whether all aspects of existing guidelines are applicable for the Amaruq project. There are two particular aspects that warrant discussion.

First, in relation to short-term exposure guidelines, it is important to note that guidance is based on findings for adults and juveniles (which are more sensitive than eggs and larvae over short durations), and that the guidance is based primarily on reviews looking at application to stream environments. In a stream environment, compared to a lake environment, it is difficult for fish to swim away from suspended sediments because the high degree of mixing in the water column facilitates higher uniformity in TSS concentrations. In contrast, in lakes, in particular for sediment plumes associated with construction activities or discharges, high TSS concentrations would generally be expected to be localized, with dilution over distance. In a lake situation, adult and juvenile fish (the most sensitive life stages to short-term exposure) should readily be able to swim away from a sediment plume.

Second, in relation to long-term exposure guidelines, it is important to note that guidance is heavily influenced by findings indicating the sensitivity of eggs to low-level exposure to TSS over long durations. Consequently, the long-term exposure guidelines would be rather conservative if applied during times when eggs are not present, or in areas of a lake or stream that are not spawning habitat.

2.2.2 Turbidity Guidelines

Turbidity guidelines put forth by the CCME (1999) are based on extrapolation from the TSS guidance above, adjusted by a factor of about 3:1 (a typical average ratio for TSS: turbidity). In the case of turbidity for clear water, CCME (1999) recommends a maximum increase of 8 Nephelometric

Turbidity Units (NTU) from background levels for a short-term exposure (e.g., 24-hour period), and a maximum average increase of 2 NTU from background levels for a longer term exposure (e.g., 30-day period).

CCME (1999) notes that in some cases short-term resuspension of sediments and nutrients in the water column can augment primary productivity, and in other cases changes in light penetration may be inconsequential if a system is limited by other factors such as nutrients. The Caux *et al*. (1997) study considered effects of suspended sediment not only on fish but also on algae and zooplankton. In the end, the recommendations put forth by Caux *et al*. (1997) are based mainly on the most sensitive taxonomic group, which is salmonids.

However, research has shown that widespread, chronic turbidity can result in reduced light penetration and subsequent reductions of primary productivity (Fisheries and Oceans Canada, 1999; Canadian Council of Ministers of the Environment, 1999; Lloyd, Koenings, & Laperriere, 1987). Consequently, water clarity is of concern at broader spatial scales and longer timeframes, such as the proposed dewatering activities.

It should be noted that DFO's report on effects of sediment on fish and their habitat (DFO, 1999) endorses the guidelines for TSS put forth by the CCME (1999), but does not recommend following guidelines for turbidity. Rather, turbidity may be used as a surrogate for suspended sediment only when the relationship between the two parameters is established for a particular waterbody.

2.3 License Requirements for the Protection of Fish and Fish Habitat at Whale Tail

The Nunavut Water Board (NWB) Type A Water License for the Whale Tail Pit Project will include the maximum monthly mean (MMM) and short term maximum (STM) TSS concentrations for the dike construction, the dewatering activities and the applicable monitoring stations during operation. These requirements will be included during the erosion monitoring and water quality sampling.

SECTION 3 • EROSION MONITORING AND MITIGATION

The purpose of the Plan is to ensure that Agnico Eagle can monitor signs of erosion and minimize its resulting effects. This plan presents the monitoring and mitigating actions related to three (3) specific periods of activity for Whale Tail Pit:

- Period of construction and dewatering – during construction and operation;
- Period of freshet – during construction, operation and closure;
- Period of rise in water level in the South Basin of Whale Tail Lake – during operation.

Monitoring plan and mitigating measures are proposed below for each of these periods of activity.

3.1 Erosion During Construction and Dewatering

The construction of water management infrastructure, especially the WTD, could potentially lead to excess TSS. Dewatering could also require erosion control. A water quality monitoring program and TSS management plan is proposed in the Water Quality Monitoring and Management Plan for Dike Construction and Dewatering (Agnico Eagle, 2016) in order to minimize the effects of the construction of dewatering dikes and subsequent dewatering.

This plan provides details of water quality monitoring and management actions specifically related to the dike construction and dewatering activities. This plan includes the following components:

- Water quality monitoring and management plan for dike construction;
- Water quality and lake level monitoring and management plan for dewatering.

For those specific activities and their respective erosion monitoring and management practices, refer to the Water Quality Monitoring and Management Plan for Dike Construction and Dewatering (Agnico Eagle, 2016).

3.2 Erosion During Freshet

The freshet season at Whale Tail occurs approximately from mid-May until the end of July; however, this period of time can extend up to early fall (mid-October), when re-freezing occurs. Following the construction of the main dewatering dike (the WTD), the hydrogeological regime of the site will change during operations as water from the South Basin of Whale Tail Lake will be rerouted south until it reaches the Mammoth Lake through a newly excavated channel (the South Whale Tail Diversion Channel). Following the site construction, new areas and infrastructures will become potentially vulnerable to excess of water during the freshet season, such as, but not limited to:

- Culverts and other water management infrastructures;
- Newly constructed embankments, such as roads and berms;
- Water diversion ditches and channels.

A monitoring program and mitigating measures are proposed in the next sections.

3.2.1 Proposed Monitoring

In order to monitor the potential erosion during freshet, smaller water management infrastructures such as culverts, cross drains and ditches should be inspected on a regular basis and after significant rain events. Bigger culverts and bridges should be inspected more often if they represent a risk for daily operations, for the receiving environment or for the health and safety of workers. More specifically, the following aspects, but not limited to, should be monitored during visual inspections:

- Accumulation of debris near the inlet of the crossings, impeding the free flow of water at those locations;
- Bed erosion upstream and downstream of watercourse crossing structures;
- Scour under bridge abutments and abutment foundations;
- Erosion along cutslopes and fillslopes of embankments (rill and gully erosion), etc.

Newly excavated channels should be inspected on a regular basis and after significant rain events as well. Erosion signs along the channel flow path should be monitored. Inspections should be carried out during the spring when surficial ice moves towards the inlet of the diversion channels to ensure that no ice blockage cause water buildup upstream of the channel, which could lead to subsequent erosion problems.

The frequency of water grab samples and turbidity should follow the Type A Water License requirements and could be increased in required during the freshet season, if the TSS contents gets near or exceed the maximum allowed value as per the license.

Monitoring will be documented with site photographs and inspection forms.

3.2.2 Mitigating Measures

The following mitigation measures could be used if applicable and required to reduce risks associated with erosion:

- Riprap or clean non-acid generating/non-metal leaching rockfill could be used to armor shorelines, bridge abutments, culverts inlets and outlets and toe berms;
- Ditches managing high volumes of water could be armored for erosion control and reduce the speed of water flow;
- Sedimentation basins could be constructed at sensitive locations to allow settlement of finer sediments;
- Ditches, culverts and other water crossing structures should be maintained free of debris to allow free flow of runoff water;
- Installation of erosion control material such as turbidity barriers, silt curtains or straw booms.

Site-specific erosion issues may arise during the mine operation that require specific local corrective actions.

3.3 Erosion Due to the Rise of Water Level

The Whale Tail Dike (WTD) is an important dewatering dike that is required to enable mining of the open pit located in the north part of Whale Tail Lake. This dike is located on a shallow plateau of the

lake floor with an approximate 2 m depth of water. Once in operation, the downstream side of the dike will be dewatered and the upstream side of the dike will allow a 3.5 m raise of the water level prior to being discharged by gravity towards Mammoth Lake.

The 3.5 m rise of water level following the construction of the WTD is a potential source of erosion, specifically along the shorelines located on both shores of the Whale Tail Lake from the South Basin up until the South Whale Tail Diversion Channel.

Gradation curves obtained from samples collected at both abutments of the WTD showed that the esker located at the west shore is composed of coarser material (sand and gravel), whereas the soil near the east shore is mostly silty sand with some gravel and clay (SNC-Lavalin, 2018b). Erosion hazard varies with soil type and slope along the shorelines. These factors will be taken into account for the monitoring and mitigation presented below.

3.3.1 Proposed Monitoring

According to the water balance of the Whale Tail Lake, it is expected that the water level in South Whale Tail Lake will reach its final elevation of 156.0 m approximately two (2) years after the construction of the WTD, during the summer of 2020 (SNC-Lavalin, 2018a). Visual inspection of the shoreline stability and of the water quality on a regular basis during open water season will be required to ensure that erosion along the new banks will not mobilize excess TSS in the Whale Tail Lake, especially during the first years following construction while the water level is rising. Shorelines instability will be noted, along with signs of permafrost degradation such as ground ice melting, gully and fissuring.

The frequency of grab water samples and turbidity should follow the Type A Water License requirements and could be increased in required during the freshet season, if the TSS contents gets near or exceed the maximum allowed value as per the license.

Monitoring will be documented with site photographs and inspection forms.

3.3.2 Mitigating Measures

Because erosion of the shorelines is a rather specific problem, the installation of riprap, clean non-acid generating/non-metal leaching rockfill on the affected banks could be considered in most cases if erosion-related issues are observed. Installation of erosion control material such as turbidity barriers, silt curtains or straw booms could be done if required.

If severe erosion problems occur following the rise of the water level in the South Basin, additional site specific mitigating measures such will be developed according to the site conditions.

SECTION 4 • REFERENCES

Agnico Eagle Mines Ltd. (2016). *Water Quality Monitoring and Management Plan for Dike Construction and Dewatering.* In Accordance with Water License 2AM-MEA0815. Prepared by Agnico-Eagle Mines Limited - Meadowbank Division, Version WT, June 2016.

Canadian Council of Ministers of the Environment. (1999). *Canadian Water Quality Guidelines for the Protection of Aquatic Life - Total Particulate Matter.* (Updated 2002).

Caux, P. Y., Moore, D. R., & MacDonald, D. (1997). *Ambient water quality guidelines for turbidity, suspended particles and benthic sediments - technical appendix.* Prepared for BC Ministry of Environment, Lands and Parks.

Fisheries and Oceans Canada. (1999). *The Effects of Sediment on Fish and their Habitat.* Research Document 99/139.

Government of Canada. (2002). *Metal Mining Effluent Regulations.* SOR/2002-222. Minister of Justice of Canada. Current to April 24, 2018, last amended on December 8, 2017.

Lloyd, D. S., Koenings, J. P., & Laperriere, J. D. (1987). Effects of Turbidity in Fresh Waters of Alaska. *North American Journal of Fisheries Management, 7*(1), 18-33.

SNC-Lavalin. (2015). *Scoping Study Report of Whale Tail Pit Project, Geotechnical Infrastructures and Water Management.* 627215-0000-4GER-0001, May 2015.

SNC-Lavalin. (2018a). *Thermal analysis at Whale Tail Dike.* Report No. 651298-2100-4GER-0001_PB, February 2018.

SNC-Lavalin. (2018b). *Design report of Whale Tail Dike.* 651298-2700-4GER-0001_01, May 10, 2018.

Fish Habitat Offset Monitoring Plan, Version 1

AGNICO EAGLE

WHALE TAIL PIT

Fish Habitat Offset Monitoring Plan

Prepared by:
Agnico-Eagle Mines Limited – Meadowbank Division

Version 1
March, 2018

EXECUTIVE SUMMARY

General Information

This Fish Habitat Offset Monitoring Plan (FOMP) defines the sampling methods and criteria for success of the fish habitat offsetting features described in the Fish Habitat Offsetting Plan for Whale Tail Pit (March, 2018).

Record of Changes

A record will document all significant changes that have been incorporated in the FOMP subsequent to the latest review. The record will include the names of the persons who made and approved the change, as well as the date of the approval.

Distribution List

Agnico Eagle Mines Limited will maintain a distribution list for the FOMP, providing information about all parties that receive the plan including mine personnel, departments, and outside agencies.

IMPLEMENTATION SCHEDULE

The implementation schedule for this plan is effective immediately subject to any modifications proposed by DFO as a result of the review and approval process.

DISTRIBUTION LIST

AEM - Environmental Superintendent

AEM – Environmental Coordinator

AEM – General Mine Manager

AEM – Site Services Superintendent

AEM – Field Services Supervisor

AEM – Engineering Superintendent

DFO Arctic Region Representative

DOCUMENT CONTROL

Document Control

Version	Date (YMD)	Section	Page	Revision
Draft	2017/06/15	All	All	Initial document
1	2018/03/27	All	All	Update based on DFO consultation on offsetting concepts

Version 1

Prepared By: Meadowbank Environment Department

Approved By: _____

Ryan Vanengen
Environmental Permitting Lead – Amaruq Project

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **II**

IMPLEMENTATION SCHEDULE ..... **III**

DISTRIBUTION LIST ..... **III**

DOCUMENT CONTROL ..... **IV**

SECTION 1 • INTRODUCTION **1**

1.1 Background 1
1.2 Objectives 1

SECTION 2 • SUMMARY OF OFFSETTING MEASURES **2**

2.1 Rock Shoals 2
2.2 Constructed Sill and Elevated Water Level 3
2.3 Complementary Measures 3

SECTION 3 • MONITORING METHODS **3**

3.1 Habitat Enhancement/Creation Features 3
3.1.1 Physical Structure Monitoring 4
3.1.2 Ecological Monitoring 5
3.1.2.1 Interstitial Water Quality 5
3.1.2.2 Open Basin and Pit Water Quality 5
3.1.2.3 Periphyton Growth 6
3.1.3 Fish Use 7
3.2 Complementary Measures 7

SECTION 4 • FREQUENCY **7**

SECTION 5 • QA/QC **7**

5.1 Laboratory QA/QC 8
5.2 Field QA/QC 8

SECTION 6 • CRITERIA FOR SUCCESS **9**

6.1 Habitat Enhancement/Creation Features 9
6.1.1 Physical Structure 9
6.1.2 Interstitial Water Quality 9
6.1.3 Open Basin Water Quality 9
6.1.4 Periphyton Community 10

6.1.5 Fish Use 10
6.2 Complementary Measures 11

SECTION 7 • REPORTING AND PLAN REVIEW 11

SECTION 8 • REFERENCES 11

TABLES 21

LIST OF TABLES

Table 1. Estimated timeline for the construction of fish habitat offsets. Offsets will be realized once reflooding of Whale Tail North Basin occurs (est. 2027), dikes are breached (est. 2029), and criteria for success are met. 21
Table 2. Estimated timeline for complementary measures (research projects). 21
Table 3. Example comparison of designs and as-built physical properties of habitat compensation features. 22
Table 4. Summary of monitoring methods, analytical parameters, sampling frequency and number of samples for habitat offsetting features to be monitored. Reflooding (F) is estimated to be completed in 2028, and the dike breached in 2029 (B). Construction (C) dates vary by feature, according to Table 1. 22

SECTION 1 • INTRODUCTION

1.1 BACKGROUND

Since 2010, Agnico Eagle Mines Limited (Agnico) has operated the Meadowbank Gold Mine, approximately 70 km north of the hamlet of Baker Lake, Nunavut. In 2016, Agnico submitted applications to the Nunavut Impact Review Board and Nunavut Water Board to permit the construction and operation of the Whale Tail Pit satellite deposit on the Amaruq site.

Since mining activities related to Whale Tail Pit are planned to result in serious harm to fish as described under Section 35 of the *Fisheries Act*, Agnico is applying to Fisheries and Oceans Canada (DFO) for an authorization under Subsection 35(2) of the Act. To support this application, a Fish Habitat Offsetting Plan for Whale Tail Pit has been developed, which quantifies losses to fish habitat that are expected to occur, and describes the habitat gains that will be achieved through fish habitat offsetting measures. Further, this Fish Habitat Offset Monitoring Plan has been developed to describe the specific monitoring program that will be implemented to determine the effectiveness of fish habitat offsetting features and confirm when offsets have reached full functionality.

Existing authorizations for the Meadowbank site under *Fisheries Act* Section 35 include NU-03-0190 (streams along the Meadowbank All Weather Access Road), NU-03-0191.3 (Second and Third Portage Lakes), NU-03-0191.4 (Vault Lake), NU-08-0013 (Western Channel), and NU-14-1046 (Phaser Lake). These authorizations are supported by the 2012 No Net Loss Plan for the Meadowbank Site, and the 2016 Fish Habitat Offsetting Plan for Phaser Lake, as well as the 2017 Habitat Compensation Monitoring Plan for the Meadowbank Site.

Overall, the monitoring approach for Whale Tail Pit offsets has been developed based on methods that are consistent with those used since 2009 on the Meadowbank site (as described in the 2017 Habitat Compensation Monitoring Plan) and to enhance regional understanding of fish, fish habitat, ecosystem function and productivity. These include structural assessments of constructed features, as well as monitoring of water quality, periphyton growth, and fish use. Further, these endpoints are consistent with Traditional Knowledge concerns related to protecting fish, fish habitat and ensuring clean water (Whale Tail Pit FEIS Appendix 7-A: IQ Baseline, Agnico Eagle 2016).

1.2 OBJECTIVES

The majority of required habitat gains for Whale Tail Pit offsetting are planned to be achieved through habitat creation and enhancement efforts. These include:

- re-flooding of the de-watered Whale Tail Lake - North Basin following construction of habitat enhancement features (shoals);

and

- maintaining an elevated water level in Whale Tail Lake compared to baseline conditions;

In order to ensure that offsets are functioning fish habitat as intended and projected through Traditional Knowledge workshops, assessment of the structure and successful utilization of these features by fish are the primary goals of the monitoring program for habitat enhancement/creation offsets.

The overall objectives of this plan are:

a. To describe physical and ecological monitoring methods for each feature
b. To describe the quality assurance and control measures to be included in the monitoring program
c. To define the criteria for success
d. To present the monitoring frequency and reporting schedule

In addition to the constructed habitat offsetting features to be monitored through this plan, a portion of offsetting for Whale Tail Pit will be provided through development and coordination of a suite of complementary measures (research projects). No physical monitoring is conducted in relation to research projects, so they are referred to minimally in this plan (refer to Fish Habitat Offsetting Plan for Whale Tail Pit, March, 2018 for full descriptions of complementary measures). However, progress monitoring will be incorporated in each research project to document annual activities, and that component is described here along with criteria for success.

SECTION 2 • SUMMARY OF OFFSETTING MEASURES

The following constructed features will create or enhance fish habitat to offset losses occurring in the North Basin of Whale Tail Lake. Complementary measures included in the offsetting plan area also summarized. Further details for each are provided in the Fish Habitat Offsetting Plan for Whale Tail Pit (March, 2018).

2.1 ROCK SHOALS

Placement of rock material to change lake basin substrate from fine or mixed to coarse (i.e. the creation of rock shoals) is the most commonly used enhancement technique. This offsetting measure will occur in the dewatered area of Whale Tail Lake – North Basin outside of the pit, with the work conducted prior to reflooding.

Roads, jetties and other features will be scarified or converted to coarse substrate as necessary, prior to closure. A pit sill cap of coarse rock material will also convert fine substrate to coarse in areas where coarse substrate did not already exist. In addition, a

network of shoals (termed grid shoals based on their conceptual design pattern) will convert half of the southern area of the North Basin to higher-value habitat.

2.2 CONSTRUCTED SILL AND ELEVATED WATER LEVEL

During the operations period when Whale Tail Lake – North Basin is dry, a permanent water control structure (sill) will be constructed just upstream of Mammoth Dike. Once the Whale Tail Dike is breached and flows resume its natural direction through Mammoth Lake, this feature will ensure that water levels in Whale Tail Lake and connecting channels remain at 1 m higher than baseline conditions. It is estimated that a 1 m increase in water levels upstream of the Mammoth Dike would create approximately 46.6 ha of new aquatic habitat.

2.3 COMPLEMENTARY MEASURES

A suite of complementary measures (research projects) is proposed to include:

- Assessment of changes in aquatic productivity and fish populations due to flooding of Whale Tail South and downstream lakes during operations
- Assessment of impacts of the Baker Lake wastewater outflow on aquatic systems including fish and fish habitat
- Literature review and field validation of northern lake fish habitat preferences
- Arctic grayling occupancy modeling
- Pit lake habitat use assessment
- eDNA methods development

SECTION 3 • MONITORING METHODS

3.1 HABITAT ENHANCEMENT/CREATION FEATURES

As in the Habitat Compensation Monitoring Plan for the Meadowbank site, both physical and ecological components are included in the offset monitoring plan, to record whether each feature is constructed and is functioning as intended.

The assessment of habitat features incorporates monitoring methods with specific quantitative criteria for success (physical structure, interstitial water quality), as well as complementary “qualitative” tools (periphyton growth and fish use). All lines of evidence are then integrated in a weight-of-evidence approach to make the final determination regarding habitat feature functionality.

The proposed type and schedule of monitoring is described for each feature in Table 3 and 4, and details for each monitoring component are provided below.

3.1.1 Physical Structure Monitoring

Since the habitat evaluation procedure focuses on quantifying losses and gains to habitat, based on physical characteristics (area, depth and type of substrate), physical structure is arguably the most important component to monitor in cases where habitat offsets are derived from constructed features (such as reefs or boulder gardens).

All habitat structures constructed as offsets will be assessed post-construction to determine whether they meet the assumptions of the offsetting plan. These include area, depth and substrate characteristics. For each feature, a comparison will be made to the specifications described for these characteristics, to determine whether expected physical habitat gains are achieved in the as-built state (i.e. to confirm features were constructed as planned).

In addition to the analysis of depth, area, and substrate in the dry basins, structural integrity will be qualitatively assessed after re-flooding, to record any movement occurring during this process.

Methods of evaluation will depend on the specific offsetting feature, and are detailed in Tables 3 and 4. Depending on the feature, these methods may include:

On-the-ground photos – photos will be taken of the compensation feature pre-, during and post-construction.

Aerial photos or PhotoSat Imagery – will be taken of dry basin just prior to re-flooding, to compare areal extents of compensation features with offsetting plan predictions. Differences will be estimated visually or by GIS.

Visual observation – conducted to ground-truth substrate types for confirmation in air photos.

Field survey – conducted in the dry to determine depth-below-surface of offsetting features.

Underwater video – conducted post-flooding to qualitatively examine structural integrity of constructed features.

Results will be recorded for each feature and compared to the associated offsetting plan estimate, making use of the example provided in Table 3.

Analysis of the physical components will occur in the dry for features constructed in the de-watered basin, in order to facilitate ground-truthing of substrate and total area. This analysis will occur just prior to re-flooding, such that features are in their final condition. As-built reports will first be consulted to determine if the required information is available.

3.1.2 Ecological Monitoring

Ecological monitoring elements include interstitial water quality, open basin water quality, periphyton community biomass and fish use.

3.1.2.1 Interstitial Water Quality

Modeling during the EIA process did not indicate that metals leaching from quarried rock used to construct dikes and roads would significantly impact the aquatic environment. Nevertheless, interstitial water quality of constructed habitat offsetting features will be assessed to verify these predictions.

In order to collect a representative sample from the bioactive zone between the rocks, an electric diaphragm pump with food-grade silicon tubing is used. If possible, samples will be taken at depths between 1 and 4 m, and analyzed in an accredited laboratory for total suspended solids, and total and dissolved metals. Results will be compared to background concentrations, CCME guidelines where available, or CREMP threshold values. Locations and schedules for interstitial water quality sampling are described in Table 4.

3.1.2.2 Open Basin and Pit Water Quality

Modeling during the EIA process indicated that water quality in the re-flooded pit and lake basin would be suitable for aquatic life during the post-closure period. Although the pit area is not included as habitat, the re-flooded adjacent basin areas form part of habitat offsetting for Whale Tail Pit. Water quality within both the basin and the pit will be monitored as the pit re-fills and after breaching of the dike as part of NWB Type A Water License requirements under the site's Water Quality and Flow Monitoring Plan (during operation, closure and post-closure) and Core Receiving Environmental Monitoring Plan. Specific monitoring locations within the Whale Tail Lake North Basin will be determined by experienced field technicians.

According to the Water Quality and Flow Monitoring Plan, these assessments will occur 4x per year, and parameters to be monitored include:

Total and dissolved metals: aluminum, antimony, arsenic, boron, barium, beryllium, cadmium, copper, chromium, iron, lithium, manganese, mercury, molybdenum, nickel, lead, selenium, tin, strontium, titanium, thallium, uranium, vanadium and zinc

Nutrients: Ammonia-nitrogen, total kjeldahl nitrogen, nitrate nitrogen, nitrite-nitrogen, ortho-phosphate, total phosphorous, total organic carbon, total dissolved organic carbon and reactive silica

Conventional Parameters: bicarbonate alkalinity, chloride, carbonate alkalinity, conductivity, hardness, calcium, potassium, magnesium, sodium, sulphate, pH, total alkalinity, TDS, and TSS, turbidity;

Total cyanide and free cyanide: If CN total is detect above 0.05 mg/L in an analysis result for monitoring station in receiving environment; further analysis of CN WAD will be triggered.

In addition to the above monitoring under the Water Quality and Flow Monitoring Plan, supplemental monitoring that will inform fish habitat offsetting will be conducted as a component of the Core Receiving Environment Monitoring Plan (CREMP). This analysis will generally follow methods established in the CREMP: 2015 Update – Whale Tail Pit Addendum (May, 2016).

These supplemental analyses will include vertical depth profiles of temperature, DO and conductivity to a representative depth. Secchi depth and surface pH will also be determined at each sampling location. In addition to the list of water quality parameters above, water samples will be collected to assess organic parameters (chlorophyll-α, dissolved and total organic carbon).

Water samples will be collected from approximately 3 m depth by pumping lake water using weighted flexible (food-grade silicone) tubing, and a diaphragm pump connected to a 12 volt battery. An inline filter is connected to the end of the outflow tube when filling bottles for dissolved metals and dissolved organic carbon analyses.

Results of water quality monitoring will be compared to background concentrations, CREMP trigger or threshold levels, CCME guidelines where available, and any site-specific criteria. General locations and schedules for open basin water quality sampling are described in Table 4.

3.1.2.3 Periphyton Growth

The periphyton community consists of a collection of microorganisms, including algae, that grow attached to or in very close proximity to submerged substrate. Colonization of the community occurs over time, with rates depending on nutrient and light availability. Periphyton is an important food source for benthic invertebrates, so colonization will be monitored to ensure that quarried rock substrate provides habitat that is as suitable at this level of the food chain as natural substrate.

Periphyton sampling for habitat assessments will be carried out in the same manner as described in the Whale Tail CREMP (Azimuth, 2016), and Habitat Compensation Monitoring Plan for the Whale Tail Site.

Periphyton Samplers: Briefly, a specialized scrubber will be used to collect periphyton samples from a prescribed area of rock face, in order to calculate cell density and/or biomass ($\mu g/cm^2$). This method will be appropriate to assess growth of periphyton in the flooded littoral zone.

Underwater Video: For deeper areas (constructed shoals) underwater video will be used to make qualitative assessments of periphyton growth.

Results will be compared to reference sites, baseline data, and/or historical monitoring programs. Locations and schedules for periphyton sampling are described in Table 4.

3.1.3 Fish Use

In accordance with DFO's "Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting" (November, 2013), monitoring of fish use in the reflooded Whale Tail Lake will aim to demonstrate that the system has reached full ecological functionality (i.e. supports fish reproduction, growth, and survival). Since the use of gill nets has historically been found to result in elevated incidences of mortality, electrofishing, angling and underwater camera techniques were proposed in 2014 for the Meadowbank site, used during baseline data collection in 2016 and will continue to be used to establish fish presence around the constructed habitat features and in the open basin of Whale Tail Lake. Catch per unit effort and physical characteristics (species, length, weight, maturity, sex) will be recorded and compared to reference areas and/or historical results, as the dataset allows. Use of hydroacoustic surveys may also be employed to assess fish presence within the north basin of Whale Tail Lake.

If these techniques are not successful, a DFO representative will be contacted and the use of gill nets may need to be included. It is estimated to be likely that use of gill nets will be required to demonstrate that DFO's criteria for success related to full ecological functionality have been met, since catch through angling is typically low, and quantitative assessments of growth are not feasible using underwater camera work. Locations and schedules for monitoring of fish use are provided in Table 4.

3.2 COMPLEMENTARY MEASURES

Progress reports for each research project will be provided annually to DFO (see Section 7) from study initiation until criteria for success are met. Results of the offsetting monitoring will be shared on an annual basis with the Meadowbank Fisheries Advisory Group to further mutually inform research projects and future monitoring programs.

SECTION 4 • FREQUENCY

The initial planned sampling schedule and general locations of monitoring for each feature are described in Table 4. Specific sampling locations will be determined in the field by a qualified environment technician or biologist. Monitoring will be conducted at a minimum for the time period specified in Table 4, and may be continued if criteria for success are not met within this time frame.

SECTION 5 • QA/QC

The following QA/QC procedures are presented for general consideration, and primarily apply to assessments of habitat enhancement features. QA/QC procedures for research programs will be encouraged by Agnico but will ultimately be determined by academic partners based on individual project components.

5.1 LABORATORY QA/QC

Water Quality – Data Quality Objectives (DQOs) are numerically definable measures of analytical precision and completeness. Analytical precision is a measurement of the variability associated with duplicate analyses of the same sample in the laboratory. Completeness for this study is defined as the percentage of valid analytical results. Duplicate results will be assessed using the relative percent difference (RPD) between measurements.

The laboratory DQOs for this project are:

Analytical Precision = 25% RPD or less for concentrations that exceed 10x the method detection limit (MDL).

Completeness = 95% valid data obtained.

Periphyton Community – Laboratory analyses for periphyton samples will be conducted by experienced scientists following a standardized procedure (i.e., quality assurance). Internal quality control samples (e.g., duplicate counts) will be included to document analytical variability.

5.2 FIELD QA/QC

Water Sampling – Field QA/QC standards during water sampling will be maintained for every sample. The standard QA/QC procedures include thoroughly flushing the flexible tubing and pump to prevent cross-contamination between stations and thoroughly rinsing the sample containers with site water prior to sample collection. Trip blanks and field duplicates will be collected (approximately 1 per 10 samples). Field duplicates assess sample variability and sample homogeneity; a RPD of 50% or less for concentrations that exceed 10x the MDL is considered acceptable.

Periphyton Community – Standard procedures will be used to collect biota samples. All sampling gear will be thoroughly rinsed between sampling stations to ensure that there was no inadvertent introduction of biota from one station to another. A field duplicate will be collected for phytoplankton at one sampling station per sampling event to assess sampling variability and sample homogeneity. Due to large natural variability and the qualitative nature of this component, no specific RPD acceptability criterion is recommended for density and biomass.

Fish Use – These study components will be conducted in accordance to the general practices listed previously. All relevant spatial and depth information will be recorded. Fish biological data will be recorded as will reference spatial information. Field notebooks or field sheets will be used to compile notes and observations relevant to the studies. Fishing will be carried out by experienced technicians or biologists who are very familiar with this kind of work. Video/photo survey data will be conducted carefully to provide representative images

of target communities. All relevant spatial and depth information will be recorded and identified by the time stamp (or photo number) and tape number (or memory card number).

SECTION 6 • CRITERIA FOR SUCCESS

6.1 HABITAT ENHANCEMENT/CREATION FEATURES

Criteria for success for habitat offsetting are aimed at demonstrating fish presence, survivorship and full ecological functionality of the system (i.e. reproduction, growth, survival of fish). Specific criteria have been established for physical structure, water quality, and fish use to determine whether these conditions have been met. However, as described in Agnico's 2008 HCMP, a weight-of-evidence approach will continue to be used to determine whether habitat offsetting features are functioning as intended overall, and to make decisions regarding offsetting achievements.

The following specific success criteria will be used prior to integrating data in a weight-of-evidence evaluation of habitat enhancement or habitat creation offsetting projects.

6.1.1 Physical Structure

In order to provide the required habitat gains, constructed features should meet the specifications described for area, depth and substrate in the offsetting plan. Where specifications are not met, the total habitat units afforded by the feature in its as-built state will be calculated. If there is a deficiency in habitat units site-wide, DFO will be consulted.

6.1.2 Interstitial Water Quality

Water chemistry results will be compared to reference locations and CCME water quality guidelines as available. If necessary, follow-up sampling will be conducted as soon as practical during ice-free conditions. If water quality criteria do not meet background or CCME guidelines after two monitoring events, risk-based toxicity reference values will be compared, and additional testing, such as laboratory toxicity tests will be considered. Because onsite experience and HCMP dike face monitoring results to date at Meadowbank indicate that adverse effects are unlikely, any additional testing would be determined in consultation with DFO if required. Criteria for success will be maintenance of acceptable water quality conditions for aquatic life according to the above comparisons throughout three sequential monitoring events.

6.1.3 Open Basin Water Quality

In post-closure, water quality in the fully flooded Whale Tail Pit and Whale Tail Lake (North Basin) are predicted to be relatively constant throughout the year, and there are no predicted exceedances of the CEQG-AL criteria or the site specific water quality objective (SSWQO) developed for arsenic during the FEIS phase. Water quality will be suitable for overflow to Mammoth Lake, assuming that diffusion from the pit wall rock will not occur, nor any exchanges between the Whale Tail Pit and above lake water. As per NWB Type A

Water Licence requirements, a site wide water balance will be updated as part of the annual water management plan and end pit water quality modelling will be conducted to update these predictions. Dikes will not be breached to allow fish entry until water quality in the flooded area meets CEQG-AL, baseline concentrations, or appropriate SSWQOs in accordance with the NWB Type A. Specific criteria for success related to water quality to allow breaching of the Whale Tail Dike and entry of fish into the North Basin area will be determined in consultation with NWB (including DFO) and KIA, upon submission of the final closure plan.

Water quality within the open basin following breaching of the dike will be monitored in accordance with NWB Water License requirements. The criteria for success from a fish habitat offsetting perspective will be maintenance of acceptable water quality conditions for aquatic life according to these programs throughout three sequential monitoring events.

6.1.4 Periphyton Community

Since lakes in the Meadowbank region are ultra-oligotrophic and ice-covered for the majority of the year, periphyton development is expected to be slow. Results from monitoring of habitat features at the Meadowbank site (East Dike) demonstrate that periphyton biomass is not fully established to baseline values within 5 years following construction, although year-over-year improvements are considerable. Since periphyton growth has been extremely variable in reference sites historically (Azimuth, 2008), no specific quantitative criteria for success for this metric are proposed. However, within the weight of evidence assessment, periphyton measurements should document increases in biomass between monitoring events, and a trend towards reaching baseline biomass density.

6.1.5 Fish Use

According to DFO's "Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting" (November, 2013), monitoring of offsetting measures must be designed to confirm that serious harm to fish has been effectively counterbalanced. As a result, criteria for success for fish use are aimed at demonstrating presence, survivorship and full ecological functionality of the system (i.e. fish reproduction, growth, survival). Specifically, to establish success for Whale Tail Lake – North Basin, fish of each expected species from baseline studies will be documented as present in a natural range of sizes (for large bodied fish) around habitat features within the re-flooded area. Comparisons will generally be made to appropriate reference sites. Reproduction will be determined through observations of fry or specific assessments of spawning activities within the reflooded area, such as night-time visual searches for spawning events. If used, hydroacoustic surveys will demonstrate that fish populations in the Whale Tail North basin area (i.e. not the pit area, as that is not considered habitat) have a similar abundance, biomass or otherwise appropriate endpoint to reference areas in Whale Tail South Basin or reference lake. Criteria for success for all metrics related to fish use will be demonstration of the above-described conditions for three sequential monitoring events.

6.2 COMPLEMENTARY MEASURES

The main goal for all complementary measures is publication of research or methods development studies in the peer-reviewed literature (one or more publications per study). However it is recognized that not all factors affecting outcomes of research projects and suitability of studies for such publication are within the control of Agnico, academic partners, or DFO. As a result, in certain instances, peer-reviewed publication may not be a viable route for dissemination of knowledge gained through these projects. In such cases, Agnico suggests discussions be undertaken between researchers, DFO, and Agnico to determine a mutually agreeable solution (e.g. conference presentations, inter-agency workshops). Criteria for success of complementary measures are thus considered to be submission of one or more manuscripts per study for publication in a peer-reviewed journal.

SECTION 7 • REPORTING AND PLAN REVIEW

Annual reports describing activities conducted under this Fish Habitat Offset Monitoring Plan will be submitted with Agnico's Annual Report to the NIRB by March 31 of the following year. These will include monitoring related to constructed habitat offsets as well as progress reports on complementary measures.

The FOMP will be reviewed as required by the Meadowbank Environment Superintendent, and updated as necessary based on changes to mine site designs. All changes will be provided to DFO for approval as a revised document in the Annual Report.

SECTION 8 • REFERENCES

Agnico Eagle. 2016. Inuit Qaujimajatuqangit Baseline Report. Whale Tail Pit FEIS Appendix 7-A. June 2016.

Azimuth, 2008. Habitat Compensation Monitoring Plan, Meadowbank Gold Project. Prepared by Azimuth Consulting Group Inc. for Agnico-Eagle Mines Ltd. May, 2008.

Azimuth. 2016. Core Receiving Environment Program: 2015 Update. Whale Tail Pit Addendum. Prepared by Azimuth Consulting Group Inc., Vancouver, BC for Agnico-Eagle Mines Ltd., Vancouver, BC. May, 2016.

TABLES

Table 1. Estimated timeline for the construction of fish habitat offsets. Offsets will be realized once reflooding of Whale Tail North Basin occurs (est. 2027), dikes are breached (est. 2029), and criteria for success are met.

Lake	Feature Name	Date of Construction
Whale Tail Lake	Grid shoals	TBD - Prior to reflooding
	Road augmentation/scarification (shoals)	TBD - Prior to reflooding
	Mammoth Dike Sill	TBD - Prior to reflooding
	Whale Tail South - Flooded area	2019 - 2021

Table 2. Estimated timeline for complementary measures (research projects).

Project	Study Start Date	Estimated Study Duration
Changes in Aquatic Productivity	Summer 2018	3-4 years
Baker Lake Wastewater Assessment	Summer 2018	5 years
Lake Fish Habitat Preferences	Summer 2018	2 years
Arctic Grayling Occupancy Modelling	Summer 2018	3 years
Pit Lake Habitat Assessment	TBD	5 years
eDNA Methods Development	Summer 2017/2018	3-5 years

Table 3. Example comparison of designs and as-built physical properties of habitat compensation features.

Feature	Assessment Metric*	Method	Design	As-Built
Boulder garden	Area	Air photo	2.97 ha	3.5 ha
	Substrate	Visual observation	Coarse	Coarse (indicate actual grain size)
	Depth	Field survey	> 4 m	> 4 m
	Stability	Underwater video	-	Minor movement

*Area, depth, substrate type or stability

Table 4. Summary of monitoring methods, analytical parameters, sampling frequency and number of samples for habitat offsetting features to be monitored. Reflooding (F) is estimated to be completed in 2028, and the dike breached in 2029 (B). Construction (C) dates vary by feature, according to Table 1.

Feature	Component	Reason	Method	Parameters	Number of Samples	Sampling Schedule
Mammoth Sill	Structure	Design intent met	As-built designs Air photos Field survey of flooded zone	Area (ensure flooded area meets offsetting requirements)	-	F+1
		Stability	Visual assessment of sill	Qualitative observations	-	C+1 F+1
Basin	Open basin water quality*	Possible metals leaching, anoxia	Tube sampler Grab samples Depth profiles	Metals, nutrients, conventionals, cyanide, organic parameters. See Section 4.1.2.2	1 location within Whale Tail North Basin	4x/year, according to Type A Water License requirements (Water Quality and Flow Monitoring Plan). Additional according to CREMP.

Feature	Component	Reason	Method	Parameters	Number of Samples	Sampling Schedule
	Structure	Design intent met	Air photos Field survey	Area, substrate, depth zone	-	Prior to flooding
	Fish use	To confirm the presence, survivorship, growth, and reproduction of fish	Angling Electrofishing Underwater motion camera Hydroacoustic survey Spawning surveys Gill nets if necessary	CPUE Physical characteristics Length-weight; meristics data on incidental mortalities Total abundance Presence of spawning	TBD by field staff and results	B+1, 3, 5, 10
Roads & Grid Shoals	Structure	Design intent met	Air photos Field survey	Area, substrate, depth zone	-	Prior to flooding
		Stability	Underwater camera	Qualitative observations	Representative transects TBD by field staff	F+2
	Interstitial water	Possible metals leaching	Tube sampler	TSS Total and dissolved metals	3 locations	B+1, 3, 5, 10
	Periphyton	Base of food chain	Underwater camera	Qualitative observations	Representative transect TBD by field staff	B+1, 3, 5, 10
	Fish use	To confirm the presence, survivorship,	Angling	CPUE	One location TBD by field staff	B+1, 3, 5, 10

Feature	Component	Reason	Method	Parameters	Number of Samples	Sampling Schedule
		growth, and reproduction of fish	Underwater motion camera Gill nets if necessary	Physical characteristics		
Flooded zone	Periphyton	Base of food chain	Periphyton sampler	Biomass	Four representative locations in flooded zone TBD by field staff – two in north basin and two in south basin	B+1, 3, 5, 10
	Fish use	To confirm the presence, survivorship, growth, and reproduction of fish (small bodied fish in new flooded littoral zone)	Minnow traps, if possible Visual assessments	Length/weight, relative abundance Presence/absence	Four representative locations in flooded zone TBD by field staff - two in north basin and two in south basin	B+1, 3, 5, 10

*Monitoring and sampling protocols will be further developed and conducted as a component of Water Quality and Flow Monitoring Plan and CREMP, and will be conducted throughout the post-closure period; this duration will be determined in the final Reclamation and Closure Plan, to be submitted to NWB 1 year prior to closure.

Fish Habitat Offsetting Plan, Version 1

AGNICO EAGLE

WHALE TAIL PIT

Fish Habitat Offsetting Plan

Prepared by:
C. Portt and Associates
&
Agnico Eagle Mines Limited – Meadowbank Division

Final:
Version 1
March, 2018

TABLE OF CONTENTS

EXECUTIVE SUMMARY IV

SECTION 1 • INTRODUCTION 1

1.1 Goal 1
1.2 Hydrologic Setting 3
1.3 Water Elevations and Lake Shorelines 3
1.4 Whale Tail Study Area Fish Community 6

SECTION 2 • HABITAT EVALUATION PROCEDURE 9

2.1 HEP Model 9
2.1.1 Habitat Type Area (HT_{1-13}) 10
2.1.2 Habitat Suitability Index ($HSI_{sp,nu,fo,ow}$) 13
2.1.3 Life Function Weight 17
2.1.4 Species Weight 17
2.1.5 Access Factor 17
2.1.6 Habitat Co-factor 18

SECTION 3 • HABITAT LOSSES 19

3.1 Baseline Conditions 19
3.1.1 Site Description 19
3.1.2 Habitat Units Calculation 19
3.2 Operations Phase 25
3.2.1 Site Description 25
3.2.2 Habitat Units Calculation 26
3.3 Post-Closure Phase 30
3.3.1 Site Description 30
3.3.1 Habitat Units Calculation 30

SECTION 4 • OFFSETTING MEASURES 36

4.1 Habitat Enhancement and Creation 36
4.2 Complementary Measures 44
4.3 Timeline, Design and Construction of the Offsetting Measures 44
4.4 Monitoring 46

SECTION 5 • CONTINGENCY OPTIONS 46

5.1 Option 1 – Expanded Whale Tail Lake South Basin 46
5.2 Option 2 – Whale Tail Pit Berm 47
5.3 Option 3 – Additional Complementary Measures 47

SECTION 6 • CONCLUSION 47

SECTION 7 • REFERENCES 49

LIST OF TABLES

Table 1-1. Water elevation estimated from the July 21, 2011, imagery, the minimum, maximum and range of water elevations recorded in the field in 2015 and 2016, the difference between the minimum and maximum water elevations recorded in the field and the water elevation estimated from the July 21, 2011, imagery, and the number of days each year that the recorded water elevation was higher than the water elevation estimated from the July 21, 2011, imagery, for 2015 and 2016. 5
Table 1-2. Number of individuals of large-bodied fish species captured by gillnetting and the small-bodied fish species that were captured by electrofishing (X indicates that the species was captured) in the waterbodies that will be directly altered or have access affected during operations at the Whale Tail pit. Nemo Lake was not sampled for small-bodied fish. 8
Table 2-1. Physical characteristics of the habitat types used in the Whale Tail Lake HEP. Note that habitat type 10 is applied to all non-backfilled pit areas, independent of depth and substrate characteristics. 11
Table 2-2. Substrate category assigned to flooded terrestrial areas based on the terrestrial ecological land classification community types that are present under baseline conditions. 13
Table 2-3. HSI values for the Whale Tail fish species (sp=spawning, nu=nursery, fo=foraging, ow=overwintering). *Habitat type 10 is applied to all pit and pit cap areas regardless of depth and substrate. 16
Table 2-4. Access factor theoretically applied to each species for habitat loss and gain calculations, based on presence/absence (or anticipated presence/absence, for offsetting projects). 18
Table 2-5. Habitat co-factor for various pre- and post-compensation scenarios, according to Minns, 2012. 18
Table 3-1. Net change in fish habitat during the post-closure phase, without offsetting (losses). 32
Table 4-1. Habitat area (ha) and habitat units (HUs) gained from the implementation of the proposed habitat enhancement and creation offsetting measures. 38
Table 4-2. Timing of construction and accessibility of offsetting features (habitat enhancements and creation). 44
Table 5-1. Increase in habitat area (ha) and habitat units (HUs) compared to baseline conditions provided by contingency option 1 (maintaining fish habitat conditions as during operations). 47

LIST OF FIGURES

Figure 1-1. Location of the proposed Whale Tail Pit Study Area. 2
Figure 1-2. Hydrologic setting and lake identification codes. Mammoth Lake is A16. Whale Tail Lake is A17. Nemo Lake is C38. 4
Figure 3-1. Whale Tail Project infrastructure during operations, 2019 to 2022 (does not show flooding that will occur in Whale Tail Lake – South Basin). 20
Figure 3-2. Whale Tail Project Infrastructure 2029 (post-closure phase). 21
Figure 3-3. Whale Tail pit lake study area depths under baseline conditions. 22
Figure 3-4. Whale Tail pit study area substrates under baseline conditions. 23
Figure 3-5. Whale Tail pit study area habitat types under baseline conditions. 24
Figure 3-6. Whale Tail Pit study area depths during operations. 27
Figure 3-7. Whale Tail pit study area substrates during operations. 28
Figure 3-8. Whale Tail pit habitat types during operations. 29
Figure 3-9. Whale Tail pit depths post-closure with no offsetting. 33
Figure 3-10. Whale Tail pit substrates post-closure with no offsetting. 34
Figure 3-11. Whale Tail pit habitat types post-closure with no offsetting. 35
Figure 4-1. Habitat created by increasing the water elevation by 1 m east of the Mammoth Dike. 39
Figure 4-2. Proposed roads scarified and constructed rock shoals proposed as offsetting measures. 40
Figure 4-3. Whale Tail pit depths post-closure with a 1 m increase in water elevation east of Mammoth Lake sill, roads scarified and rock shoals constructed for offsetting. 41
Figure 4-4. Whale Tail pit substrates post-closure with a 1 m increase in water elevation east of Mammoth Lake sill, roads scarified and rock shoals constructed for offsetting. 42
Figure 4-5. Whale Tail pit habitat types post-closure with a 1 m increase in water elevation east of Mammoth Lake sill, roads scarified and rock shoals constructed for offsetting. 43
Figure 4-6. Preliminary engineering design for sill to raise water level of Whale Tail Lake by 1 m in the long term. 45

APPENDICES

Appendix A – Lake Elevations and Summary of Fish Catches during Baseline Field Investigations

Appendix B – Habitat Areas and Habitat Units, by Habitat Type, for Baseline, Operations, and Post-closure Phases

Appendix C – Complementary Measures

EXECUTIVE SUMMARY

Agnico Eagle Mines Limited: Meadowbank Division (Agnico Eagle) is proposing to develop Whale Tail Pit, a satellite deposit on the Amaruq property, in continuation of mine operations and milling of the Meadowbank Mine. The Amaruq Exploration property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq region of Nunavut.

Baseline fisheries investigations were conducted in Mammoth Lake, Whale Tail Lake, and tributary streams and lakes in 2014, 2015, and 2016. Individuals of six fish species were captured in the primary study area. These were comprised of four large-bodied species (Lake Trout, *Salvelinus namaycush;* Arctic Char, *Salvelinus alpinus*; Round Whitefish, *Prosopium cylindraceum*; Burbot, *Lota lota*) and two small-bodied species (Slimy Sculpin, *Cottus cognatus*; Ninespine Stickleback, *Pungitius pungitius*).

The goal of this document is to characterize fish habitat in areas that will be directly affected by Whale Tail Pit mining operations under baseline conditions and predicted conditions during the operations and post-closure scenarios, and to describe habitat creation and enhancement along with complementary measures that will be used to offsetlosses to fish habitat. This document presents an approach to offsetting for the Whale Tail Pit that achieves a 1.66:1 ratio of habitat gains to habitat losses.

The habitat evaluation procedure (HEP) used to quantify habitat losses and offsets for Whale Tail Pit is based on the procedure used for the 2012 No Net Loss Plan (NNLP) for the Meadowbank Mine, and incorporates changes introduced between 2014 and 2016 based on DFO review of plans for Vault Lake, Phaser Lake, and the conceptual and draft offsetting plans for Whale Tail Pit (June, 2016; June, 2017)).

Changes to baseline fish habitat will occur during the operations and post-closure phases of Whale Tail Pit. During the operations phase there will be habitat losses due to dewatering or isolation of portions of Whale Tail Lake and some of its tributary lakes and connecting watercourses. Much smaller habitat losses will also occur in Mammoth Lake during operations as a result of diking and dewatering and in Nemo Lake due to the construction of a freshwater intake jetty. Habitat gains will occur from flooding of terrestrial areas south of the Whale Tail Dike. Overall, there is a 48.6 ha increase in the area of fish habitat and a 42.7 unit increase in the number of habitat units (HUs) during operations relative to baseline conditions. However, since flooding of terrestrial zones is only planned to occur over a 4-7 year period prior to drawdown, fish habitat availability during the operations phase is conservatively not considered a habitat offset, and calculations were performed for reference only. In the final net change calculation, only differences between baseline and post-closure conditions are compared.

Post-closure, in the absence of offsetting, most of the area affected during operations will revert to baseline conditions. The dikes will be breached, dewatered areas will be reflooded and isolated areas will be reconnected. The largest change between baseline and post-

closure conditions is the creation of Whale Tail Pit. For the purposes of offsetting calculations, and at the request of DFO, it has been assumed that the flooded pit and pit cap will have no fish habitat value. Therefore, although the excavation of the pit into terrestrial areas will increase the surface area of Whale Tail Lake by 27.4 ha after flooding, the number of habitat units present will decrease. There also remains a small decrease in the area and number of habitat units in Nemo and Mammoth Lakes. Following closure, without offsetting, there would be a net decrease of 14.45 HUs compared to baseline conditions.

As offsetting for these losses, it is proposed to construct a sill in the connecting channel between Whale Tail Lake and Mammoth Lake to raise the elevation of Whale Tail Lake by 1 m which will flood a band around the perimeter of Whale Tail Lake. This increase would convert land to aquatic habitat and modify much of the existing habitat by increasing its depth. It is also proposed to construct 8.77 ha of shoals in the portion of Whale Tail Lake that is dewatered during operations, and to scarify the roads within that area prior to reflooding, converting them from mixed to coarse habitat. The net result of all habitat creation and enhancement measures is an increase of 21.26 ha and 15.03 HUs relative to the post-closure condition with no offsetting. This results in an offsetting to losses ratio of approximately 1:1 (losses = 14.45 HUs, gains = 15.03 HUs).

DFO has indicated support for complementary measures to provide 60% of the required offsetting. Following discussions of suitable research topics with DFO, Agnico Eagle has worked with researchers to develop proposals for a suite of research activities to benefit local stakeholders and contribute to the understanding of aquatic systems. These complementary measures are valued at 60% of constructed offsets (9.02 HUs), providing a total offsetting ratio of 14.45 HUs lost to 24.05 HUs gained (1:1.66).

SECTION 1 • INTRODUCTION

Agnico Eagle Mines Limited: Meadowbank Division (Agnico Eagle) is proposing to develop Whale Tail Pit, a satellite deposit on the Amaruq property, in continuation of mine operations and milling of the Meadowbank Mine. The Amaruq Exploration property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq region of Nunavut (Figure 1-1).

1.1 GOAL

The goal of this document is to characterize fish habitat in areas that will be directly altered by Whale Tail Pit mining operations. Changes to fish habitat between baseline conditions and predicted conditions during the operations and post-closure scenarios are compared.

Options being considered to offset residual serious harm to fish that would occur as a result of mining activities at Whale Tail Pit were introduced in the Conceptual Fish Habitat Offsetting Plan (Agnico Eagle, 2016). In subsequent meetings to discuss offsetting for the project, DFO indicated that, given the need for knowledge regarding how fish populations and communities in the north respond to habitat changes, it would be acceptable for 60% of offsetting to consist of complementary measures. Those complementary measures would focus on funding scientific research that will improve the understanding of how aquatic systems in the far north respond to perturbations from human activities and/or the development of technologies to reduce impacts from human activities. The amount of research funding provided would be based on the predicted cost of achieving the desired offsets using typical offsetting methods that involve habitat alteration.

The approach used here to quantify harm and offsetting (previously termed compensation) builds upon methods developed for the Meadowbank mine site from 2012 through 2016. This offsetting approach was introduced in the 2012 Meadowbank no-net-loss plan (NNLP) after researching techniques and projects implemented at other northern mines, holding workshops and site visits with the local Hunter's and Trapper's Organization, Kivalliq Inuit Association and the DFO Habitat and Science & Research Departments, and reviewing the literature for information on effectiveness of compensation. Offsetting concepts specific to Whale Tail Pit were discussed with community groups during TK workshops initially held in Baker Lake in February 2016; follow-up workshops were held during the authorization phase of the project.

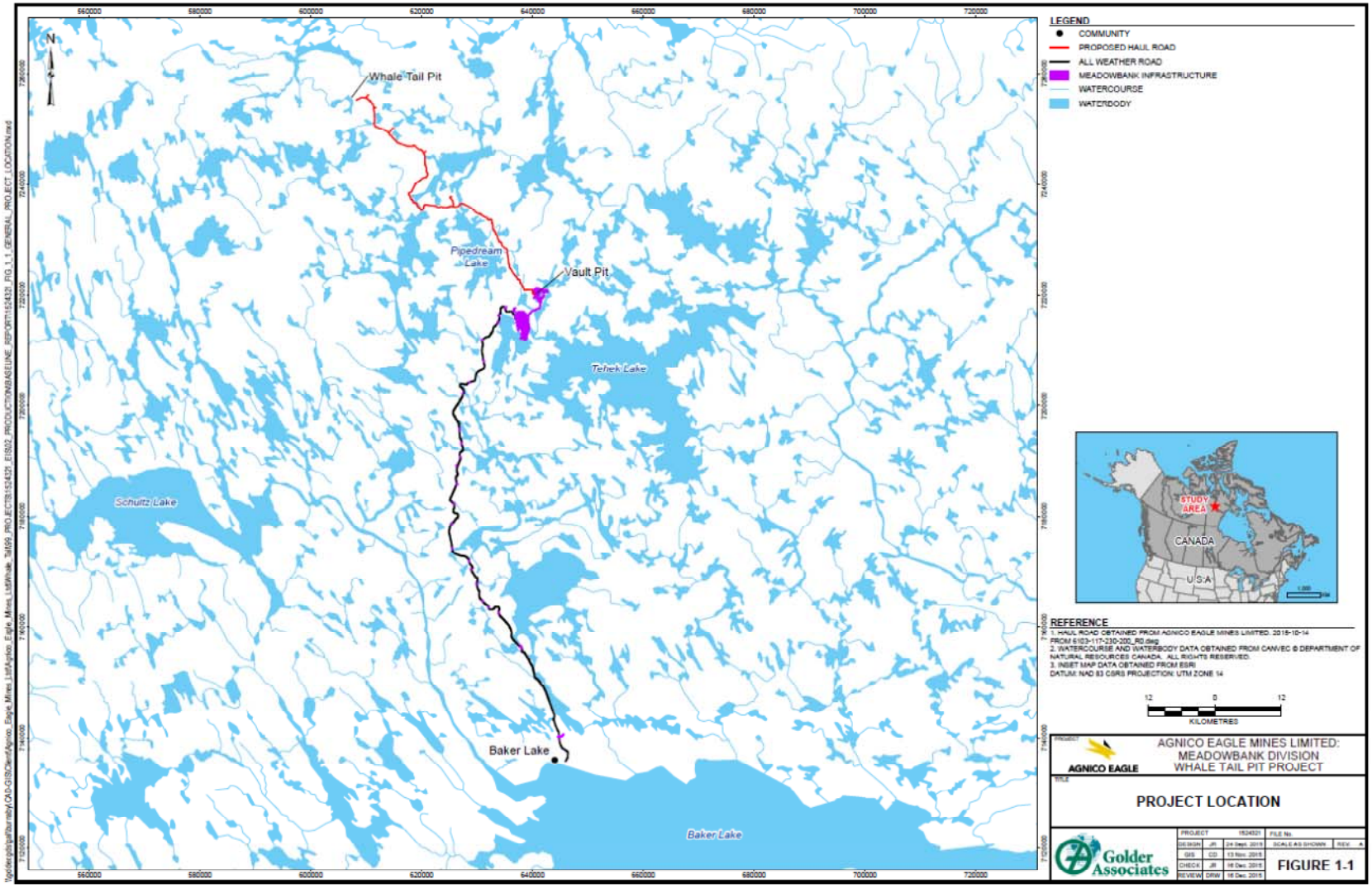


Figure 1-1. Location of the proposed Whale Tail Pit Study Area.

1.2 HYDROLOGIC SETTING

The hydrologic setting of Whale Tail Pit is shown in Figure 1-2. Lakes were assigned alpha-numeric codes to facilitate discussion, with the letter designating the subwatershed and, within each branch, the number increasing in an upstream direction. Lake A17 is referred to as Whale Tail Lake. Lake A16 is referred to as Mammoth Lake and lake C38, in the subwatershed immediately north of the Whale Tail Pit, is referred to as Nemo Lake.

The primary study area is in the headwaters of subwatershed A. All flow from the primary study area ultimately reaches lake DS1, but there are two pathways of flow downstream from Lake A12. The primary flow path, which conveys the majority of the flow, passes through lakes A11, A10, A9, A8 and A7, and then into Lake A32 before continuing through Lakes A6, A5, A4, A3, A2, A1 and into DS1. The secondary flow path is from Lake A12 to Lake A77 and then to Lake A76. Lake A76 has two outlets; with about half the outflow of the lake flowing to the east through Lake A41 to rejoin the primary flow path at Lake A10, while the other half flows west through Lakes A75, A74, A73, A72, A71, A70, A69 and into Lake DS1.

1.3 WATER ELEVATIONS AND LAKE SHORELINES

The shorelines used to determine baseline habitat areas in the Conceptual Fish Habitat Offsetting Plan (Agnico Eagle, 2016) were from CanVec mapping. Comparison of these shorelines to satellite imagery from July 21, 2011, indicated that the water levels represented by the CanVec shorelines were lower than those shown in the imagery. Water elevations were estimated by overlaying the digital elevation model for the study area and the July 21, 2011, satellite imagery for three lakes where actual water level data were available for 2015 and 2016 and the estimated elevations were compared to the field data1. The results (Table 1-1) were shared with DFO (meeting held in Winnipeg, March 23, 2017) and it was agreed that the water elevations and shorelines used to calculate habitat areas in the final offsetting plan would be determined using DEM and the July 21, 2011, imagery. Those elevations are provided in Appendix A.

[1] The following determination of shoreline elevations was provided in response to DFO IR 4 and 7. Agnico Eagle (January, 2017). DFO IR 4 – Freshwater Environment – Habitat Alteration; DFO IR 7 – Monitoring, Mitigation and Management Plans – Conceptual Offsetting Plan. January 20th, 2017 submission RE: NIRB File No 16MN056 Application No: 124683/NWB File No. 2AM WTP ----: Information Requests Received from Parties Regarding Agnico Eagles Mines Ltd's "Whale Tail Pit" Project.

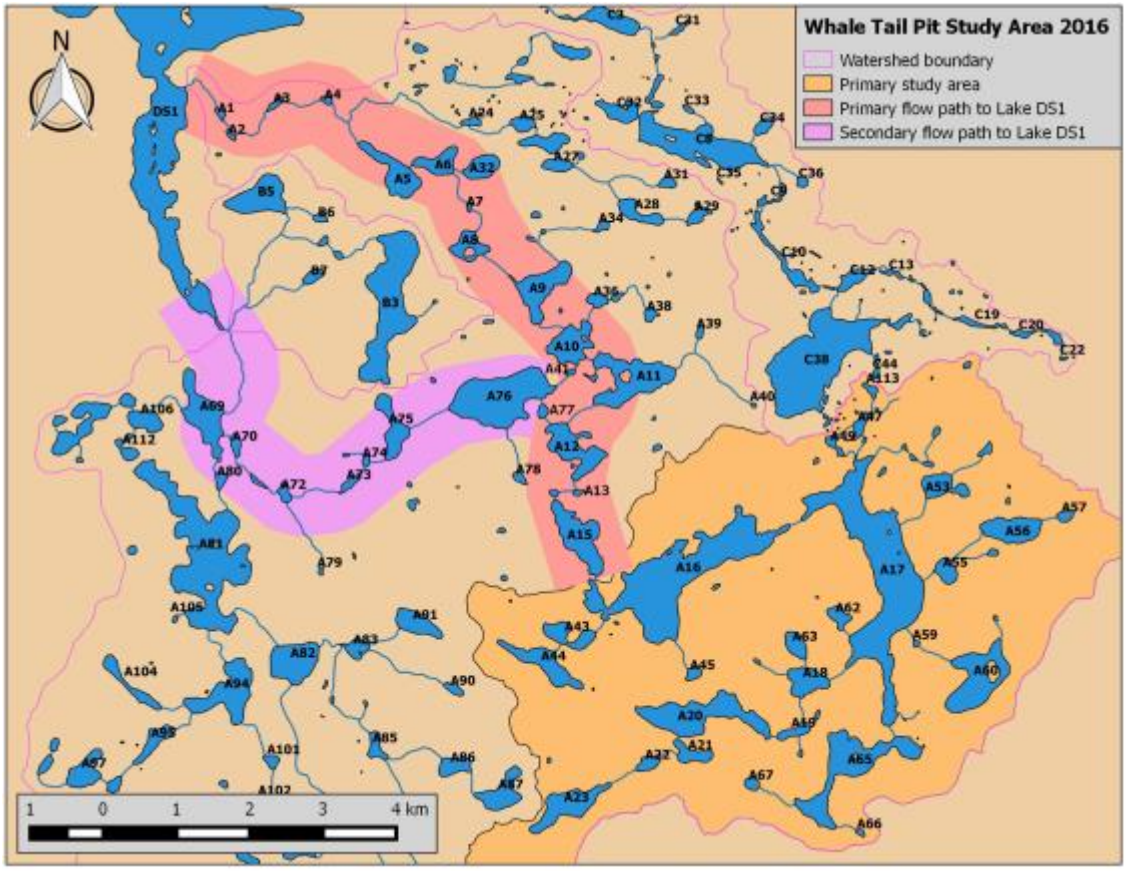


Figure 1-2. Hydrologic setting and lake identification codes. Mammoth Lake is A16. Whale Tail Lake is A17. Nemo Lake is C38.

Table 1-1. Water elevation estimated from the July 21, 2011, imagery, the minimum, maximum and range of water elevations recorded in the field in 2015 and 2016, the difference between the minimum and maximum water elevations recorded in the field and the water elevation estimated from the July 21, 2011, imagery, and the number of days each year that the recorded water elevation was higher than the water elevation estimated from the July 21, 2011, imagery, for 2015 and 2016.

Parameter	**Whale Tail Lake (A17)**		**Lake A18**		**Nemo Lake (C38)**	
Water elevation estimated from July 21, 2011 imagery (masl)	153.02		154.05		156.00	
Year	2015	2016	2015	2016	2015	2016
Maximum water elevation (masl)	153.31	153.11	154.20	154.10	155.98	156.04
Minimum water elevation (masl)	152.46	152.59	153.80	153.78	155.65	155.70
Range (m)	0.85	0.53	0.40	0.32	0.33	0.34
Difference between estimated water elevation and the recorded maximum (m)	0.29	0.09	0.15	0.05	-0.02	0.04
Difference between estimated water elevation and the recorded minimum (m)	-0.56	-0.43	-0.25	-0.27	-0.35	-0.30
# of days water elevation was higher than the water elevation estimated from shoreline elevation	10	5	11	5	0	11

1.4 WHALE TAIL STUDY AREA FISH COMMUNITY

Baseline fisheries investigations conducted in Mammoth Lake, Whale Tail Lake, and tributary streams and lakes in 2014, 2015 and 2016 are described in C. Portt and Associates (2018). The results are summarized here.

A total of six fish species are present in the primary study area, comprised of four large-bodied species (Lake Trout, *Salvelinus namaycush;* Arctic Char, *Salvelinus alpinus*; Round Whitefish, *Prosopium cylindraceum*; and Burbot, *Lota lota*) and two small-bodied species (Slimy Sculpin, *Cottus cognatus*; and Ninespine Stickleback, *Pungitius pungitius*).

Arctic Grayling occur further downstream in the watershed but upstream migration barriers prevent them from moving into the primary study area. The major barriers are a steep set of rapids on the primary flow path and a long section where there is only sub-surface, interstitial flow, even during spring freshet, on the secondary flow path. In addition to those primary barriers, there are connecting channels between a number of other lakes along these flow paths where there is only interstitial flow except during spring freshet. The absence of Arctic Grayling in the primary study area is consistent with the paucity of suitable spawning habitat and absence of riverine adult habitat in the tributaries to Mammoth and Whale Tail Lake.

Lake Trout was the most abundant species in gill net catches and the most widely distributed among the lakes, followed by Round Whitefish and Arctic Char (Table 1-2). Few Burbot were captured. Gill netting catch per unit effort was low for all species. In Mammoth, Whale Tail and Nemo Lakes combined, average catch per unit effort in gill nets, calculated as the number of individuals captured per hour of soak time using a standard Agnico Eagle gill net was 0.5, 0.1 and 0.01 for Lake Trout, Round Whitefish and Arctic Char, respectively. Lake Trout was the most frequently observed large-bodied species on underwater video recorded in Whale Tail Lake.

Electrofishing more than 3400 m of lake shoreline and pond habitat resulted in the capture of approximately 250 Ninespine Stickleback, 55 Slimy Sculpin, 2 juvenile Arctic Char and 3 juvenile salmonids, either Arctic Char or Lake Trout, which were not identified to species. Ninespine Stickleback was the most frequently observed small-bodied fish species on underwater video recorded in Whale Tail Lake.

No large-bodied fish were captured in Lake A45 or in Lake A113 and it is thought that none are present. Lake A45 is 2.9 ha in area and has a maximum depth of 4.5 m. There is no surface connection between Lake A45 and any other waterbody. No fish were captured in a 2 hour gill net set in Lake A45 in 2015 or in a 29.2 hour gill net set in 2016 using a standard Agnico index gill net gang comprised of 22.7 m long and 1.8 m deep panels of 126, 102, 76, 51, 38, and 25 mm stretched mesh (total gang length = 136.4 m). Lake A113 is 2.1 ha in area with a maximum depth of less than one metre and there is no defined channel connecting it to other waterbodies or watercourses downstream. There, no fish were captured in 3 panels of gill net (22.7 m long and 1.8 m deep panels of 38 mm, 51 mm and 76 mm mesh) set for 16.6 hours in 2015.

At least one large-bodied fish species was captured in eleven of the larger lakes, in addition to Whale Tail, Mammoth and Nemo and Ninespine Stickleback and Slimy Sculpin were also present in most of those. In three of the smaller waterbodies, only Ninespine Stickleback were captured. There were several isolated or nearly isolated small lakes and ponds in which no fish were captured. Most of these are located north of Whale Tail Lake.

All of the watercourses in the primary study area freeze during the winter. There are two broad categories of watercourses present. One type consists of connecting channels between larger lakes. These are generally wide and shallow with boulder and cobble substrate. Some of these connecting channels never have surface flow. Others have sufficient depth during spring freshet for adult large-bodied fish to pass through them but, as flow subsides, they become shallower and impassible to and unusable by large fish and, eventually, all of the flow is interstitial.

Based on the sampling conducted, there is little movement of large fish through the connecting channels that have sufficient depth to pass large fish during the spring. Hoop nets set in or immediately downstream from connecting channels in 2015 and 2016 during the freshet, when there was sufficient water present for large-bodied fish to move through the channels, did not capture any fish. Low numbers of juvenile Lake Trout and Round Whitefish, as well as Ninespine Stickleback and Slimy Sculpin, were captured by electrofishing in the connecting channels (Table A 2) before flow became totally interstitial.

The other type of watercourses present is small streams, most of which drain smaller catchments. These shallow streams often have multiple channels (i.e. are braided). The mean total wetted width of the Whale Tail Lake tributaries ranged from 0.7 m to 7.6 m and their mean depth ranged from 6 cm to 17 cm. Riffle and run habitat is dominant and there are few pools in these tributaries. Peat is the dominant substrate in most of these watercourses.

Electrofishing effort and catches in small streams in the primary study area during the 2015 and 2016 field seasons are summarized in Table A 3. Effort totalled 35,657 electroseconds and 6,330 m. Portions of the largest of these streams were fished on up to eight occasions. Ninespine Stickleback and Slimy Sculpin were the most widely distributed species in the Whale Tail Lake tributaries. Low numbers of juvenile Arctic Char were captured in five of the tributaries and juvenile Lake Trout were captured in two. Juvenile Burbot were captured in three tributaries and a juvenile Round Whitefish was captured in one.

One Lake Trout and one Arctic Char were captured in a hoop net set near the mouth of stream A55-A17 for 12 days in late June and early July of 2015. In the latter part of June and early July of 2016, gill nets were set across two of the smaller tributary streams to assess fish movement. A gill net set across stream A53-A17 near its mouth for a total 17 days caught one adult Arctic Char. A gill net set across stream A55-A17 near its mouth for a total of 16 days caught seven adult Arctic Char, five moving upstream and two moving downstream.

Table 1-2. Number of individuals of large-bodied fish species captured by gillnetting and the small-bodied fish species that were captured by electrofishing (X indicates that the species was captured) in the waterbodies that will be directly altered or have access affected during operations at the Whale Tail pit. Nemo Lake was not sampled for small-bodied fish.

Waterbody	Lake Trout	Arctic Char	Round Whitefish	Burbot	Ninespine Stickleback	Slimy Sculpin
A18	0	8	0	0	X	X
A19	0	2	0	1	X	X
A20	11	0	6	0		
A22	2	1	0	0	X	X
A45	0	0	0	0	X	
A47	0	1	0	0	X	
A49	3	0	0	0		X
A53	1	2	0	0	X	
A55	5	0	0	1		X
A62	3	0	0	0	X	
A63	1	0	0	0		X
A65	2	0	2	0	X	X
A113	0	0	0	0	X	
Mammoth Lake	49	0	20	0	X	X
Whale Tail Lake	34	2	5	0	X	X
Nemo Lake	22	0	0	0	ns	ns

SECTION 2 • HABITAT EVALUATION PROCEDURE

The habitat evaluation procedure (HEP) used to quantify habitat losses and offsets for Whale Tail Pit in this report is based on the procedure used for the 2012 NNL assessment for the Meadowbank Mine and incorporates refinements that have been introduced during subsequent work between 2014 and 2016 to develop offsetting measures for Vault and Phaser Lake. Various changes have also been incorporated as a result of DFO review of the conceptual (June 2016) and draft offsetting plans (June 2017) for Whale Tail Pit.

The HEP involves the classification of lake habitat into ten habitat types, based on depth and substrate. For the Whale Tail Pit HEP three additional habitat types have been incorporated to address connecting channels between lakes and small streams, as described in Section 2.1.1. Suitability of each habitat type is ranked between 0 and 1 for each of four life functions (spawning, nursery, foraging, overwintering) for each fish species that is (or is predicted to be) present. The area of each habitat type (in hectares) is multiplied by a habitat suitability index (HSI) and a series of weights (a species weight, a life-function weight and an access weight) and summed in order to derive a value in habitat units (HUs) that describes both the quality and quantity of habitat. These calculations are made for the pre-construction, or baseline, condition and for predicted conditions during the operations and post-closure phases of the project.

Net changes in HUs between phases depend on losses or gains in the area of each habitat types (1 - 13) that are present, and the suitability of each habitat type for each fish species. The HEP model is described in further detail below.

2.1 HEP MODEL

The HEP model used here can be described, for each fish species (spp 1-n) as:

$$\mathbf{HU}_{\text{spp 1-n}} = \sum_{\text{HT 1-10}} \left(\sum_{\text{sp,nu,fo,ow}} (\mathbf{HT}_{\text{1-10}} \times \mathbf{HSI}_{\text{sp,nu,fo,ow}} \times \mathbf{life\ function\ weight} \times \mathbf{species\ weight}) \right) \times \mathbf{access\ factor} \times \mathbf{habitat\ co\text{-}factor}$$

Where HT_{1-10} = area (ha) of habitat types 1 through 10

$HSI_{sp,nu,fo,ow}$ = habitat suitability index for each life function:

- sp = spawning use
- nu = nursery use
- fo = foraging use
- ow = overwintering use

2.1.1 Habitat Type Area (HT_{1-13})

The foundation of the HEP is the delineation of areas that provide certain "habitat types" based on depth and substrate (Table 2-1). Habitat types 1 – 9 are lake habitats and were components of the original Meadowbank HEP model. These habitats are delineated by intersecting depth and substrate polygons.

Habitat Type 10 was added to the HEP model during the development of the Phaser Lake offsetting plan at the request of DFO to address uncertainty with respect to fish utilization of the deep pit areas. At that time, DFO indicated that the uncertainty arises primarily because there are "no examples of successful re-establishment of self-sustaining fish populations in refilled pits in Canada's North upon which to base end pit lake design" and there is a possibility that the deep areas of flooded pit may become meromictic (i.e. permanently stratified) and therefore be unsuitable for fish (DFO letter to Agnico Eagle dated November 27, 2015). DFO requested that the deep areas of the pit be designated Habitat Type 10 and that zero habitat value be assigned to those deep areas. An earlier conceptual offsetting plan was prepared for Whale Tail using that approach, in which the portion of the pit that is shallower than 22 m was assigned a habitat type based on its depth and it being coarse substrate and the portion deeper that 22 m was assigned Habitat Type 10. After reviewing that conceptual offsetting plan, DFO requested that, at Whale Tail, the entire pit area, regardless of depth and including the pit cap, be designated Habitat Type 10. This has been done for the calculations in this report.

Habitat Type 11 was initially used in the 2012 NNLP for the Meadowbank site to denote pit areas with some level of assigned habitat value. However in this offsetting plan for Whale Tail Pit, the designation HT11 was assigned to the connecting channels that occur between several of the lakes in the Whale Tail Pit study area. These channels are wide and have predominantly boulder and cobble substrates. They have shallow surface flow over most or all of their length during spring freshet and only interstitial flow over most or all of their length later in the open-water season. They freeze during the winter. The edge of the water in the connecting channels was observed in the field to correspond closely to the edge of the tundra vegetation. Therefore, these channels were delineated by digitizing the edge of the tundra vegetation in the July 21, 2011, satellite imagery. The upstream and downstream limits of the connecting channels are defined by the intersection of the upstream and downstream lake elevations with the DEM. When an area that is Type 11 habitat under baseline conditions is flooded during the operations or post-closure phases it becomes the lake habitat type with coarse substrate that corresponds to its new depth.

Habitat types 12 and 13 are also specific to this study and represent small streams with fine and coarse substrate respectively. These streams were characterized from field measurements made using a point-transect method during the period July 5 through July 8, 2016 (C. Portt and Associates, 2018). Many of these small streams have multiple channels and the width of each of the channels was measured at transects across the watercourses and those widths were summed to determine the total wetted width at a transect. To facilitate GIS analysis, the primary flow path of each of these streams was digitized based

on the July 21, 2011, satellite imagery and a ‘stream polygon’ was created by assigning the total wetted width to the digitized flow path at each transect location. This allows the areas of stream habitat to be visualized and calculated during baseline and subsequent stages using standard GIS techniques. The portion of stream habitat that is fine substrate (Habitat Type 12) or coarse substrate (Habitat Type 13) was calculated by multiplying the stream polygon area by the proportion of the points where substrate was fine or coarse based on the field measurements. In the operations and post-closure phases, when Type 12 or 13 habitat was flooded due to increased water levels it was considered converted to lake habitat and the habitat type was assigned based on depth and substrate.

Table 2-1. Physical characteristics of the habitat types used in the Whale Tail Lake HEP. Note that habitat type 10 is applied to all non-backfilled pit areas, independent of depth and substrate characteristics.

Habitat Type	Depth Zone	Substrate
1	0-2 m	Fine
2	0-2 m	Mixed
3	0-2 m	Coarse
4	2-4 m	Fine
5	2-4 m	Mixed
6	2-4 m	Coarse
7	>4 m	Fine
8	>4 m	Mixed
9	>4 m	Coarse
10	Pit and pit cap*	Pit and pit cap*
11	connecting channels	Coarse
12	small streams	Fine
13	small streams	Coarse
* Depth and substrate in pit and pit cap areas are not relevant to suitability, which is assigned 0 value (see Section 2.1.2).		

In order to calculate the extents of each habitat type, bathymetry for each of the lakes was merged with the digital elevation model in GIS. Bathymetry for Whale Tail, Mammoth and Nemo Lakes was provided by Agnico. For the smaller lakes that were deep enough to operate a boat, bathymetry was determined using a Humminbird 798ci HD SI Sonar unit. The sonar unit recorded georeferenced standard and side-scan sonar data. Straight, parallel boat runs, orientated to best characterize the lake's features, were used to record slightly overlapping side-scan images of the lake bottom. Additional sonar recordings were then made to obtain standard sonar data for as much of the lake bottom as was practical. A stake was driven into the ground at the water’s edge on the day that the Sonar data were collected and this elevation was later determined by a survey crew, so that the depth data could be converted to elevations and integrated with the digital elevation model. Visual point observations of the substrate were also made, either from the surface where the water was clear and shallow enough, or using an Aqua-Vu 740c underwater colour video system where the water was deeper. All visual substrate observations were georeferenced with a Garmin GPSmap76CSx gps unit.

The side-scan images were processed using ReefMaster software (ver. 1.8) to create a single georeferenced side-scan mosaic of the lake's bottom, and the standard sonar data were processed to create maps of bottom hardness and water depth. ReefMaster determines bottom hardness by analysis of the sonar output/input ratio, and lag, to calculate a unitless relative hardness and roughness value that is displayed as a colour-coded map. The georeferenced data (side-scan image, bottom hardness and water depth maps, and visual point observations) were layered using GIS software (QGIS version 2.8). In anticipation of the need to prepare substrate mapping, on September 2, 2014, oblique aerial photographs were taken, from a helicopter, of the shoreline and near-shore areas of Mammoth Lake, Whale Tail Lake, Nemo Lake and the adjacent smaller lakes and ponds. Additional oblique photographs were taken in June and August of 2016. Using the overlaid data, with reference to the oblique aerial photographs (n=229), the areas of the various substrate types were identified and hand digitized as polygons in GIS, creating substrate maps. With the exception of Nemo Lake this was done for each lake in its entirety. For Nemo Lake substrate mapping was only prepared in the area that would be impacted by the freshwater intake, as no other alterations of Nemo Lake are anticipated.

A few small, shallow ponds near the north end of Whale Tail Lake were too shallow to permit use of a boat and motor. The depths and substrates in these ponds were visually assessed from shore in 2015, and depth and substrate mapping was prepared based on those observations, aerial imagery, and the oblique aerial photographs taken in 2014 and 2015.

All habitat type area calculations and mapping were completed by Dougan and Associates using standard GIS methods consistent with mapping procedures used in AEM (2012) and Phaser Lake offsetting plan. The digital elevation model was used to determine depth and the depth information was overlain with the substrate layers, determined as decribed above, to delinate polygons with the characteristics of habitat types 1 through 9. The area of habitat types 1 – 9 was determined by summing the area of those polygons.

For the operations and post-closure phases, depths were determined using the water elevations proposed for each phase and the digital elevation model. The substrate under baseline conditions was left unchanged unless a physical change was made to the habitat (i.e. a dike was built or grid shoals were built). These alterations are described in the sections that describe the changes in habitat area during the operations and post-closure phases. If connecting channels were flooded so that they became lake habitat, their new habitat types was assigned based on their depth and their existing coarse substrate. If small streams were flooded so that they became lake habitat their new habitat type was based on depth and their existing substrate. The substrate for terrestrial areas that are flooded during operations or post-closure was assigned based on the ecological land classification community types, as shown in Table 2-2.

Table 2-2. Substrate category assigned to flooded terrestrial areas based on the terrestrial ecological land classification community types that are present under baseline conditions.

Substrate Category	ELC Community Type
Coarse	Boulder/gravel
	Lichen/rock
Fine	Graminoid tundra
	Wet graminoid
	Sand
Mixed	Graminoid/Shrub tundra
	Heath tundra
	Heath upland
	Heath upland/rock complex
	Lichen tundra
	Shrub tundra
	Shrub/heath tundra

2.1.2 Habitat Suitability Index ($HSI_{sp,nu,fo,ow}$)

The habitat suitability term represents the relative quality of each habitat type for each life function of each fish species present in the region. In the case of this HEP, the life functions spawning, nursery, foraging and overwintering were considered. Habitat suitability for each life function is indicated through a ranking of 0, 0.25, 0.5, 0.75 or 1. HSIs for all fish species[2] and habitat types used in this HEP are shown in Table 2-3. The HSIs for the lake habitats (habitat types 1 – 9) were developed through a series of consultations and workshops beginning in July 2011 with KivIA, HTO, and DFO in Baker Lake, and a series of workshops held with Golder Associates and DFO between November 2011 and December 2011 (by webex and in Ottawa). The process is further described in AEM (2012). Further review of the HEP by Dr. Ken Minns (August, 2017) recommended continued use of this method by Agnico Eagle. As stated previously, for the time being, it has been conservatively assumed that habitat type 10 will provide no fish habitat (i.e. all HSIs are zero) with the understanding that HSIs and the provision of habitat units will be re-evaluated if field investigations demonstrate that there is no stratification or that fish use the pelagic zone above a chemocline.

The HSIs for habitat types 11, 12, and 13 were assigned based on their habitat characteristics and the fish sampling conducted as part of the Whale Tail pit baseline

[2] Addresses, DFO 1- Freshwater Environment – Habitat Losses technical comment regarding consideration of all species, including bottom dwellers. Agnico Eagle (April, 2017). April 7th, 2017 submission NIRB File No. 16MN056 Application No: 124683/ NWB File No. 2AM WTP ---- : Receipt of Technical Review Comment Submissions for the NIRBs Review and NWB Consideration of Agnico Eagle Mines Ltd's " Whale Tail Pit" Project Proposal and associated Water License Application

investigations, taking into consideration the HSIs previously developed for lake habitats[3]. The connecting channels have primarily boulder and cobble substrate. There is shallow water above the substrate during the spring freshet in most of these channels but later in the summer there is only interstitial flow. No adult large-bodied fish have been observed or captured by electrofishing in these connecting channels and hoop nets set in or immediately downstream from these connecting channels in 2015 and 2016 captured no fish. A single Arctic Char was captured in a gill net set across the connecting channel between Lake A18 and Whale Tail Lake from June 22 – 28, 2016 and July 2-8, 2016. Based on these data, these connecting channels do not provide foraging habitat for large-bodied fish (foraging HSI = 0). Juvenile Lake Trout and juvenile Lake Whitefish have been captured by electrofishing in the connecting channels and it has been assumed that juvenile Arctic Char and juvenile Burbot can also use this habitat during the open-water season. Therefore, for all large-bodied species the connecting channels have been assigned the same nursery HSIs as coarse substrate in the 0 – 2 m lake depth stratum. The connecting channels freeze during the winter and therefore have been assigned HSIs of zero for overwintering for all species and zero for spawning for fall/winter-spawning species, which includes all of the large-bodied species that are present.

Slimy Sculpin and Ninespine Stickleback, the two small-bodied species that are present in the study area, have both been captured in the connecting channels and are likely to use the shallow areas and interstitial spaces in much the same way that they do in shallow areas with coarse substrate in lake habitats. Therefore, for these two species the HSIs for coarse substrate in the 0 – 2 m deep stratum has also been used for the connecting channels.

The dimensions of the small streams in the Whale Tail Pit primary study area are summarized in Appendix A, Table A 4. These streams typically have multiple channels and are shallow, with mean depths ranging from 6 cm to 17 cm. Peat is the dominant substrate in the majority of the watercourses and only watercourse A55-A17 is dominated by coarse substrates. These watercourses freeze in the winter and have been assigned HSIs of zero for overwintering for all species and zero for spawning for fall/winter-spawning species, which includes all of the large-bodied species that are present.

Electrofishing catches in these streams were dominated by Ninespine Stickleback and Slimy Sculpin and for these two species the HSIs for fine and for coarse substrates in the 0 – 2 m lake depth habitat (Habitat Types 1 and 3 respectively) were applied to Habitat Types 12 and 13 for spawning, nursery and foraging.

One or more juveniles of all of the large-bodied species were captured in the small streams, although the numbers were low. The nursery HSIs for fine and for coarse substrates in the 0

[3] The stream habitat types were developed in response to DFO 4 and 8 Information Request. Agnico Eagle (January, 2017). DFO- 4 and 8 – Freshwater Environment- Habitat Alteration. January 20th, 2017 submission RE: NIRB File No 16MN056 Application No: 124683/NWB File No. 2AM WTP ----: Information Requests Received from Parties Regarding Agnico Eagles Mines Ltd's "Whale Tail Pit" Project.

– 2 m lake depth habitat (Habitat Types 1 and 3 respectively) have been applied to Habitat Types 12 and 13 for the four large-bodied species.

The absence of adult large-bodied fish from the electrofishing catches in the small streams is consistent with them being so shallow, and confirms that, as would be expected, there is little if any foraging in these streams by adults of the large-bodied species. It is thought that the few individuals that were captured in gill nets or hoop nets set in these streams were moving between lake habitats. The small streams have been assigned a HSI of zero (0) for foraging by the four large-bodied species.

Table 2-3. HSI values for the Whale Tail fish species (sp=spawning, nu=nursery, fo=foraging, ow=overwintering). *Habitat type 10 is applied to all pit and pit cap areas regardless of depth and substrate.

Habitat Type	Depth	Substrate	Arctic Char				Lake Trout				Round Whitefish			
			SP	NU	FO	OW	SP	NU	FO	OW	SP	NU	FO	OW
1	<2 m	Fines	0	0.25	0.25	0	0	0.25	0.25	0	0	0.25	0.75	0
2	<2 m	Mixed	0	0.25	0.25	0	0	0.5	0.5	0	0	0.75	0.5	0
3	<2 m	Coarse	0	0.5	0.5	0	0	1	0.75	0	0	0.75	0.5	0
4	2-4 m	Fines	0	0.5	0.5	0.75	0	0.5	0.5	0.75	0	0.25	1	0.75
5	2-4 m	Mixed	0.5	0.75	0.75	0.75	0.5	0.75	0.75	0.75	0.5	0.75	0.75	0.75
6	2-4 m	Coarse	1	1	1	0.75	1	1	1	0.75	1	1	0.75	0.75
7	>4 m	Fines	0	0.25	0.5	1	0	0.25	0.5	1	0	0.25	1	1
8	>4 m	Mixed	0.5	0.5	0.75	1	0.5	0.5	0.75	1	0.25	0.25	0.5	1
9	>4 m	Coarse	1	0.5	1	1	1	0.5	1	1	0.75	0.5	0.5	1
10*	pit area	pit area	0	0	0	0	0	0	0	0	0	0	0	0
11	connecting channel	Coarse	0	0.5	0	0	0	1	0	0	0	0.75	0	0
12	stream	Fines	0	0.25	0	0	0	0.25	0	0	0	0.25	0	0
13	stream	Coarse	0	0.5	0	0	0	1	0	0	0	0.75	0	0
Habitat Type	**Depth**	**Substrate**	**Burbot**				**Slimy Sculpin**				**Ninespine Stickleback**			
			SP	NU	FO	OW	SP	NU	FO	OW	SP	NU	FO	OW
1	<2 m	Fines	0	0.25	0.25	0	0	0	0.25	0	1	1	1	0
2	<2 m	Mixed	0	0.75	0.5	0	0.25	0.25	0.5	0	0.5	0.5	0.75	0
3	<2 m	Coarse	0	1	0.5	0	1	1	1	0	0	0.25	0.75	0
4	2-4 m	Fines	0	0.25	0.25	0.75	0	0	0.25	0.75	0	0	0.5	0.75
5	2-4 m	Mixed	1	0.5	0.75	0.75	0.25	0.25	0.5	0.75	0	0	0.25	0.75
6	2-4 m	Coarse	0.75	0.5	1	0.75	0.75	0.75	1	0.75	0	0	0.25	0.75
7	>4 m	Fines	0	0	0.25	1	0	0	0	1	0	0	0	1
8	>4 m	Mixed	1	0	0.75	1	0	0	0.25	1	0	0	0	1
9	>4 m	Coarse	0.75	0.25	1	1	0.5	0.5	0.5	1	0	0	0	1
10	pit area	pit area	0	0	0	0	0	0	0	1	0	0	0	0
11	11	connecting channel	0	1	0	0	1	1	1	0	0	0.25	0.75	0
12	12	stream	0	0.25	0	0	0	0	0.25	0	1	1	1	0
13	13	stream	0	1	0	0	1	1	1	0	0	0.25	0.75	0

2.1.3 Life Function Weight

This HEP values all life functions equally, with a weight of 0.25 each assigned for spawning, nursery, foraging and overwintering.

2.1.4 Species Weight

The overall species weights used in the HEP method sum to 1 across species. The species weights for various Meadowbank offsetting plans are comprised of a biomass weighting and a fishery value weighting:

Species weight = (biomass weight/2) x (fishery weight/2)

In the conceptual Whale Tail pit offsetting plan (Agnico, 2016) the biomass weight was based on the relative biomass of the species determined during fish-outs of Meadowbank site lakes that have been drained, with one percent allocated to each of slimy sculpin and ninespine stickleback, as they are not susceptible to the gill nets used in the fish-outs. Also, in the conceptual Whale Tail pit offsetting plan (Agnico, 2016) a modification of this approach was proposed that included an aboriginal fishery value which would be determined through community consultations (as requested by DFO for the updated Vault Lake no net loss plan; February, 2016). However in subsequent discussions, DFO has indicated a preference for all species to be weighted equally[4]. Therefore, each of the six species that are present in the study area has a weight of 0.165 in the calculations presented in this document.

2.1.5 Access Factor

In a workshop conducted in February, 2012 (The Basic Concepts of No Net Loss Accounting - February, 2012) Dr. Charles K. Minns suggested the use of an access factor when fish assemblages are expected to change in the offsetting scenario. According to this concept, the access factor is 1 for any species present in the habitat area, and 0 for any species not present (Table 2-4). Each species receives an access factor in both the loss and gain calculations. Therefore, the opening of access to a habitat area for a species (that did not have access previously), results in an increase of habitat units. Similarly, the loss of access results in a loss of habitat units. These gains or losses may be complete (i.e. affect all species), or partial (only some species are affected). The presence or absence of a species in loss calculations is typically based on the observed presence/absence of each

[4] Agnico Eagle (January, 2017). KivIA – IR – Aquatic- Final fish habitat offsetting plan. January 20th, 2017 submission RE: NIRB File No 16MN056 Application No: 124683/NWB File No. 2AM WTP ----: Information Requests Received from Parties Regarding Agnico Eagles Mines Ltd's "Whale Tail Pit" Project. &

Agnico Eagle (April, 2017). DFO 5- Freshwater Environment – Changes to Lake Ecosystem Productivity. April 7th, 2017 submission NIRB File No. 16MN056 Application No: 124683/ NWB File No. 2AM WTP ---- : Receipt of Technical Review Comment Submissions for the NIRBs Review and NWB Consideration of Agnico Eagle Mines Ltd's " Whale Tail Pit" Project Proposal and associated Water License Application

species during baseline monitoring studies (AEM, 2012, 2013, 2016). If a change in access is predicted for an offset scenario (i.e. due to the removal of a barrier to fish movement) the change would need to be confirmed as part of compensation monitoring.

Table 2-4. Access factor theoretically applied to each species for habitat loss and gain calculations, based on presence/absence (or anticipated presence/absence, for offsetting projects).

Scenario	Access Factor	
	Losses	Gains
Species Present	1	1
Species Not Present	0	0

Typically, the access factors applied are based on the observed presence/absence of each species during baseline monitoring studies (AEM, 2012, 2013, 2016). For the calculations in this report, an access factor of 1 has been applied for all six fish species that have been captured in the study area. The effect of isolating the north-east pond during operations has been addressed by conservatively estimating that habitat is temporarily 'lost' during that time period, but re-gained during post-closure.

2.1.6 Habitat Co-factor

The habitat co-factor represents any changes to non-mapped habitat quality (thermal, hydrological, biological or chemical regimes) that will occur as a result of impacts or offsetting. The use of this factor is suggested by Dr. Ken Minns, and his suggested values as presented in a workshop for DFO in February, 2012 are shown in Table 2-5. No habitat co-factor has been applied to the HEP calculations presented in this report

Table 2-5. Habitat co-factor for various pre- and post-compensation scenarios, according to Minns, 2012.

Change in regime	Description	Baseline conditions factor	Post-closure factor
Degradation (expected)	Thermal, hydrologic, chemical and/or biological regime shifts away from preferred state for fish habitat	1	> 0 and < 1
No change	-	1	1
Enhancement (anticipated or proposed)	Thermal, hydrologic, chemical and/or biological regime expected to shift towards preferred state for fish habitat	> 0 and < 1	1

SECTION 3 • HABITAT LOSSES

In order to mine Whale Tail Pit, a series of three dewatering dikes will be constructed to isolate the pit area. The area within those dikes will be dewatered to allow mining to occur (operations phase). When mining is completed, the dikes will be breached, allowing the pit and adjacent lake basin area to flood and water elevations to return to baseline conditions (post-closure phase). Site infrastructure during these operations and post-closure phases is shown in Figure 3-1 and Figure 3-2.

This section describes calculation of habitat losses occurring as a result of mining activities during both the operations and post-closure phases, compared to baseline conditions. Extents of losses and gains were calculated for all impacted areas using the HEP described in Section 2. However, since flooding of terrestrial zones is only planned to occur over a 4-7 year period prior to drawdown, fish habitat availability during the operations phase is conservatively not considered a habitat offset, and calculations were performed for reference only. In the final net change calculation, only differences between baseline and post-closure conditions are compared.

3.1 BASELINE CONDITIONS

3.1.1 Site Description

Baseline site conditions are described in Section 1.

3.1.2 Habitat Units Calculation

As calculated using the HEP described in Section 2, depth zones, substrate types (fines, mixed, coarse), and habitat types under baseline conditions throughout the primary study area are shown in Figure 3.3, 3.4 and 3.5, respectively.

Net change in habitat units between the baseline, operations, and post-closure scenarios are detailed in Sections 3.2 and 3.3, below

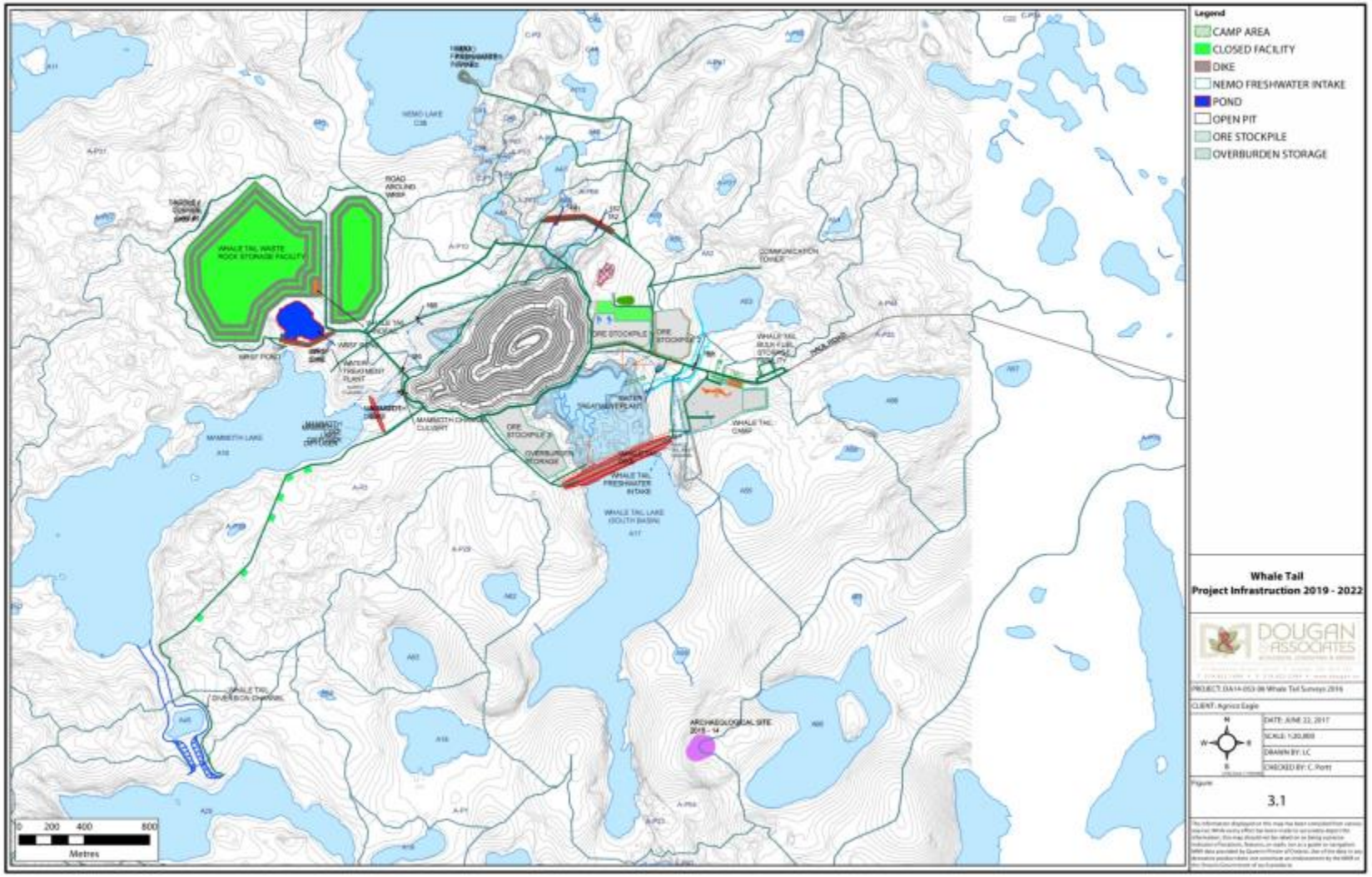


Figure 3-1. Whale Tail Project infrastructure during operations, 2019 to 2022 (does not show flooding that will occur in Whale Tail Lake – South Basin).

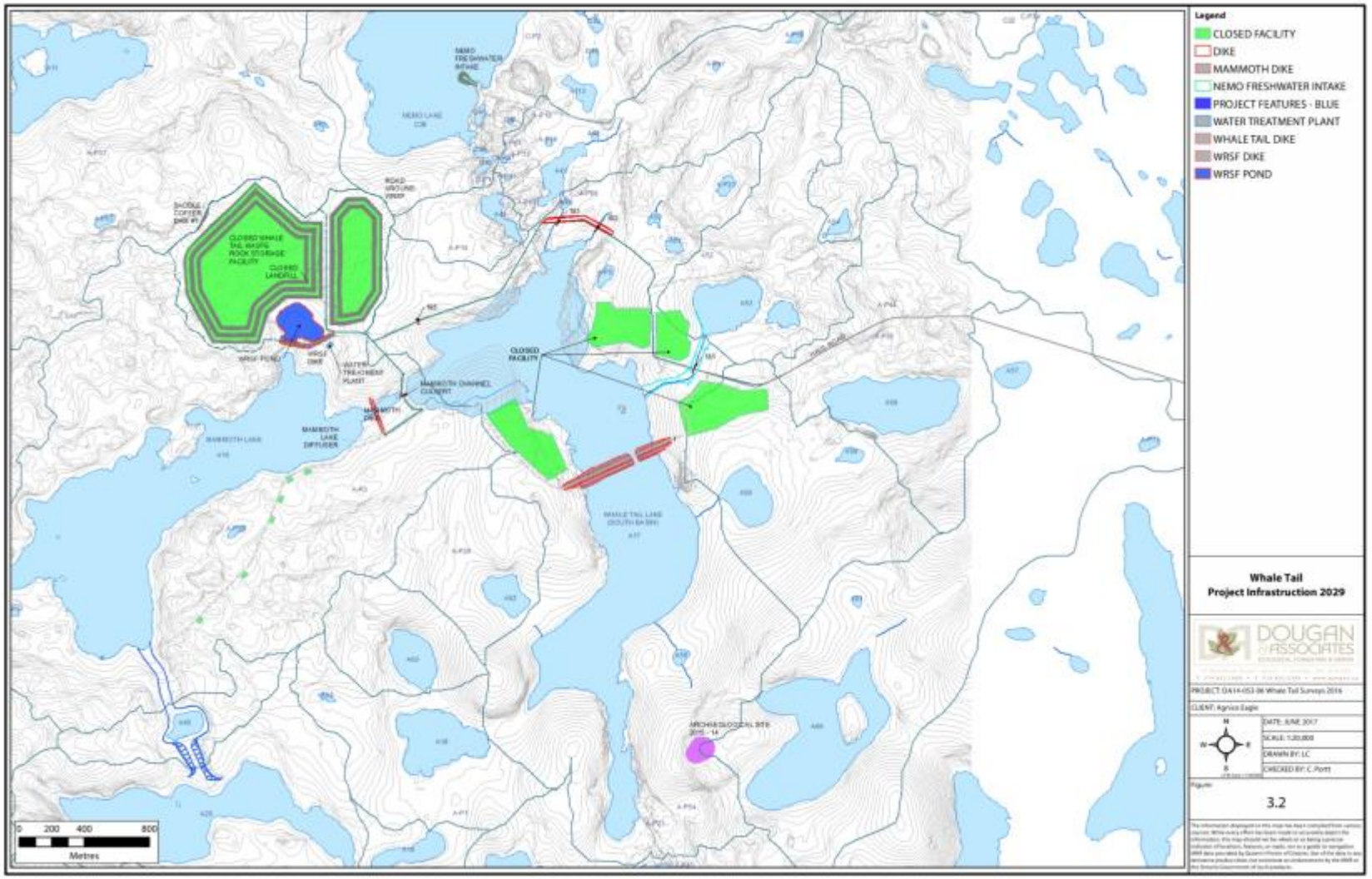


Figure 3-2. Whale Tail Project Infrastructure 2029 (post-closure phase).

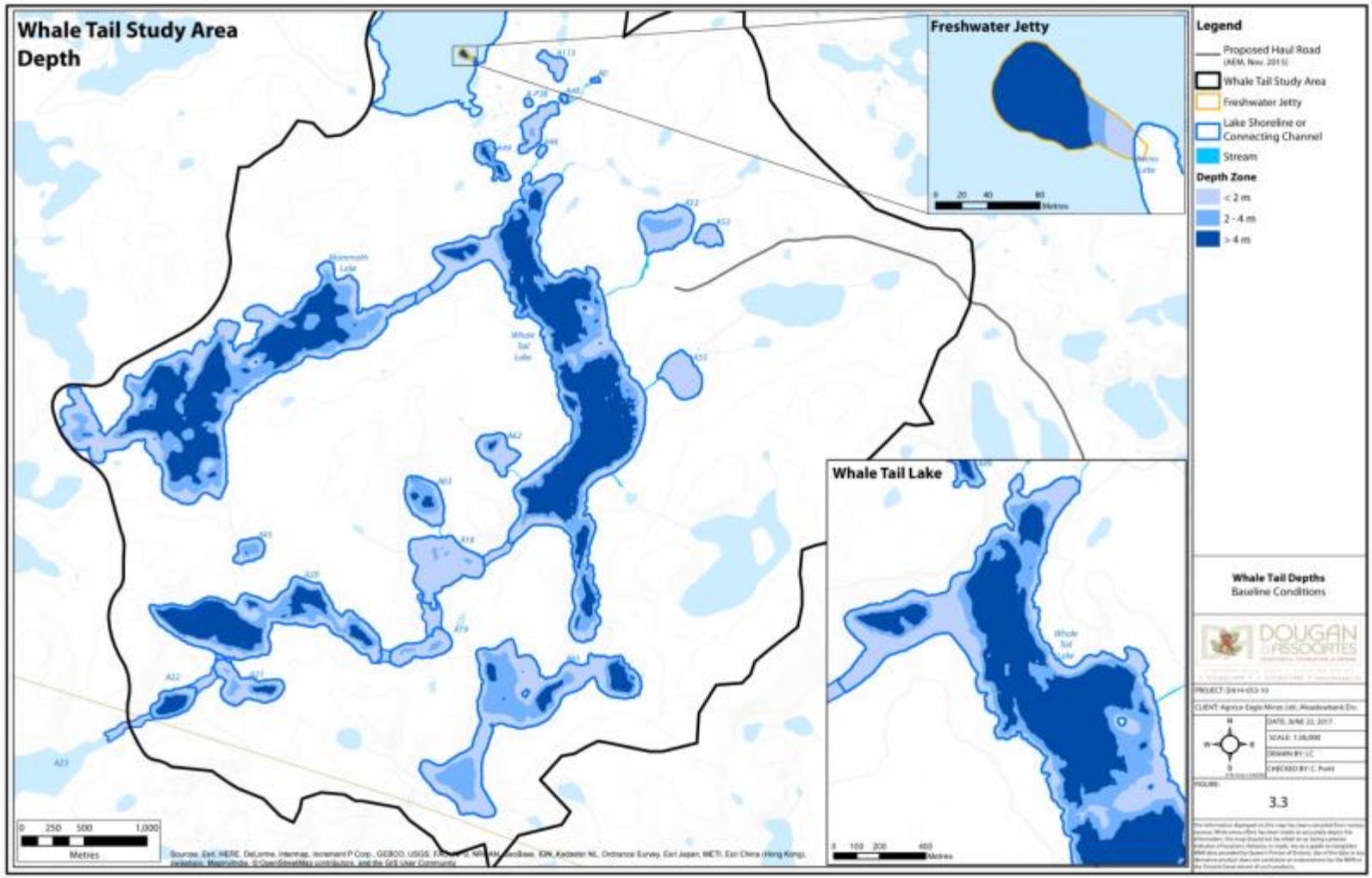


Figure 3-3. Whale Tail pit lake study area depths under baseline conditions.

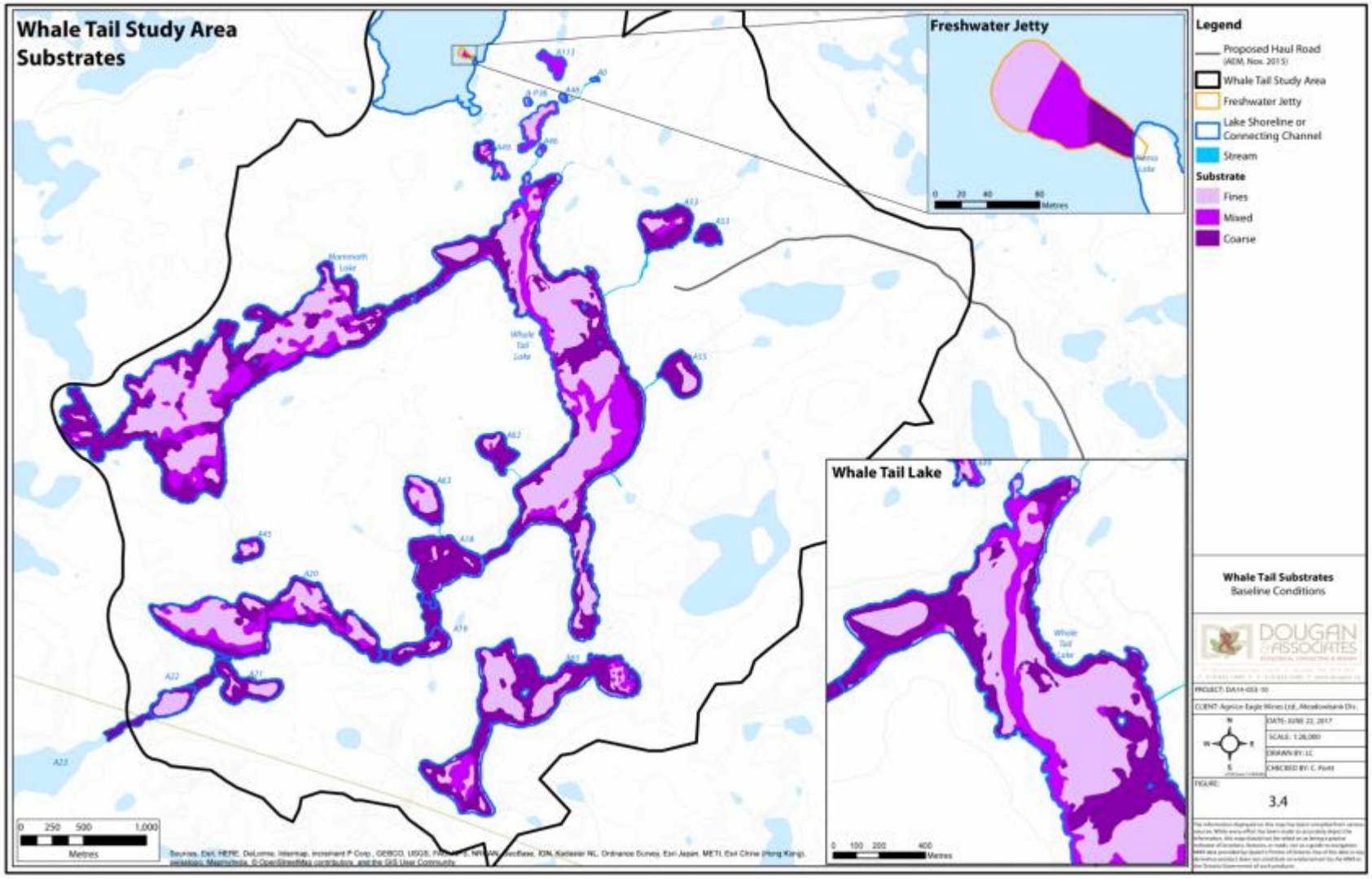


Figure 3-4. Whale Tail pit study area substrates under baseline conditions.

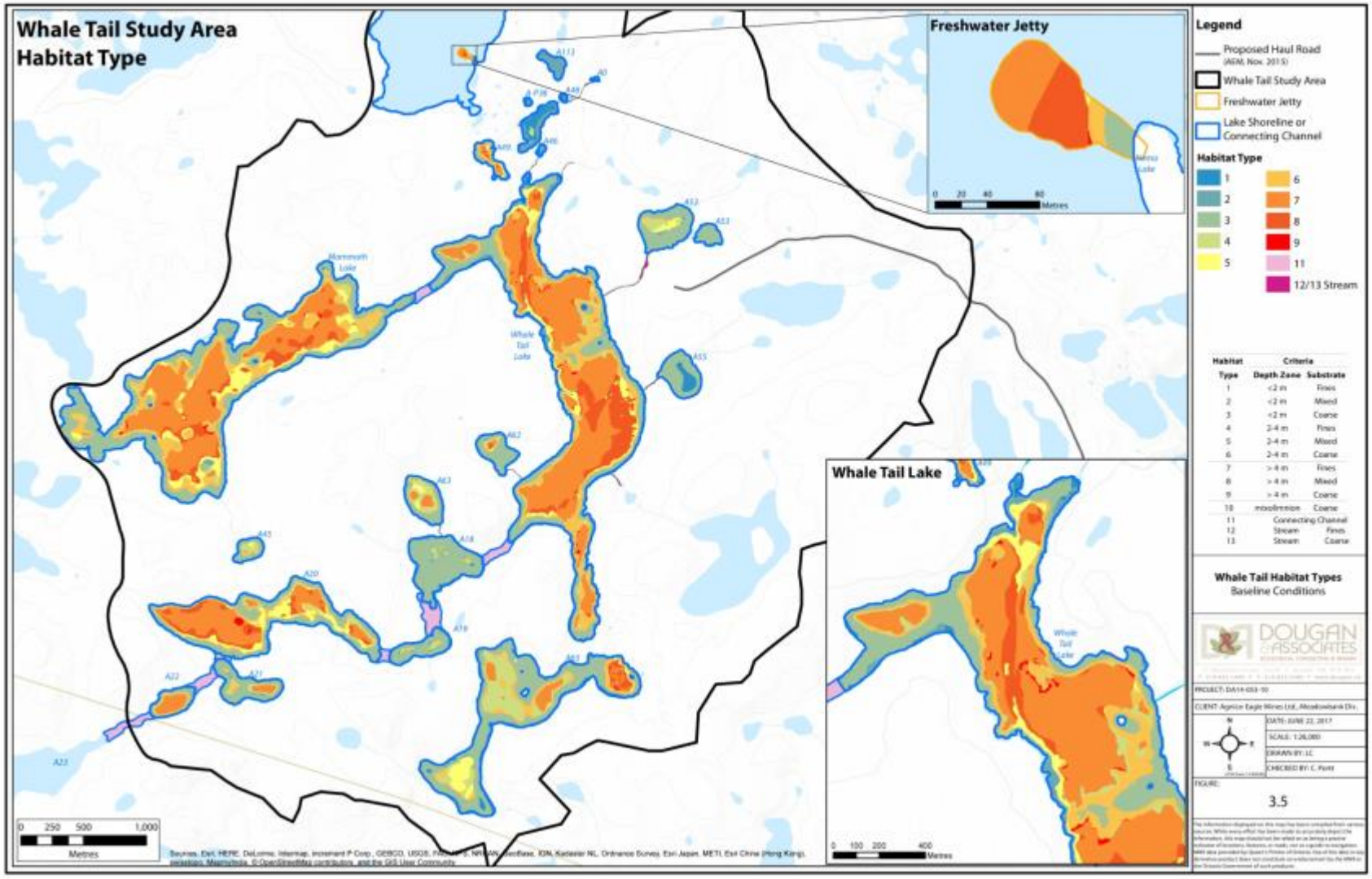


Figure 3-5. Whale Tail pit study area habitat types under baseline conditions.

3.2 OPERATIONS PHASE

3.2.1 Site Description

The area to be enclosed by dikes and dewatered during mine operations includes the northern basin of Whale Tail Lake and a small portion at the east end of Mammoth Lake, as well as the connecting channel between those two lakes. The exterior surface of the dikes will be coarse substrate.

An area to the north of Whale Tail Lake, that includes a number of small lakes and ponds which currently drain to Whale Tail Lake, would be isolated by the north dike. In this area, referred to as the north-east pond, the water level would rise to 156.47 masl, resulting in the flooding of some terrestrial areas. This area would drain to Nemo Lake. For the purposes of offset planning, it has been assumed that fish from Nemo Lake would not have access to the north-east pond and therefore it will be completely isolated. It has also been assumed that, due to the limited amount of deep habitat in the north-east pond, fish might not survive the winter there. Therefore the habitat present in the area occupied by north-east pond under baseline conditions is assumed to be 'lost' during the operations phase. If monitoring determines that fish survive there, an operations phase offsetting credit could be calculated.

The Whale Tail Dike will bisect Whale Tail Lake into north and south basins. South of the Whale Tail Dike the water level will rise from 153.02 (baseline; see Section 1.3) to 156 masl during operations. This will result in the flooding of terrestrial areas, so that a number of lakes now connected to each other or to Whale Tail Lake (South Basin) by connecting channels (lakes A18, A19, A20, A21 and A22) or small streams (lakes A55, A62, A63), or have no surface connection to Whale Tail Lake (lake A65), would become contiguous. This larger contiguous waterbody is referred to as the Whale Tail Lake (South Basin) and is an *expanded Whale Tail Lake*; fish salvaged during the fishout of Whale Tail Lake (North Basin) will be transferred to the Whale Tail Lake (South Basin) (Agnico Eagle, 2017a). The Whale Tail Lake (South Basin) will drain to Lake A45 via a constructed channel and Lake A45 will drain to Mammoth Lake via an existing boulder feature. The boulder feature between Lake A45 and Mammoth Lake does not exhibit surface flow under existing conditions, even during spring freshet. It has not yet been determined if it will be necessary to modify that connection, but for the purposes of the habitat calculations it has not been assigned any fish habitat value during any phase of the project.

Lake A53, east of Whale Tail Lake, currently drains to the portion of Whale Tail Lake that would be dewatered via a small stream. A new watercourse will be constructed to convey this flow to the south basin of Whale Tail Lake. The lower reach of the existing watercourse will be eliminated. The proposed route of this realignment is shown in Figure 3-1. It has been assumed that the width and the proportions of fine and coarse substrates of the realigned portion will be the same as those of the existing watercourse.

There will be a reduction in the flow to Mammoth Lake and downstream during the period when the expanded Whale Tail Lake is filling, before flow via Lake A45 occurs. Flow into Mammoth Lake approaches zero during the latter part of the ice-free season under baseline

conditions. During the period when the expanded Whale Tail Lake is filling, the water level in Mammoth Lake is expected to be at or near what is its minimum elevation under baseline conditions. This will occur again during closure when the pit is refilling. This temporary condition has not been incorporated into the HEP calculations.

In addition to the alterations within the Whale Tail Lake and Mammoth Lake drainages, a water intake jetty would be constructed in Nemo Lake that will result in a change in depth and substrate, including an area that will be raised so that it is above the water surface and no longer fish habitat. The jetty will have coarse substrate.

3.2.2 Habitat Units Calculation

Changes in habitat area and habitat units between the baseline conditions and the operations phase as calculated using the HEP described in Section 2 are provided for each habitat type in Appendix B, Table B-1. At the request of DFO, the locations and areas of habitat losses and gains and habitat modified are presented in Appendix B, Table B-2. Change in habitat for each lake/stream system are provided in Appendix B, Table B-3. Overall, there is a 49.24 ha increase in the area of fish habitat and a 42.93 increase in the number of habitat units during operations.

As indicated previously, for the operations phase, the extent of flooding and the depths were calculated based on an elevation of 156 masl elevation for the expanded Whale Tail Lake and no change from baseline conditions to the elevation of Mammoth Lake. The dike side slopes and the freshwater jetty in Nemo Lake will have coarse substrate. The constructed channel connecting the expanded Whale Tail Lake to Lake A45 will be less than 2 m deep and have coarse substrate. It has been assumed that the connection between Lake A45 and Mammoth Lake will continue to be subsurface/interstitial during operations and that it will not provide fish habitat. The depth zones, substrate types (fines, mixed, coarse) and habitat types for the operations phase are shown in Figure 3.6, 3.7 and 3.8 respectively

There are relatively small decreases in the habitat area and habitat units in Nemo Lake as a result of the construction of the freshwater intake jetty. The area of Mammoth Lake is decreased due to the construction of the Mammoth dike and the dewatering of the portion of Mammoth Lake that is east of that dike, resulting in a concomitant number of habitat units.

The expanded Whale Tail Lake during operations (407.3 ha) includes the portion of Whale Tail Lake that is not dewatered or covered by the Whale Tail dike (plus the other existing lakes, connecting channels and streams that are within the flooded area (280.0 ha), land that is flooded (127.4 ha), and the portion of the south side of the Whale Tail dike that is below the water (0.4 ha). The total area of habitat lost, including the habitat that is isolated in the north-east pond, is 73.7 ha. In addition to the increase in habitat area, during the operations phase the habitat value increases in some of the existing habitats where depth increases, contributing to the overall increase in habitat units.

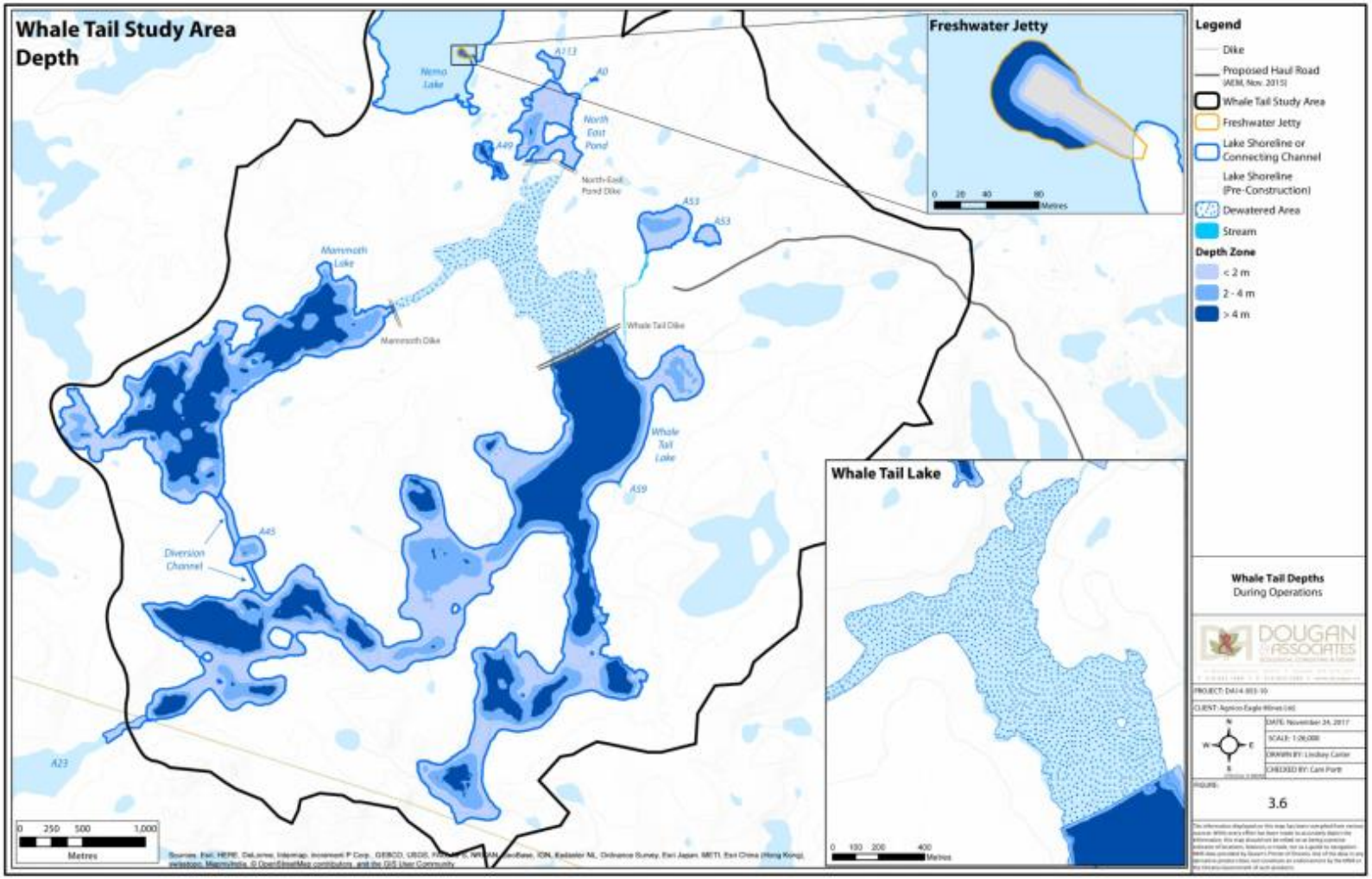


Figure 3-6. Whale Tail Pit study area depths during operations.

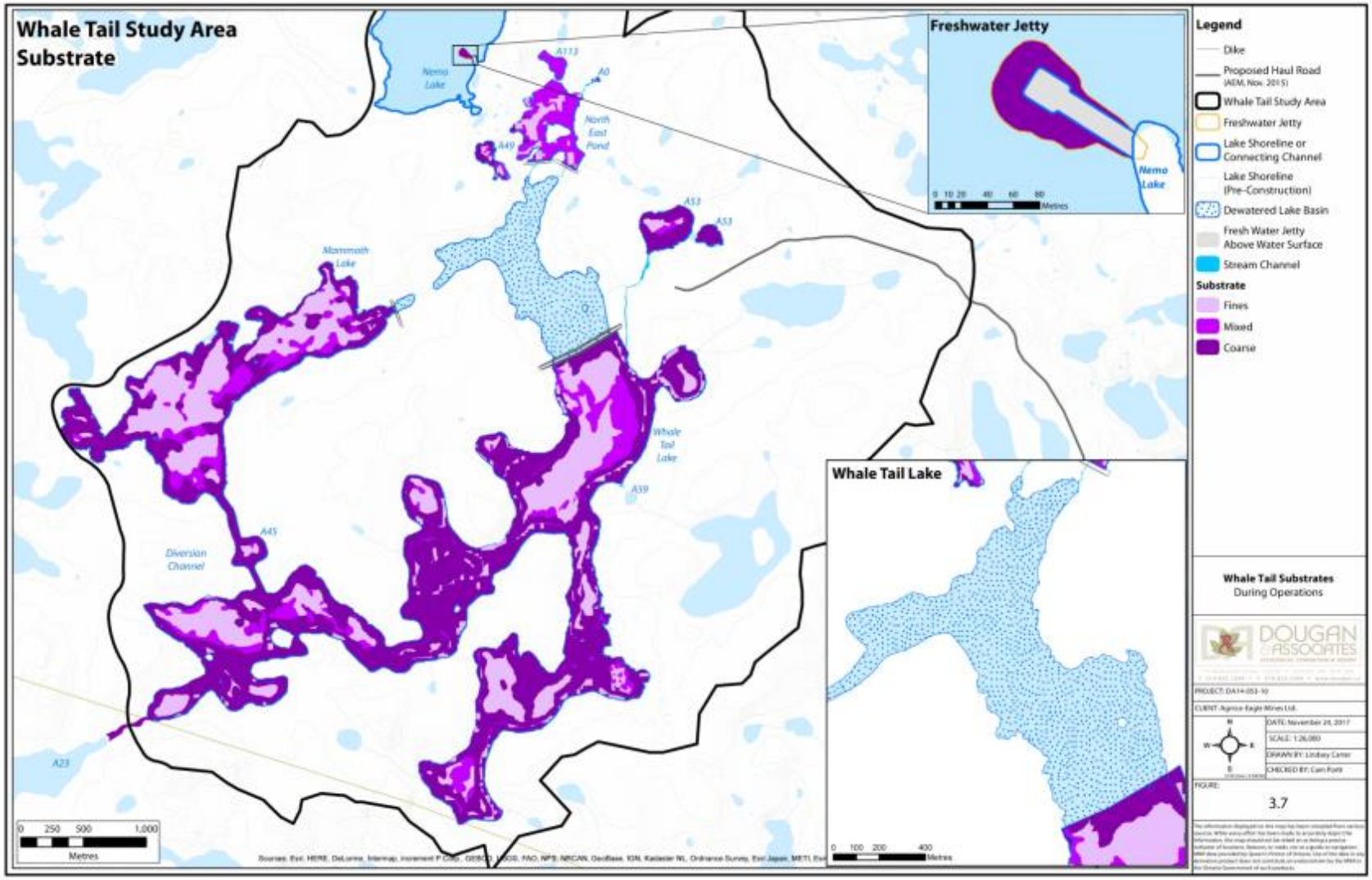


Figure 3-7. Whale Tail pit study area substrates during operations.

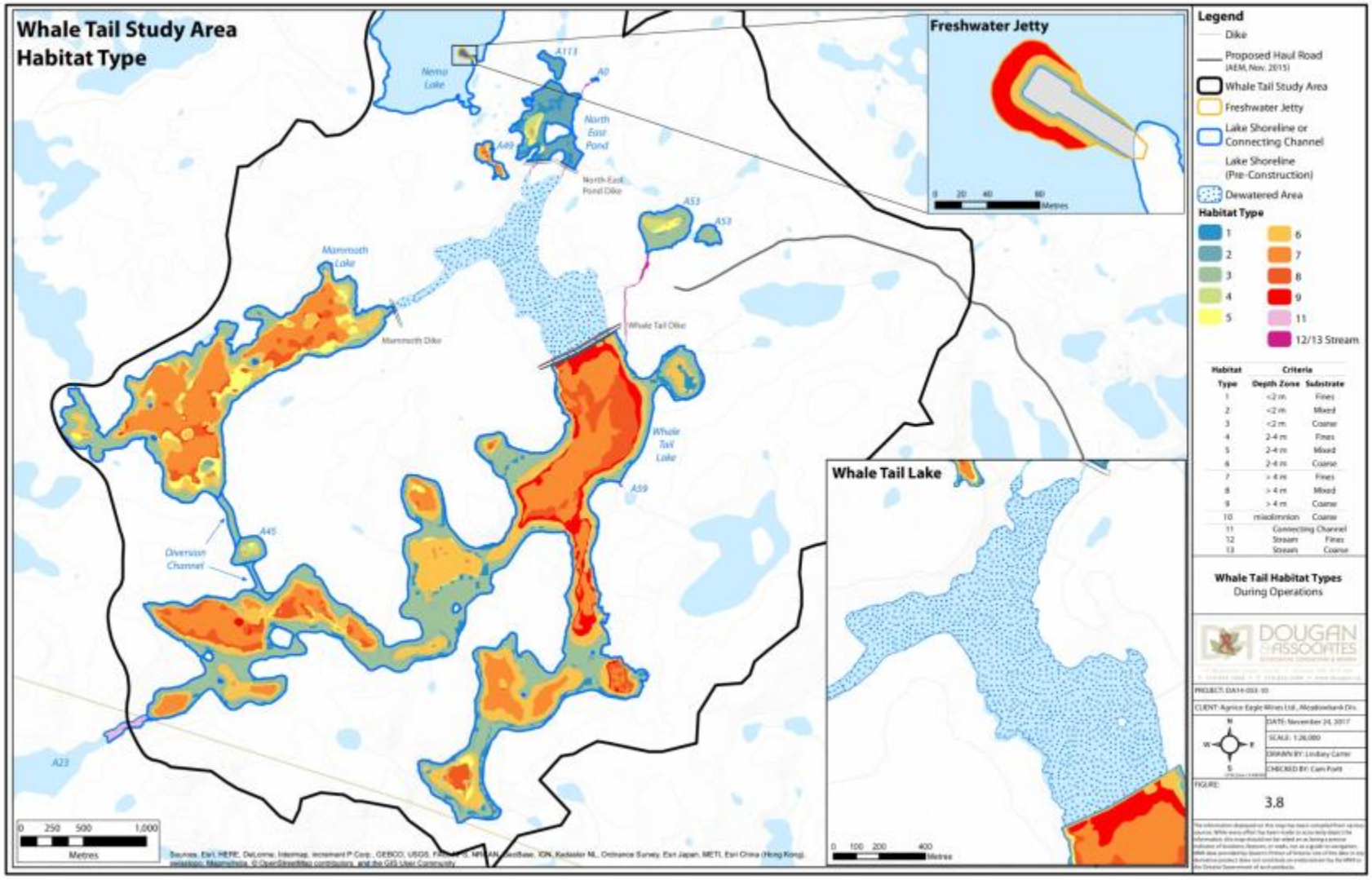


Figure 3-8. Whale Tail pit habitat types during operations.

3.3 POST-CLOSURE PHASE

3.3.1 Site Description

Consistent with approved closure plans reviewed during the NWB/ NIRB review, based on current water quality predictions and on the current mine plan for Whale Tail Pit, it is assumed that dewatering dikes would be breached and water levels would return to pre-mine elevations following mine closure by 2029 (refer to Figure 3-2). Therefore, aquatic habitats would revert to their pre-mine condition with the following exceptions:

1. The area of Whale Tail Lake will be increased by 26.17 ha as a consequence of terrestrial areas being excavated and becoming part of the flooded pit and pit cap, post-closure. This area has also been assigned Habitat Type 10.

2. The Whale Tail Dike that bisects Whale Tail Lake will be breached but not removed following mine closure. Therefore it will continue to occupy a portion of what was previously Whale Tail Lake and a portion of it will be above the water. For the purposes of habitat calculations, it has been assumed that a 100 m wide breach will be created in the Whale Tail Dike. This area has been assigned Habitat Type 3..

3. The Mammoth Dike that isolates the eastern end of Mammoth Lake will be reduced in height, so that it becomes shallow lake habitat with coarse substrate (Type 3 habitat).

4. The North-east Dike will be breached at the locations where two small watercourses existed pre-construction, so that the watercourses are re-established and the lakes and ponds are reconnected to Whale Tail Lake through the approved access road culverts.

5. The portion of the watercourse connecting Lake A53 to Whale Tail Lake that was re-aligned will be returned to its former channel.

6. Roads that are flooded post-operations will remain in their operations phase condition and have mixed substrate.

7. A jetty to the attenuation pond that is in the dewatered area during operations will remain in its operations phase condition and have coarse substrate.

8. The jetty for the freshwater intake in Nemo Lake will remain in its operations phase condition.

3.3.1 Habitat Units Calculation

Net changes in habitat area (ha) and habitat units (HUs) between the baseline and the post-closure phase, without offsetting (i.e. habitat losses), are summarized in Table 3-1 for each habitat type. The locations (lakes/steams) and areas of habitat losses and gains and habitat modified are presented in Appendix B, Tables B-4 and B-5.

Depth zones, substrate types (fines, mixed, coarse), and habitat types following closure and reflooding of the pit, in the absence of any measures to offset for harm to fish habitat, are shown in Figures 3.9, Figure 3.10 and 3.11 respectively. For these calculations it was assumed that the elevations of all lakes would revert to their pre-construction levels. It was also assumed that substrate within the area that was dewatered did not change from pre-construction conditions unless it was excavated as part of the pit or the pit cap (where substrate is irrelevant because these areas are assigned Habitat Type 10), or covered by infrastructure (dikes, roads, jetties).

There is the same small reduction in both habitat area and habitat units in Nemo Lake as during operations, due to the construction of the freshwater jetty which will remain in place post-closure. There is no reduction in either the habitat area or the habitat units in Mammoth Lake because the Mammoth Dike is lowered and is coarse substrate, thus becoming Type 3 habitat.

Post-closure, 27.9 ha of habitat is added to Whale Tail Lake due to the excavation of the pit. This includes 27.4 ha that was terrestrial habitat under existing conditions; the remainder was part of the connecting channel between Whale Tail and Mammoth Lakes. There is a loss of 1.7 ha from Whale Tail Lake because part of the Whale Tail dike remains above the water and another 0.1 ha is lost because a portion of the water attenuation pond ramp remains above the water. The result is a net increase of 26.2 ha in the area of Whale Tail Lake.

Although the area of Whale Tail Lake increases, the number of habitat units in Whale Tail Lake decreases by 14.2. This reduction is largely because the pit and pit cap occupy 30.3 ha that were part of Whale Tail Lake under baseline conditions. Post-closure, this area is assigned habitat type 10, which has been assigned zero fish habitat value.

The net change between baseline and post-closure conditions, or overall project related fish habitat losses in the absence of offsetting, is a loss of 14.5 habitat units.

Table 3-1. Net change in fish habitat during the post-closure phase, without offsetting (losses).

Habitat Type	Hectares			HUs		
	Baseline	Post-closure - no offsetting	Net Change	Baseline	Post-closure - no offsetting	Net Change
1	1.58	1.26	-0.32	0.38	0.30	-0.08
2	4.60	4.55	-0.05	1.29	1.28	-0.01
3	81.42	71.44	-9.99	32.23	28.28	-3.95
4	11.30	10.11	-1.19	4.24	3.79	-0.45
5	15.87	14.89	-0.98	9.26	8.68	-0.57
6	41.71	37.90	-3.82	31.72	28.82	-2.90
7	128.36	114.45	-13.91	48.14	42.92	-5.22
8	30.87	28.77	-2.10	16.08	14.99	-1.09
9	3.76	3.79	0.03	2.54	2.57	0.02
10	0.00	58.30	58.30	0.00	0.00	0.00
11	2.15	1.50	-0.65	0.65	0.45	-0.20
12	0.58	0.58	0.00	0.10	0.10	0.00
13	0.18	0.18	0.00	0.05	0.05	0.00
Total			**25.33**			**-14.45**

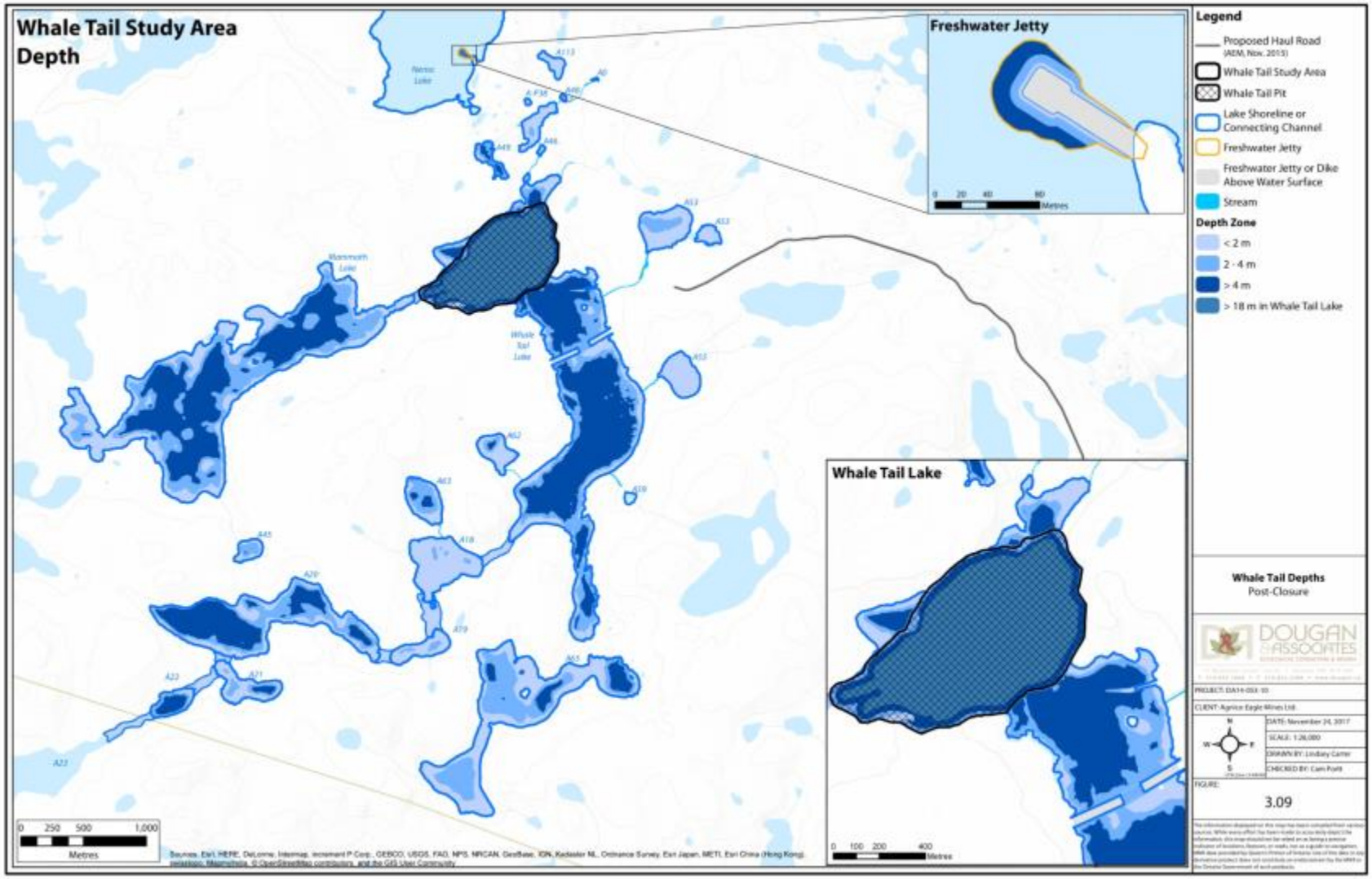


Figure 3-9. Whale Tail pit depths post-closure with no offsetting.

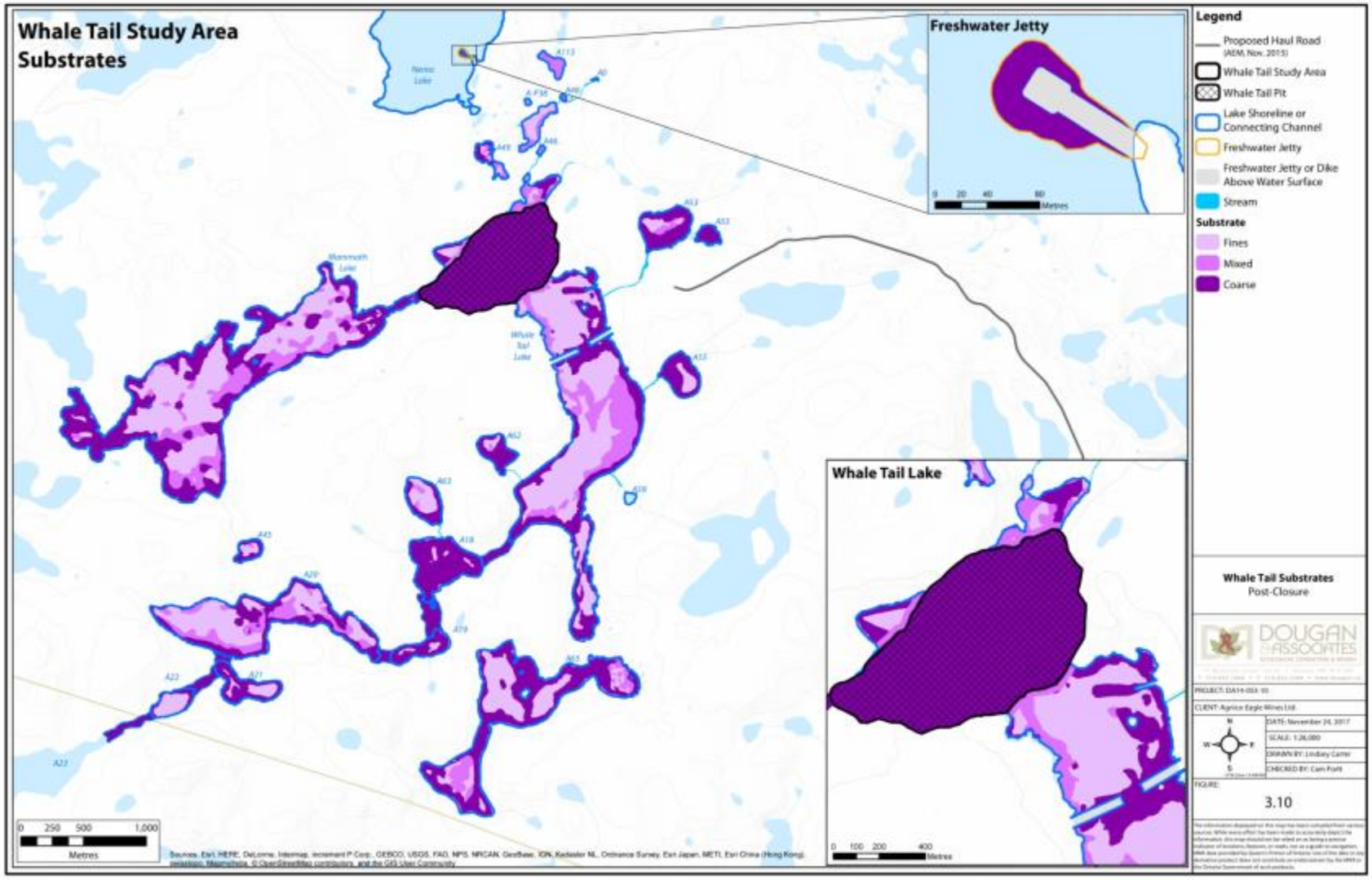


Figure 3-10. Whale Tail pit substrates post-closure with no offsetting.

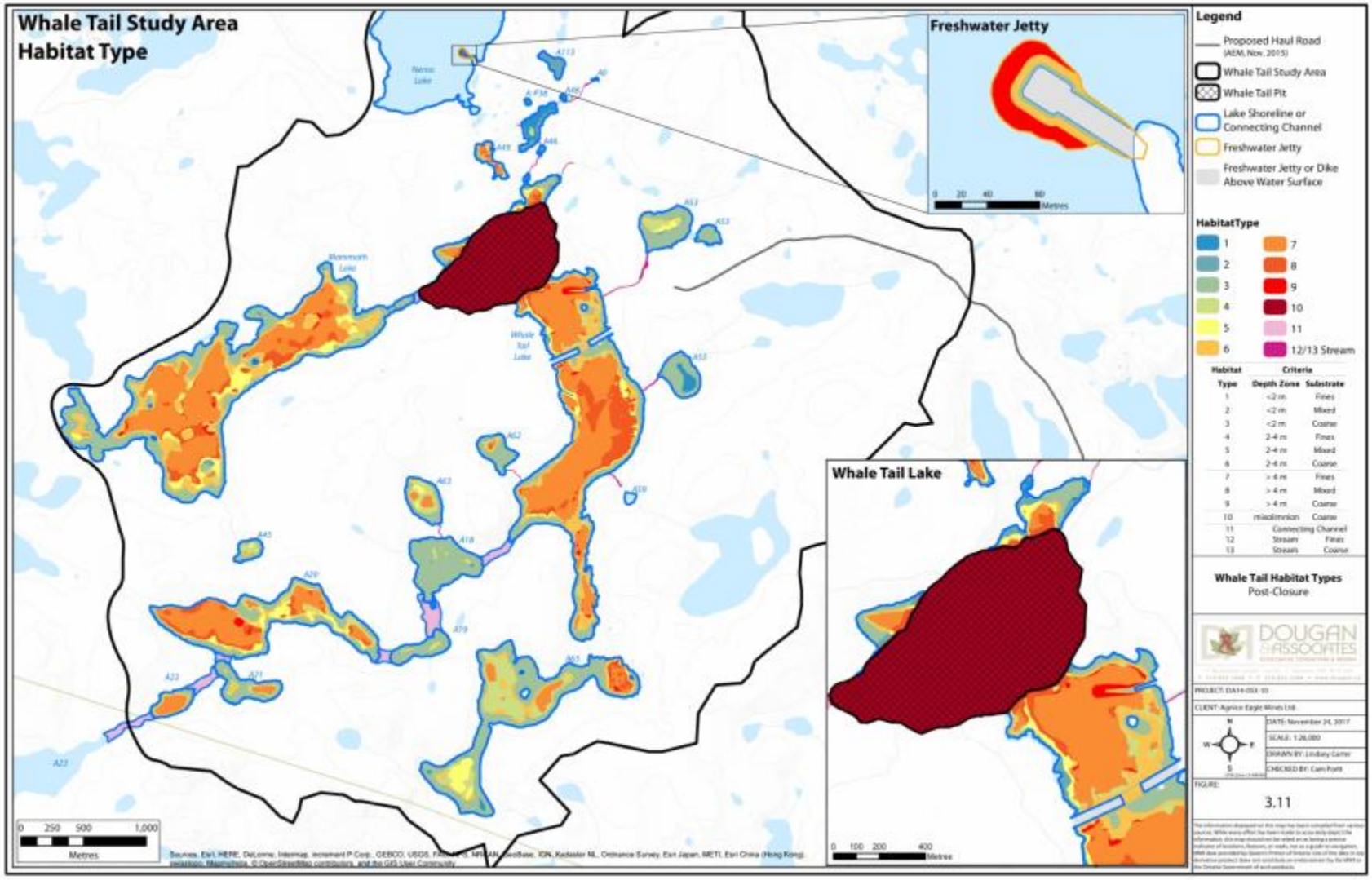


Figure 3-11. Whale Tail pit habitat types post-closure with no offsetting.

SECTION 4 • OFFSETTING MEASURES

The substantial increase in habitat area and habitat units in the expanded Whale Tail Lake during the operations phase is expected to result in an increase productivity of the aquatic system (Minns and Portt, 2017 pers. comm. June 14). Following closure, however, without offsetting, even though there will be an increase in the area of aquatic habitat due to the flooding of areas excavated as part of the pit, there will be a net decrease of 14.45 habitat units compared to baseline conditions. This occurs because no habitat value is attached to the pit or pit cap. Offsetting is required to address this loss.

Offsetting measures may be grouped into the following general categories (Fisheries and Oceans Canada, 2013):

- Habitat restoration and enhancement, which includes physical manipulation of existing habitat to improve habitat function and productivity;
- Habitat creation which is the development or expansion of aquatic habitat into a terrestrial area;
- Chemical or biological manipulation, which includes chemical manipulation of water bodies, and stocking of fish or shellfish, management or control of aquatic invasive species;
- Complementary measures, which are investments in data collection and scientific research related to maintaining or enhancing the productivity of commercial, recreational or Aboriginal fisheries.

A combination of habitat creation, by raising the water level of Whale Tail Lake, habitat enhancement, and complementary measures to offset the loss of habitat units is presented below.

4.1 HABITAT ENHANCEMENT AND CREATION

It is proposed that, as an offsetting measure, a sill is installed in the connection between Mammoth Lake and Whale Tail Lake that allows flow from Whale Tail to Mammoth Lake but maintains Whale Tail lake at an elevation of 154.02 masl, which is 1 m higher than its baseline elevation. This increase would create new habitat around the periphery of Whale Tail Lake and the connecting channel between Whale Tail Lake and Mammoth Lake, as well as around the portion of Mammoth Lake that is east of the sill (Figure 4.1). It will also create a small amount of additional habitat along the Whale Tail Dike due to the water level increase.

The 1 m increase in water elevation will also result in some habitat modifications. Small sections of the streams that are tributary to Whale Tail Lake will be converted to lake

habitat, as will the remaining section of the connecting channel between Whale Tail Lake and Mammoth Lake and a portion of connecting channel A18-A17. Depth will increase in the portion of Mammoth Lake that is east of the Mammoth Lake dike and throughout Whale Tail Lake.

Coarse substrate has the highest habitat value and conversion of mixed or fine substrate to coarse substrate is a common habitat enhancement practice. Therefore, in addition to increasing the water level by 1 m east of connection between Whale Tail Lake and Mammoth Lake, the roads within the area that is flooded will be scarified to convert them from mixed to coarse substrate and 8.77 ha of rock shoals will be constructed in areas of fine substrate within the portion of Whale Tail Lake that is dewatered during operations (Figure 4.2). The shoal construction converts those areas to coarse substrate and was assumed to increase their elevation by 1 m. The elevation of the roads was assumed not to change due to scarification.

The depth zones, substrate types (fines, mixed, coarse) and habitat types for the post-closure phase with these offsetting features (a 1 m increase in the water level elevation east of the Mammoth dike, scarification of the roads and construction of 8.77 ha of grid shoals) are shown in Figures 4.3, 4.4, and 4.5, respectively. These offsets provide an increase of 21.26 ha and 15.03 habitat units over the post-closure scenario without offsets (Table 4-1) (Changes relative to baseline for each lake or stream are summarized in Appendix B Table B-6).

These planned offsetting features result in an offsetting gains to losses ratio of approximately 1:1 (gains of 15.03 HU and losses of 14.45 HU).

Table 4-1. Habitat area (ha) and habitat units (HUs) gained from the implementation of the proposed habitat enhancement and creation offsetting measures.

Habitat Type	Hectares			Habitat Units		
	Post-closure no offsets	Post-closure with offsets	Net Change	Post-closure no offsets	Post-closure with offsets	Net Change
1	1.260	4.176	2.916	0.302	1.001	0.699
2	4.552	11.021	6.470	1.280	3.100	1.820
3	71.436	69.026	-2.410	28.277	27.323	-0.954
4	10.113	6.353	-3.760	3.792	2.382	-1.410
5	14.887	12.433	-2.454	8.684	7.253	-1.431
6	37.897	49.292	11.395	28.817	37.482	8.665
7	114.451	109.449	-5.002	42.919	41.044	-1.876
8	28.774	30.607	1.833	14.987	15.941	0.955
9	3.791	17.016	13.226	2.567	11.521	8.955
10	58.298	58.667	0.370	0.000	0.000	0.000
11	1.499	0.232	-1.267	0.453	0.070	-0.383
12	0.577	0.546	-0.031	0.102	0.097	-0.006
13	0.176	0.155	-0.022	0.053	0.047	-0.007
Total			**21.264**			**15.027**

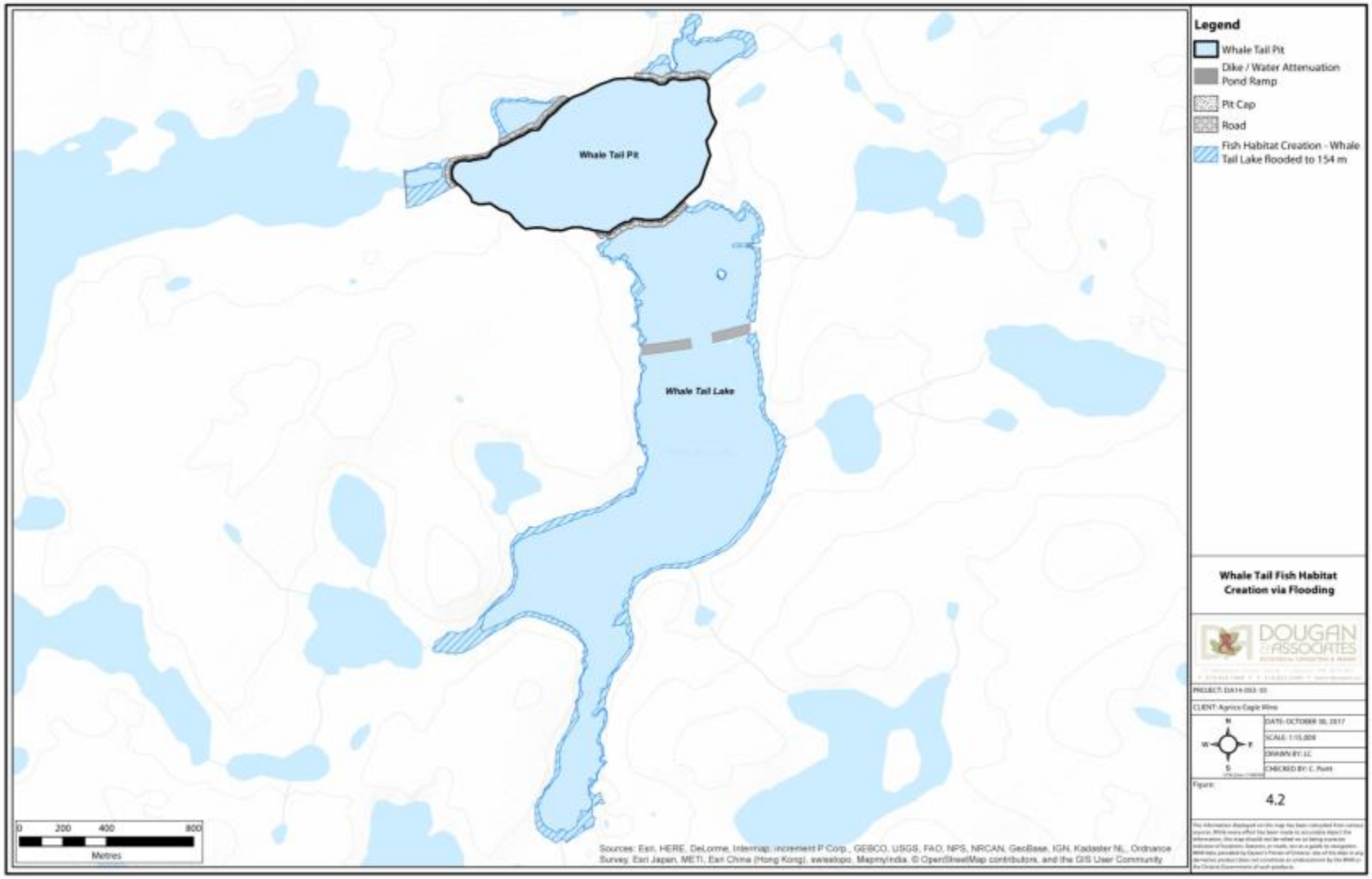


Figure 4-1. Habitat created by increasing the water elevation by 1 m east of the Mammoth Dike.

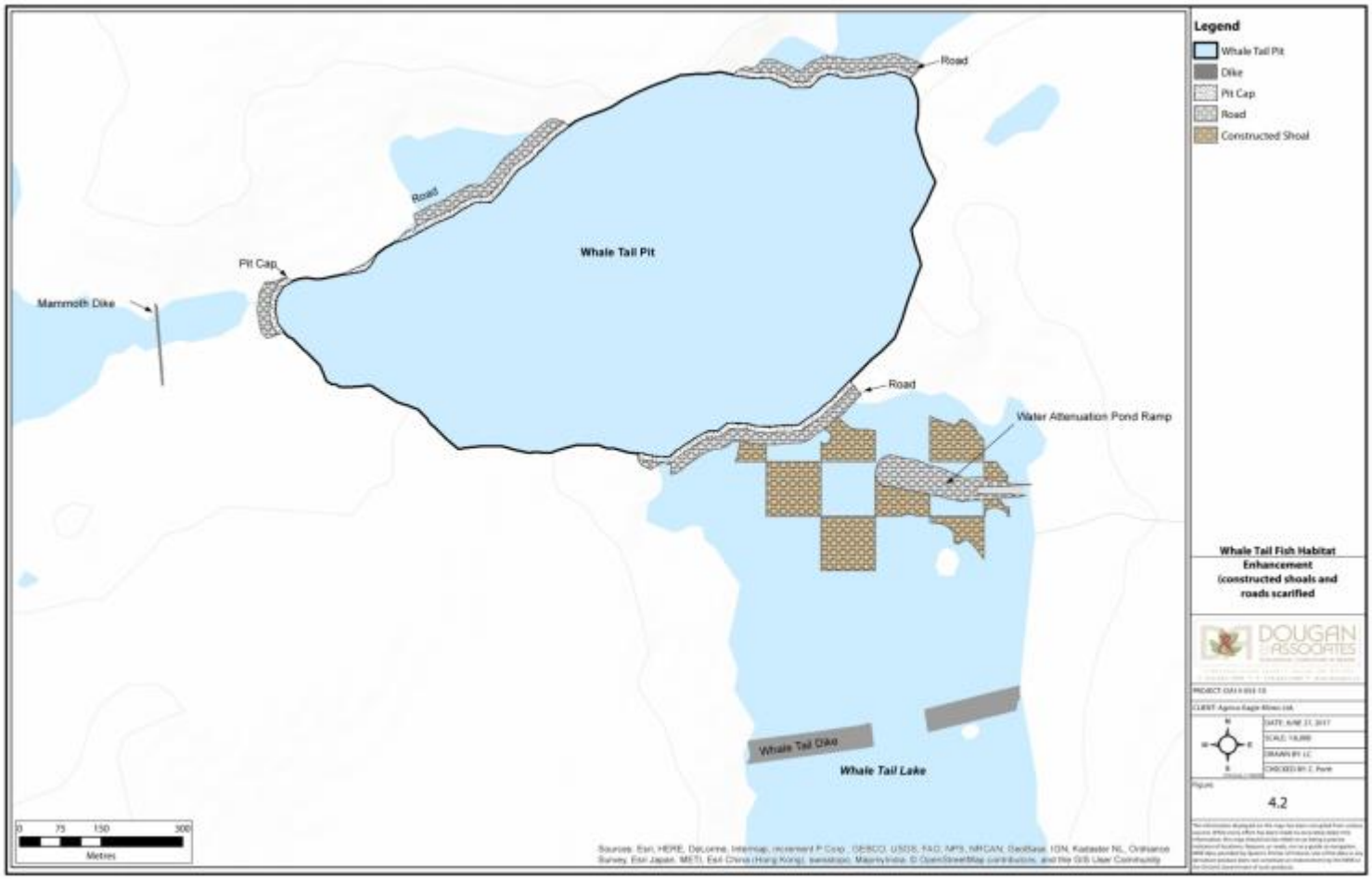


Figure 4-2. Proposed roads scarified and constructed rock shoals proposed as offsetting measures.

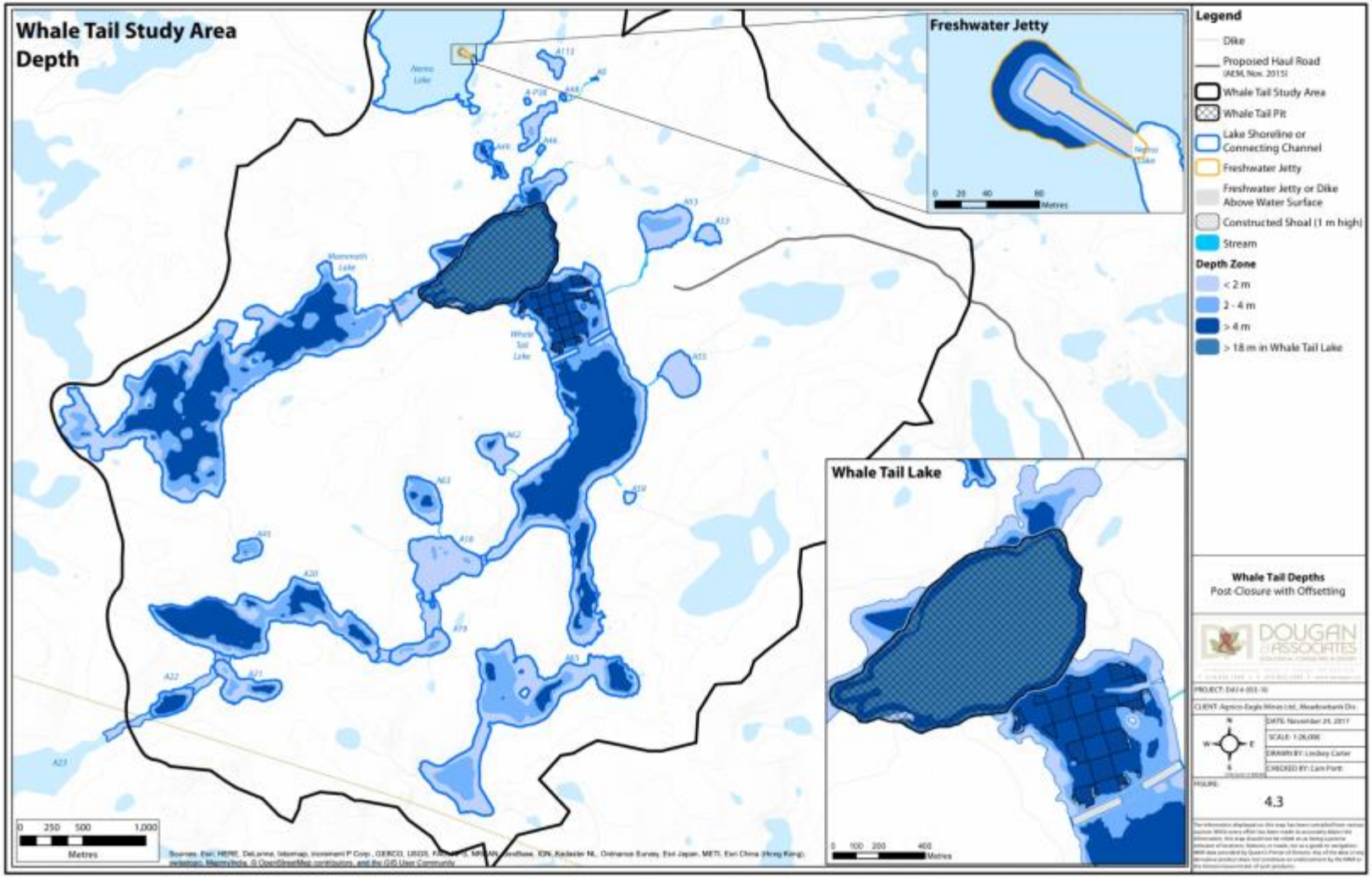


Figure 4-3. Whale Tail pit depths post-closure with a 1 m increase in water elevation east of Mammoth Lake sill, roads scarified and rock shoals constructed for offsetting.

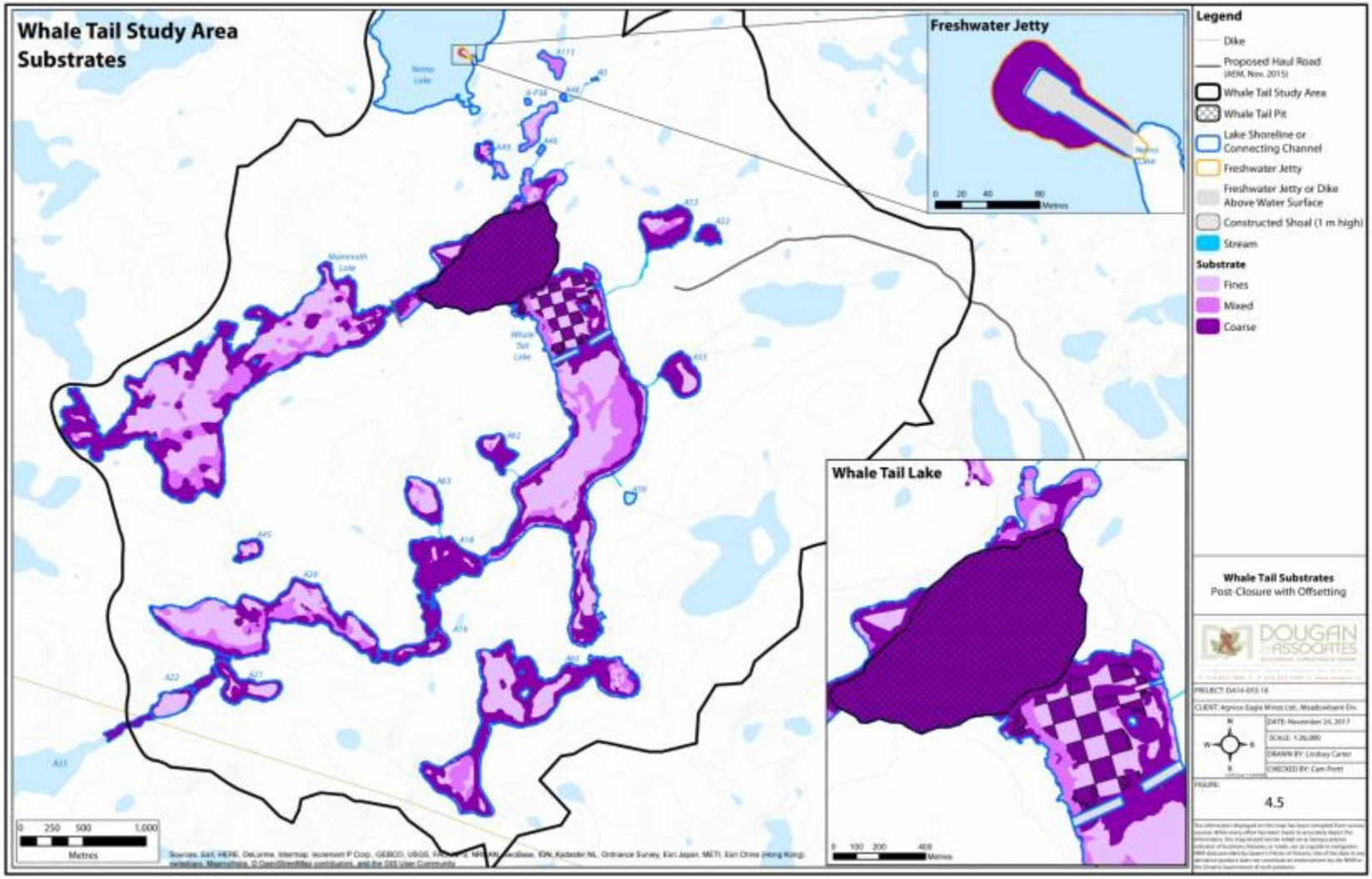


Figure 4-4. Whale Tail pit substrates post-closure with a 1 m increase in water elevation east of Mammoth Lake sill, roads scarified and rock shoals constructed for offsetting.

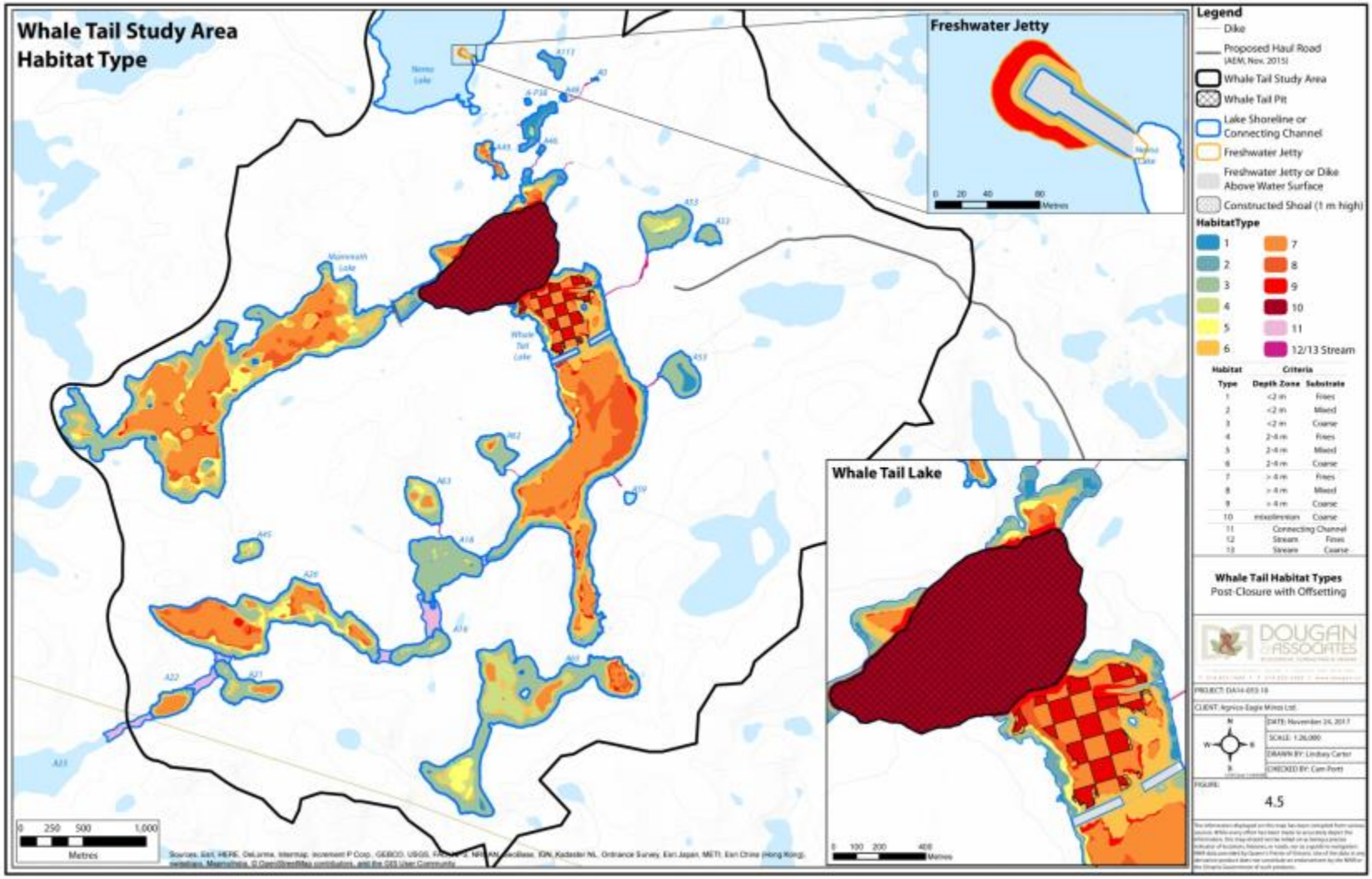


Figure 4-5. Whale Tail pit habitat types post-closure with a 1 m increase in water elevation east of Mammoth Lake sill, roads scarified and rock shoals constructed for offsetting.

4.2 COMPLEMENTARY MEASURES

As defined by Fisheries and Oceans Canada (2013), “complementary measures are investments in data collection and scientific research related to maintaining or enhancing the productivity of commercial, recreational or Aboriginal fisheries.” As discussed in Section 1.1, for the Whale Tail pit, DFO has indicated support for complementary measures to provide 60% of the required offsetting. Agnico Eagle is supportive of funding research as a complementary measure to offset habitat losses resulting from the Whale Tail Pit and has provided to DFO for consideration project descriptions for a suite of research activities to benefit local stakeholders and contribute to the understanding of aquatic systems (Appendix C). These complementary measures are valued at 60% of constructed offsets (0.6 * 15.03 HUs = 9.02 HUs), providing a total offsetting ratio of 14.45 HUs lost to 24.05 HUs gained (1:1.66). Through this accounting method, the proposed complementary measures actually account for 38% of total offsets based on HUs (9.02 HUs / 24.05 HUs = 38%).

4.3 TIMELINE, DESIGN AND CONSTRUCTION OF THE OFFSETTING MEASURES

The following estimated timeline of water management activities is described in the Whale Tail Pit - Water Management Plan Addendum (FEIS, June, 2016). The exclusion of fish from available habitat in Whale Tail Lake – North Basin will extend from the initiation of dike construction (2018), dewatering and the fishout (2019), until re-flooding is complete (2025) and dikes are breached to allow fish re-entry (estimated 2029). Until the expanded Whale Tail Lake – South Basin is returned to baseline water levels (2022 – 2025), a large quantity of supplemental habitat will be available throughout that area due to flooding of terrestrial zones (see Section 3.2).

Construction timing of offsetting features is described in Table 4-2.

Table 4-2. Timing of construction and accessibility of offsetting features (habitat enhancements and creation).

Feature	Construction Complete	Offset Accessible to Fish
Scarification of roads	2022	2029
Construction of shoals	2022	2029
Sill	2025	2029
1-m Increase in Water Level	2025	2029

Preliminary engineering designs for the sill to raise water levels within Whale Tail Lake are provided in Figure 4-6.

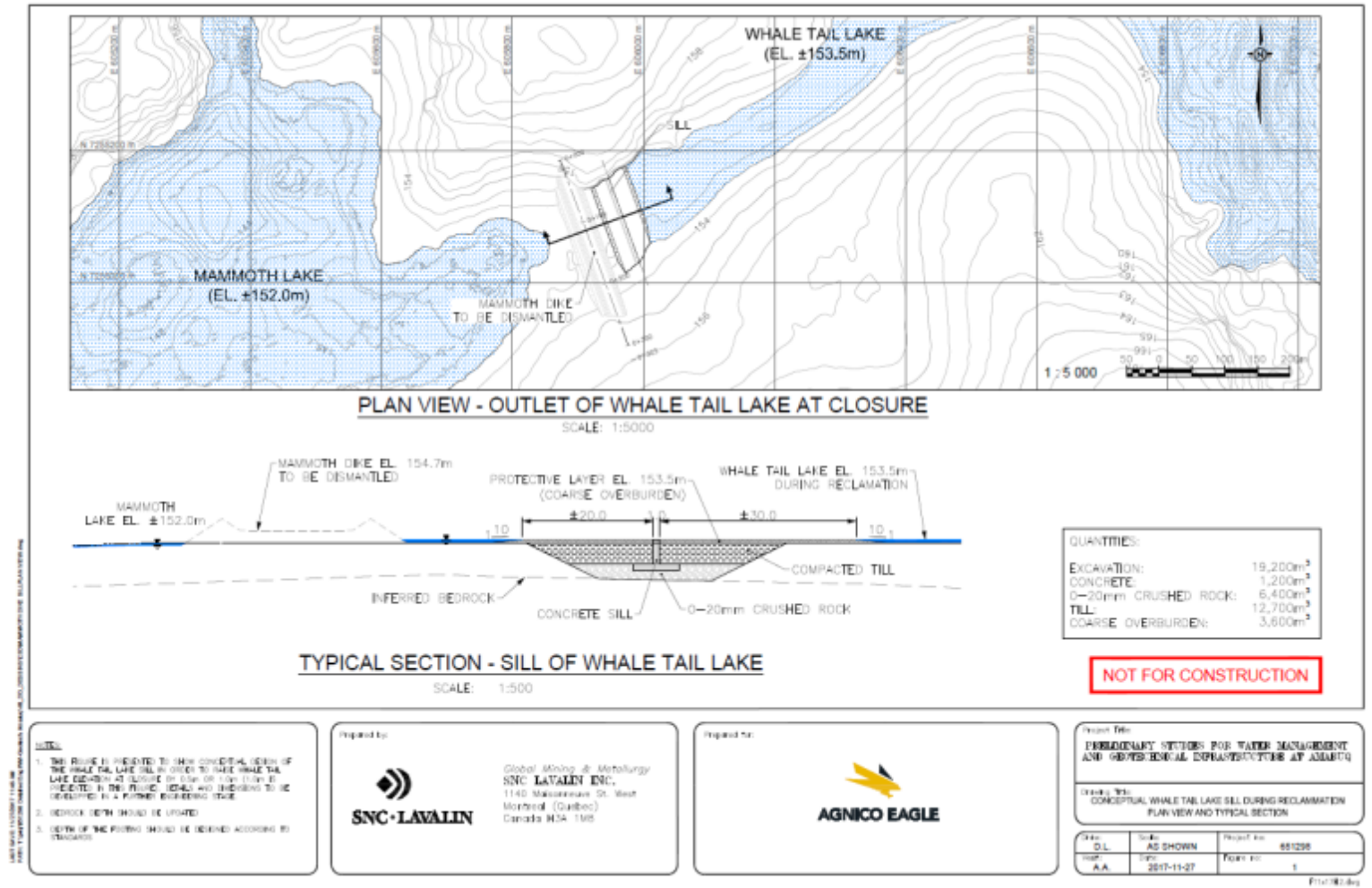


Figure 4-6. Preliminary engineering design for sill to raise water level of Whale Tail Lake by 1 m in the long term.

4.4 MONITORING

Monitoring to confirm that offsetting measures have been properly implemented and are effectively counterbalancing the serious harm to fish habitat occurring in Whale Tail Lake will be conducted as described in Agnico Eagle's Whale Tail Pit Fish Habitat Offset Monitoring Plan (March, 2018).

The planned duration and type of monitoring will allow for demonstration of full ecological functionality of the system (i.e. growth, reproduction and survival), with clearly identified criteria for success. Once criteria for success have been demonstrated, Agnico expects that there would be a reduction in the Letter of Credit (LOC) held by DFO in the amount corresponding to the successful offset.

SECTION 5 • CONTINGENCY OPTIONS

As a requirement in DFO offset planning Agnico Eagle recognizes uncertainty exists in all projections of future conditions. Therefore, Agnico Eagle is proposing three potential contingency options[5] that could be implemented in the case that the primary offsets are determined not to provide functional fish habitat (e.g. if conditions within the reflooded area do not permit breaching of the Whale Tail Dike to allow fish re-entry).

5.1 OPTION 1 – EXPANDED WHALE TAIL LAKE SOUTH BASIN

If deemed feasible, contingency option 1 could involve maintaining all or a portion of the flooded conditions south of the Whale Tail Dike. In concept, the Whale Tail Dike would not be breached to allow fish entry into Whale Tail Lake. As during the operations phase described in Section 3, water would continue to flow into Mammoth Lake through the southern diversion channel, rather than through Whale Tail Lake – North Basin. Based on preliminary planning to support DFOs requirements, habitat area (ha) and habitat units gained through this contingency offsetting option (i.e. maintaining habitat conditions as during operations in the long term) are summarized in Table 5-1. Provided this option is feasible, it could provide an increase over baseline conditions of up to 42.7 HUs, and would therefore provide more offsets than the primary option of habitat enhancement and creation (15.03 HUs). Agnico expects that these supplemental HUs could be banked or utilized towards future offsetting projects. Modifications of contingency option 1, such as a maintaining a lower level of flooding, could also be further investigated.

[5] These options are highly conceptual in support of the base case; as discussed with DFO, these concepts will require greater feasibility and engineering evaluation

Table 5-1. Increase in habitat area (ha) and habitat units (HUs) compared to baseline conditions provided by contingency option 1 (maintaining fish habitat conditions as during operations).

Habitat Location	Hectares	Habitat Units
Nemo Lake	-0.2	0.02
Mammoth Lake	-1.2	-0.47
Whale Tail Lake (South Basin) expanded during operations)	240.1	122.15
Other Lakes and Ponds[1]	-183.62	-77.01
Connecting channels	-8.0	-2.41
Streams	-0.3	-0.06
Diversion Channel A17-A45	1.8	0.54
Total	**48.6**	**42.72**

[1]Other lakes south of Whale Tail Lake become part of expanded Whale Tail Lake.

5.2 OPTION 2 – WHALE TAIL PIT BERM

As per NWB Type A requirements, water quality modeling will continue to be updated on an annual basis until closure. If it is determined that water quality within the flooded basin area could be deficient in nutrients required to support lower trophic levels and fish populations, this second proposed contingency option could aim to construct a berm or dike along the southern edge of Whale Tail Pit, in order to reduce the potential for the pit area to function as a nutrient sink. This feature may help to maintain nutrient supply within the basin area by preventing sediments from being washed into the pit. However further considerations of engineering design and water quality modeling would need to be explored to fully develop and understand the utility of this option.

Overall this contingency option may increase the potential for the primary offsetting option to function as intended as fish habitat, Assuming the berm is feasible and will function as fish habitat, change in habitat units over the primary offsetting scenario would be minimal, maintaining the originally proposed ratio of gains to losses. This contingency option would therefore provide approximately 15 HUs.

5.3 OPTION 3 – ADDITIONAL COMPLEMENTARY MEASURES

Based on the calculation method used here, the currently proposed complementary measures represent 38% of total offsets (9.03 of 24.05 HUs). DFO has previously indicated to Agnico Eagle (meeting March 15, 2017) that they would approve 60% of offsets as complementary measures for the Whale Tail Pit project. Thus, as a contingency option, an additional 5.4 HUs could be obtained through development and funding of supplemental research projects. This contingency option could be used in tandem with Option 2 to help to offset any small reduction in habitat gains that might occur as a result of berm construction.

SECTION 6 • CONCLUSION

There will be serious harm to fish habitat as a result of Whale Tail Pit development during both the operations and post-closure phases, resulting in a loss of 14.5 habitat units.

Accepted methods of habitat enhancement and habitat creation will be utilized, along with complementary measures, to offset the serious harm that will occur.

Offsets proposed for the Whale Tail Pit Project include:

- Construction of a sill in the connecting channel between Whale Tail Lake and Mammoth Lake that will increase the water level in Whale Tail Lake by 1 m;
- Conversion of roads to coarse substrate and construction of 8.77 ha rock shoals, together these represent 15.03 HUs; and
- Complementary measures consisting of a suite of research studies to benefit local stakeholders and contribute to the understanding of aquatic systems, representing 9 HUs.

Combined, this offsetting package achieves a ratio of habitat units lost to habitat units gained of 1:1.66.

SECTION 7 • REFERENCES

AEM, 2012. AEM Meadowbank Division – No Net Loss Plan. October 15, 2012.

AEM, 2013. Meadowbank Mine – Draft No Net Loss Plan Implementation Cost Estimate and Construction Schedule. Version 2. May 2013.

AEM, 2016. Meadowbank Gold Project – Habitat Compensation Monitoring Plan. AEM Meadowbank Division. Version 3. February, 2016.

Agnico Eagle. 2017a. Conceptual Whale Tail Lake (North Basin) Fishout Work Plan. Version 1. February 2017.

Agnico Eagle. 2017b. Fisheries and Offsetting Monitoring Plan Whale Tail Pit. Version 1. June 2017.

C. Portt and Associates. 2018. Whale tail pit 2014 - 2016 fish and fish habitat field investigations: Agnico Eagle Mines Ltd. - Meadowbank Division. xi +157 pp.

C. Portt and K. Minns. 2017. Personal Communication on June 14th, 2017. Toronto, Ontario. Discussion with Portt, Minns and DFO (by webex) regarding HEP model and conceptual offsetting plans including the flooding of Whale Tail Lake (South Basin).

DFO, 2013. Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting. Ecosystem Programs Policy, Fisheries and Oceans Canada. Ottawa, Ontario. November, 2013. ISBN: 978-1-100-22930-0

Appendix A –

Lake Elevations Used for Existing Conditions and Summary of Fish Catches during Baseline Field Investigations

Table A 1. Elevations used to represent baseline conditions for the determination of depths and shorelines.

Lake	Water elevation (masl) determined from the July 21, 2011 imagery
A113	156.47
A18	154.05
A19	154.85
A20	154.77
A21	154.83
A22	155.01
A45	156.47
A47	154.94
A49	159.28
A62	155.59
A63	154.62
A65	154.84
Mammoth Lake (A16)	152.57
Nemo Lake (C38)	156.00
Whale Tail Lake (A17)	153.02

Table A 2. Electrofishing effort and catches in connecting channels between lakes.

Connecting channel	Date	Distance (m)	Juvenile Lake Trout	Juvenile Round Whitefish	Ninespine Stickleback	Slimy Sculpin
A16-A15	8/25/2015	43	1		2	5
	6/21/2016	59				
	6/24/2016	23				
A16-A15 Total		**125**	**1**		**2**	**5**
A17-A16	7/9/2016	189	2	1	1	1
A18-A17	6/26/2015	100				1
	7/5/2015	112				5
	8/30/2015	30	1		6	
	6/22/2016	104				1
	6/25/2016	141				
	7/8/2016	113		16		
	8/20/2016	27			2	
A18-A17 Total		**627**	**1**	**16**	**8**	**7**
A19-A18	7/9/2015	32				
A19-A18 Total		**32**				
Grand Total		**1213**	**5**	**17**	**11**	**17**

Table A 3. Electrofishing effort and catches in small streams in the primary study area. All Arctic Char, Lake Trout, Salvelinus sp. (which are either Arctic Char or Lake Trout), Round Whitefish and Burbot are juveniles. Large catches of Ninespine Stickleback in A46-A17 occurred immediately downstream of a ledge that appeared to impede upstream migration.

Watercourse	Date	Electro-seconds	Distance (m)	Arctic Char	Lake Trout	*Salvelinus* sp.	Round Whitefish	Burbot	Ninespine Stickleback	Slimy Sculpin
A0-A48	8/1/2015	196	10						2	
A113-A47	8/1/2015	68	10						1	
	6/19/2016	160	191							
A113-A47 Total		**228**	**201**						**1**	
A46-A17	6/28/2015	579	201	1					11	8
	7/9/2015	925	148	1					153	8
	7/12/2015	85	na						100	
	8/30/2015	470	36							
	6/22/2016	110	36						20	
	6/24/2016	608	162	1					27	8
	7/7/2016	498	142	1					600	7
	8/19/2016	993	194					1	7	5
A46-A17 Total		**4268**	**919**	**4**				**1**	**918**	**36**
A47-A17	6/19/2016	500	348						1	
A47-A46	7/9/2015	136	17							1
	6/24/2016	77	13							
A47-A46 Total		**213**	**30**							**1**
A48-A47	7/6/2016	1403	147						6	
A49-A47	7/7/2016	290	59							
	8/20/2016	58	7							
A49-A47 Total		**348**	**66**							
A50-A17	6/28/2015	265	51						5	
	7/9/2015	1204	163	2	1				56	9
	8/30/2015	180	52	1				1	2	

Watercourse	Date	Electro-seconds	Distance (m)	Arctic Char	Lake Trout	*Salvelinus* sp.	Round Whitefish	Burbot	Ninespine Stickleback	Slimy Sculpin
	6/22/2016	208	37	1					20	
	6/24/2016	180	38						3	
	7/7/2016	1050	195	1					10	4
	8/19/2016	275	66							2
A50-A17 Total		**3362**	**602**	**5**	**1**			**1**	**96**	**15**
A53-A17	6/20/2015	1664	571						7	
	7/8/2015	2142	182	5					78	77
	8/30/2015	518	359		4					26
	6/18/2016	2565	563						4	4
	7/8/2016	2415	357	1					28	43
	8/26/2016	433	248	3					5	23
A53-A17 Total		**9337**	**2280**	**9**	**4**				**122**	**170**
A55-A17	6/21/2015	996	166						6	
	7/6/2015	3330	167	1		1			20	50
	8/30/2015	483	46				1		17	1
	6/19/2016	917	182	1					1	1
	6/26/2016	1482	159							8
	7/8/2016	676	141	1				1		31
	8/19/2016	758	22						59	7
A55-A17 Total		**8642**	**883**	**3**		**1**	**1**	**1**	**103**	**98**
A59-A17	6/27/2015	730	126	1						6
	7/9/2015	1444	97						2	21
	8/30/2015	535	181	1						7
	6/22/2016	766	126						4	6
	7/7/2016	1115	122			2				24
	8/20/2016	630	56	2					4	8
A59-A17 Total		**5220**	**708**	**4**		**2**			**10**	**72**

Watercourse	Date	Electro-seconds	Distance (m)	Arctic Char	Lake Trout	*Salvelinus* sp.	Round Whitefish	Burbot	Ninespine Stickleback	Slimy Sculpin
A62-A17	7/7/2015	1025	107						1	
	7/7/2016	707	129							
A62-A17 Total		**1732**	**236**						**1**	
A63-A18	7/5/2015	848	81							3
	7/7/2015	793	81							3
A63-A18 Total		**1641**	**162**							**6**
A-P23-A17	6/26/2015	582	95							2
Grand Total		**38702**	**6747**	**25**	**5**	**3**	**1**	**3**	**1260**	**403**

Table A 4. Maximum number of channels, mean total wetted width (sum of the width of all channels at a transect), and mean and maximum depth of small streams in the Whale Tail Study area.

Stream	Maximum number of channels	Mean total wetted width (m)	Mean depth (cm)	Maximum depth (cm)
A0-AP48	2	2.5	8	30
A47-A46	1	2.0	9	21
to A47	1	3.4	6	12
A50-A17	2	0.7	9	26
A53-A17	8	7.6	7	27
A55-A17	2	7.2	17	36
A59-A17	8	6.7	9	20
A62-A17	2	1.2	6	42
A63-A18	2	2.8	7	22
A46-A17	2	1.9	11	36

Appendix B

Habitat Areas and Habitat Units, by Habitat Type, for Preconstruction, Operations, and Post-closure Phases

Table B-1. Habitat areas (ha) and habitat units (HUs) for all habitats under baseline conditions and during operations phase.

Habitat Type	Habitat Area (ha)		Habitat Units (HUs)	
	Baseline	Operations	Baseline	Operations
1	8.39	13.65	2.01	3.27
2	11.27	2.90	3.17	0.81
3	175.40	201.11	69.43	79.61
4	33.11	14.08	12.42	5.28
5	25.09	13.51	14.64	7.88
6	53.63	101.24	40.78	76.98
7	157.88	145.73	59.21	54.65
8	37.97	43.71	19.77	22.77
9	4.90	26.79	3.32	18.14
10	0.00	0.00	0.00	0.00
11	9.38	3.18	2.83	0.96
12	0.70	0.39	0.12	0.07
13	0.19	0.18	0.06	0.06
Total	517.92	566.47	227.76	270.48
Change		**48.56**		**42.72**

Table B-2. Area of habitat that is lost, isolated in the north-east pond, unaltered, modified and created during the operations phase.

Changes to habitat	Area in hectares
Habitat lost during operations	
Lake habitat dewatered	
Nemo Lake filled and above water during operations	0.2
Whale Tail Lake dewatered or covered by dike and above water during operations	69.5
Mammoth Lake dewatered or covered by dike and above water during operations	1.2
Connecting channels dewatered	0.9
Small streams dewatered	0.03
Total habitat lost during operations	74.3
Habitat isolated in north-east pond during operations	
Existing lake and pond habitat	7.6
Existing stream habitat	<0.1
Total isolated in north-east pond (assumed not to be fish habitat, so effectively also a loss)	7.6
Habitat not altered during operations	
Mammoth Lake	150.5
Portion of connecting channel A23-A22	1.4
Portion of watercourse A53-A17	0.4
Total habitat not altered during operations	152.3
Existing Habitat modified during operations	
Existing Nemo Lake covered by freshwater jetty (that remains below water)	0.4
Existing Mammoth Lake covered by Mammoth dike (that remains below water)	0.0
Existing Whale Tail Lake (water level increased)	94.8
Existing Whale Tail Lake covered by Whale Tail dike (that remains below water)	0.4
Other existing lakes in expanded Whale Tail Lake (water levels increased)	177.8
Lake A45 water levels increased	2.9
Existing connecting channels converted to lake habitat	7.1
Existing streams converted to lake habitat	0.3
Total existing habitat modified during operations	283.8
Habitat created during operations	
Land flooded around expanded Whale Tail Lake	127.4
New channel alignment for stream A53-A17	0.2
Connecting channel constructed between expanded Whale Tail Lake and A45	1.8
Land flooded around Lake A45	1.6
Total habitat created during operations	130.9

Table B-3. Changes in habitat area and habitat units between baseline conditions and the operations phase for each lake/stream system.

Lake/Stream	Change from existing conditions to operations phase	
	Hectares	**Habitat Units**
Nemo Lake	-0.2	-0.02
Mammoth Lake	-1.2	-0.47
Whale Tail Lake	240.1	122.15
Other Lakes and Ponds	-183.6	-77.01
Connecting channels	-8.0	-2.41
Streams	-0.3	-0.06
Diversion Channel A17-A45	1.8	0.54
Net change	48.6	42.72

[1]Most become part of the expanded Whale Tail Lake

Table B-4. Areas of habitat that are lost, unaltered, modified or created during the post-closure phase with no offsetting.

Changes to habitat	Area in hectares
Habitat lost during post-closure phase	
Nemo Lake filled	0.2
Streams dewatered	none
Whale Tail Lake (covered by dike and water attenuation ramp and dry post-closure)	1.8
Mammoth Lake (covered by dike and dry post-closure)	none
Total habitat lost during post-closure phase	2.0
Habitat not altered during post-closure phase (includes areas reflooded)	
Mammoth Lake not modified	151.6
Whale Tail Lake habitat not modified	130.6
Connecting channel A17-A16 habitat not modified	0.3
Connecting channel A18-A17 – (a portion is altered in offsetting scenario so required for comparison)	1.3
Streams not altered - (but altered in offsetting scenario so required for comparison)	0.7
Total habitat not altered post-closure	284.5
Habitat modified during post-closure phase	
Existing Nemo Lake covered by freshwater jetty	0.4
Whale Tail Lake and connecting channel A16-A17 converted to pit or pit cap	30.9
Whale Tail Lake and connecting channel A16-A17 converted to roads	2.2
Whale Tail Lake converted to attenuation pond jetty	1.1
Whale Tail Lake converted to dike (portion that is below water)	1.2
Mammoth Lake - (covered by remains of dike, now lowered to become lake habitat)	0.1
Total habitat altered during post-closure phase	35.9
Habitat created during post-closure phase	
Whale Tail Lake habitat created post-closure (due to pit excavation)	27.4

Table B-5. Changes in habitat area and habitat units between baseline conditions and post-closure phase with no offsetting, for each lake/stream system.

Lake/Stream	Change from existing conditions to post-closure phase with no offsetting	
	Hectares	**Habitat Units**
Nemo Lake	-0.2	0.02
Mammoth Lake	0.0	0.00
Whale Tail Lake	26.2	-14.23
Connecting channel A17-A16[1]	-0.6	-0.20
Other connecting channels	0.0	0.00
Streams	0.0	0.00
Total	25.3	-14.45

1. Becomes part of the expanded Whale Tail Lake (South Basin)

Table B-6. Change in post-closure habitat areas and habitat units, relative to baseline, that will result from the proposed offsetting features, for each lake/stream system.

Lake/Stream	Changes resulting from a 1 m increase in the water level upstream from the Whale Tail Lake to Mammoth Lake sill, scarification of roads and construction of 8.77 ha rock shoals, compared to baseline conditions	
	Hectares	**Habitat Units**
Nemo Lake	-0.2	-0.02
Mammoth Lake[1]	-1.2	-0.47
Whale Tail Lake	50.0	1.67
Connecting channel A17-A16[1]	-0.9	-0.27
Connecting channel A18-A17[1]	-1.0	-0.31
Streams	<-0.1	-0.01
Total	46.6	0.58

1. Becomes part of the expanded Whale Tail Lake (South Basin)

APPENDIX C – COMPLEMENTARY MEASURES

SECTION 1 • INTRODUCTION

As suggested by DFO in 2017, a portion of fish habitat offsetting for Whale Tail Pit may be comprised of complementary measures in the form of fisheries-related research. Research projects will be aimed at closing knowledge gaps regarding the biology and habitat requirements of northern fish species, developing tools and validating methods to facilitate and advance ongoing monitoring, and/or characterizing responses of fish-bearing aquatic systems to direct anthropogenic manipulations.

The following research projects are proposed as complementary measures to offset fish habitat losses associated with the Whale Tail Pit project. Conceptual design of each project has been discussed with DFO over the past year. Details of projects that will occur in the nearer term have been established with interested academic partners but may evolve over the life of the project based on initial field experiences. This program will continue to be developed and coordinated by Agnico, in collaboration with academic partners, and reporting to the Meadowbank Fisheries Research Advisory Group (MFRAG; see Section 2.6).

While these projects are proposed as complementary measures, and Agnico will work towards achieving their criteria for success as identified in the Fish Habitat Offset Monitoring Plan (March, 2018), it should be recognized that total funding for complementary measures is detailed in the calculated Letter of Credit (LOC) held by DFO, and described in the Cost Estimate for Whale Tail Offsetting (March, 2018). Depending on the final chosen suite of research projects and their scope, additional studies or objectives may be feasible. Ultimately, projects will be chosen and their direction confirmed or updated annually based on interests of stakeholders including KIA, academic partners, Hunting and Trapping Organizations (HTO) and DFO, through the Meadowbank Fisheries Research Advisory Group (see Section 2.6).

Where appropriate, research projects are designed to work in tandem with existing monitoring programs such as the Core Receiving Environment Monitoring Program (CREMP) and monitoring for habitat enhancement/creation offsetting features. However, research studies are planned to collect supplementary data over and above regular monitoring programs, and to assess scientifically-driven hypotheses, independent of compliance monitoring.

A common goal will be to publish results in peer-reviewed literature to provide a tangible benefit for future assessments of northern fish populations. Outside of deliverables related to scientific publications, Agnico will emphasize and facilitate local community input and capacity building as a component of each study.

SECTION 2 • COMPLEMENTARY MEASURES

Four general topics are proposed as research study directions for Whale Tail Pit complementary measures, with one or more specific associated research projects. Topics include:

1. Assessment of changes in aquatic productivity and fish populations due to flooding of Whale Tail South and downstream lakes during operations

2. Assessment of impacts of the Baker Lake wastewater outflow on aquatic systems including fish and fish habitat

3. Characterization of northern fish species' habitat preferences

    - Literature review and field validation of northern lake fish habitat preferences
    - Arctic grayling occupancy modeling
    - Pit lake habitat use assessment

4. eDNA methods development

The objectives and methods of the associated research studies as planned at this time are described in detail below. Information on approximate total budgets and estimated levels of Agnico support for each project are described in Section 2.5, and role of the MFRAG is described in Section 2.6.

2.1 CHANGES IN AQUATIC PRODUCTIVITY

2.1.1 Introduction

Flooding of the Whale Tail South Basin and upstream lakes during operations will result in a release of nutrients from terrestrial sources into the aquatic system. Although a change in trophic status was also predicted in the EIS in relation to effluent discharge into Mammoth Lake, mitigative options are now being investigated to minimize those impacts, so research projects will focus on the flooded zone south of the Whale Tail dike.

Currently, relatively little information is available in the open literature to support development of productivity models for Arctic lakes. Not only is this information integral to environmental impact assessment, but understanding drivers of productivity will help inform future directions of HEP methods.

The following objectives and methods have been developed in consultation with the proposed lead researcher, Dr. Heidi Swanson (University of Waterloo).

2.1.2 Objectives

Specifically, this research study will aim to understand changes in fish population productivity and habitat use during and after flooding occurs, as determined through relative abundance and/or biomass and condition factor within the resident fish population.

Since flooding activities are planned to occur over a relatively short term (2-3 years), the study will specifically include a focus on small-bodied fish, which are expected to react first to changes in nutrient profiles. Nevertheless, methods will also include hydroacoustic surveys that can assess changes at the community level, and a substantial body of information for condition factor and abundance of large-bodied fish will be collected during the fishout of Whale Tail Lake – North Basin. If elevated water levels are maintained in Whale Tail Lake over a longer term (as

proposed as a contingency offsetting measure), post-impact assessments could be carried out using that data.

Changes in productivity will be related to water quality variables and changes in lake morphometry (especially area). Use of newly flooded habitats will be assessed and related to habitat characteristics.

2.1.3 Methods

The following specific methods related to surveillance and analysis of fish populations are planned to be included as part of this study:

- Hydroacoustics surveys, both before and after flooding. Key variable investigated: kg fish/hectare

- Minnow trap/fyke net surveys, both before and after flooding. Key variable investigated: catch per unit effort

- Presence-only surveys, after flooding. Key variable investigated: fish presence in newly-flooded habitats, and relationships with habitat covariates.

- Collection of small-bodied fishes for trophic ecology and growth parameters, both before and after flooding. Key variables investigated: sources of carbon (pelagic or benthic, trophic position, growth rates).

Assessments of changes in fish populations will take into account relationships with the following water quality parameters, some of which are planned to be collected through compliance monitoring programs, and some of which are supplementary:

- Quantity and quality of dissolved organic carbon

- Total and dissolved concentrations of nitrogen

- Total and dissolved concentrations of phosphorus

- TSS

- Chlorophyll-a

- Major anions and cations

- Stable isotope ratios on dissolved inorganic carbon

2.1.4 Timeline

This study is planned to begin in Summer 2018 due to tight timelines related to dike construction and flooding of Whale Tail – South Basin. Based on current mine plans and offsetting measures, this study will occur over a 3 – 4 year time period.

See Section 2.5 for a summary of proposed timelines for each project.

2.1.5 Project Deliverables

As described in the Fish Habitat Offset Monitoring Plan (March, 2018), criteria for success (deliverables) of all research projects are centred around publication of one or more manuscripts per study in a peer-reviewed journal, such that research outcomes would be broadly available to the scientific community. However it is recognized that not all factors affecting outcomes of research projects and suitability of studies for such publication are within the control of Agnico, academic partners, or DFO. As a result, in certain instances, peer-reviewed publication may not be a viable route for dissemination of knowledge gained through these projects. In such cases, Agnico suggests discussions be undertaken between researchers, DFO, and Agnico to determine a mutually agreeable solution (e.g. conference presentations, inter-agency workshops).

Specifically, this study will improve scientific understanding of relationships between productivity of northern fish communities and nutrient inputs derived from natural sources. This information will be valuable for consideration by proponents and regulatory agencies during future assessments of impacts in aquatic systems due to flooding.

2.2 BAKER LAKE WASTEWATER ASSESSMENT

2.2.1 Introduction

Currently, wastewater from the hamlet of Baker Lake is released through a series of tundra ponds into Baker Lake, ultimately affecting fish and fish habitat. Since 2012, Agnico has maintained an interest in characterizing these impacts, and working with the hamlet to ameliorate their wastewater treatment, with significant support from the community. In the fall of 2017, Agnico presented the conceptual research project and potential associated wastewater upgrades to the Hamlet Council, and again received strong support. It was noted by an elder during consultation (Agnico Eagle, 2016)that Airplane Lake, which receives run-off from the wastewater lagoon and landfill was once used by locals for fishing and recreation, but is no longer fished due to concerns of contamination.

Having identified this project as a potential complementary measure for the Whale Tail Pit project, Agnico has begun working with a research team including Dr. Rob Jamieson (Dalhousie University), Drs. Mark Hanson and Charles Wong (University of Manitoba), and Drs. Brendan McConkey and Heidi Swanson (University of Waterloo) to tailor an appropriate research program.

Since this research will directly assess changes in the aquatic system related to fish and fish habitat, and will provide significant value to the local community, Agnico is proposing to partially fund this study as a complementary measure for Whale Tail Pit offsetting. Additional funding will be sought through application for an NSERC CRD, with Agnico acting as industrial partner.

The following objectives and methods have been developed by the research team indicated above.

2.2.2 Objectives

1. Validate passive wastewater treatment system design guidelines for Arctic regions

2. Develop and incorporate human health risk assessment into Arctic wastewater system design and planning process

3. Characterize microbial community structure in Arctic wastewater treatment systems and receiving waters and assess ARG transfer mechanisms

4. Characterize trace metal sources, transport pathways and environmental risks in Arctic wastewater systems

5. Quantify improvements in fish habitat and health associated with Arctic wastewater treatment system upgrades

2.2.3 Methods

Preliminary methods developed by the research team to address these objectives are described below.

1: The hydraulic performance and treatment kinetics of the current wastewater treatment system will be characterized during the 2018 treatment season. Initial field work would be conducted during the spring melt period. The current wetland treatment area would be instrumented with water level loggers to quantify flow rates at several points throughout the system (upstream of Lagoon Lake, outlet of Lagoon Lake, outlet of Finger Lake, inlet to Airplane Lake). Stage-discharge relationships would be developed for each location to relate water level to discharge rate. A rhodamine dye tracer study would also be conducted to characterize the hydraulic retention time and mixing behavior of the current treatment system. The ability of the current treatment system to meet effluent quality criteria for regulated parameters (CBOD5, TSS, etc) would be evaluated. A mass balance modeling approach would be used to derive treatment rate constants for the wetland, and the level of dilution occurring in the system. A similar assessment would be conducted in August to characterize the performance of the current system during the non-melt period.

2: A spatial analysis would be conducted to identify 2-4 alternative locations for a new passive wastewater treatment systems. For each site a conceptual design for a pond-wetland based treatment system would be developed and effluent quality would be predicted for each alternative site using performance models previously developed by our research group. The relative human health risks associated with each option would also be evaluated using quantitative microbial risk assessment (QMRA) approaches. A variety of participatory research approaches would be employed to engage the community and better understand concerns and risks associated with potential options for wastewater management, and to identify an appropriate location for the treatment facility.

3: Once the new facility is constructed and operational the hydraulic behavior and treatment performance would be evaluated using methods previously described in 1. This data would be used to validate the performance model predictions and treatment rate kinetics. Autonomous

water quality sensors would also be installed in both the pond and wetland to continuously measure oxygen status, temperature and pH throughout the treatment season.

3: We hypothesize that otoliths provide a history of trace element exposure in fish via water and food pathways that can be used in ecological risk assessment. To test this hypothesis, we will sample for select trace elements in the proposed compartments along the wastewater release pathway (with a focus on Airplane and Baker Lake, plus reference sites), as well as reconstruct the trace element history through sediment coring. The exposures will be evaluated relative to water quality guidelines and hopefully partitioned by source (e.g., background vs landfill vs wastewater). We predict that the new treatment system will reduce trace element release, and that this will be associated with a decline in otolith concentrations. To this end, fish will be sampled pre- and post- construction and otoliths analyzed via laser-ablation ICP-MS.

4: Pathways of contaminant movement tend to focus on large-scale drivers in the Canadian Arctic. We hypothesize that aquatic insects represent a possible vector of metals and ARGs to pristine ecosystems not physically connected to wastewater flows. Emergent insects from the wastewater pathway and reference locations will be captured over the course of the off-ice season, identified, and their metals and ARGs quantified.

5: Standard toxicity bioassays have been developed for many cosmopolitan species, but rarely do their ranges include the Arctic. This element will seek to develop and validate a laboratory-based plant bioassay to screen for contaminants in water and sediments. The test will have two aspects that a user could select; a seedling germination phase and a full plant phase. The data can be then used to screen for the impacts of effluent release, design of treatment wetlands, as well as remediation and restoration efforts at contaminated sites.

6: Shifts in microbial community composition is one of the more rapid biological changes that may occur in response to changing environmental conditions. Microbial communities will be assessed both by 16S and rRNA gene analyses, providing a broad assessment of microbial populations. The researchers' current Polar Knowledge grant (C.Wong, PI) will collect data during and after the 2018 spring melt, and this data will be used to help establish a baseline for microbial community composition for sites near the Baker Lake wastewater treatment system, providing data for reference and potentially impacted sites. This work would be extended to a 'before and after' analysis linked to implementation of a new wastewater treatment system.

7: Antibiotic resistance genes (ARGs) are a type of environmental pollutant, and are associated with the spread of pathogenic drug resistance. ARGs are naturally occurring in the environment, but may increase in abundance through selection by antibiotics. ARGs may also be introduced to new environments through human activities and specifically though wastewaters. We will determine the presence and abundance of known ARGs at near-site and reference lakes and determine if there is a correlation with wastewater and wastewater treatment.

8: The microbial populations that are active in northern climates can differ significantly from populations in temperate climates. Based partly on the data from 6 and 7 we will target selected microorganisms for further characterization, to understand their role in nitrification, denitrification, and antibiotic resistance. A large majority of cold-climate bacteria remain uncultured and we will target these to provide insights into metabolic pathways and gene

function. By characterizing the composition and functions of northern wastewater microbial communities, molecular analyses will provide baseline data for optimizing such processes, and evaluate potential risks from antibiotic resistance proliferation.

9: Arctic fishes are often energy-limited, and freshwater Arctic ecosystems can be quite sensitive to nutrient inputs. We hypothesize that fishes living in Airplane Lake will have relatively higher lipid content, growth rates, and condition than fishes living in Baker Lake (prior to the treatment upgrade). Indicators of exposure to contaminants, including GSI and LSI, will also be higher in Airplane Lake than in Baker Lake prior to treatment upgrade. We predict that the new treatment system will result in a decline in indicators of contaminant exposure in fishes in Airplane Lake. Fish growth rates and condition many also decline as nutrient inputs decrease.

2.2.4 Timeline

Initial field work is planned to commence in summer 2018, following further community consultations this spring. Field studies will continue over a five-year duration, including a pre- and post-construction monitoring period. Construction of a new water treatment facility is tentatively planned for 2020.

2.2.5 Project Deliverables

As a large scale, multi-faceted research study, a suite of publications is expected as an outcome of this project. Specifically, these will include guidelines for passive wastewater treatment system design in Arctic regions, assessments of microbial system functions, ARGs and trace metal sources, transport pathways and environmental risks associated with Arctic wastewater systems, development of a toxicity assay for Arctic macrophytes, and analysis of changes in resident fish at organism and population scales in response to upgrades in water treatment technologies. Ultimately, observed responses of fish communities can be related to changes in water chemistry and lower trophic levels, which are significant components of fish habitat quality.

Along with written publications, researchers will present their studies at scientific meetings, providing experience and developing skills of graduate students.

Outside of the traditional scientific arena, this project has received strong community support in its early stages, and Agnico is fully engaging their Community Relations department to assist researchers in developing a program for consultations and capacity building within the Baker Lake community in regards to this project.

Though costs are not included as a complementary measure, this work will facilitate construction of an optimal wastewater treatment system for the community, which is a clear tangible benefit.

2.3 CHARACTERIZATION OF FISH HABITAT PREFERENCES

In recent years, HEP models for northern species have commonly been based on HSIs developed from Richardson et al. 2001, which itself identified a significant data gap surrounding habitat preferences of these fishes. In order to develop this body of available information and

help reduce uncertainty in future habitat assessments, Agnico will help to facilitate one or more research studies on habitat preferences of fish common to the Meadowbank area. Currently, three projects related to fish habitat preferences are proposed.

2.3.1 Lake Fish Habitat Preferences

2.3.1.1 Introduction

In order to work towards updating HSIs for northern lake fish species, Agnico is proposing to collaborate with a team of researchers from various academic institutions and DFO, to support a literature review and field assessment of northern fish species' habitat associations.

The research team would be lead by Dr. Susan Doka (DFO Central and Arctic Region), and would include Tom Hoggarth, Liz Patreau, Bev Ross and Martyn Curtis (DFO Fisheries Protection Program and Ecosystem Management), Drs. Mike Rennie & Nandakumar Kanavillil (Lakehead University), Dr. Ken Minns (DFO Science Emeritus & University of Toronto), Drs. Neil Mochnacz, Paul Blanchfield (DFO Science), as well as graduate students to be determined.

Initially, Agnico is proposing to provide in-kind support for travel and accommodations of field crews on their Meadowbank site for this project, but this involvement could be extended depending on evolution of the study and interests of the MFRAG. More details on initial proposed budgets and levels of support for each project are provided in Section 2.5.

The objectives and methods below were provided by Dr. Doka.

2.3.1.2 Objectives

1. To systematically review the literature and compile unpublished information on northern fish species and their habitat associations and environmental tolerances since the last compilation of data was generated for lakes (Richardson et al 2001). Rivers (last reviewed in Evans et al 2001) may be addressed at a later date. This compilation may include the fish-out database held by DFO Science Winnipeg (Hedges, unpub data).

2. To outline data gaps in our knowledge of northern species and their life-cycle habitat needs and environmental tolerances that would be related to impacts from mining and offset creation or improvements.

3. To sample northern fish communities of several lakes in Nunavut in natural, impacted and offset areas to compare to the literature and data findings above and fill data gaps locally required for an evidence-based approach to calibrating, validating and standardizing evaluation methods for habitat loss and offsets for major projects in the area.

4. To scope the area for a future telemetry project to address a known gap, namely overwintering habitat usage.

2.3.1.3 Methods

Literature review: Following closely the Centre of Environmental Evidence guidelines for systematic literature review, a graduate student with Lakehead University under the co-

supervision of Dr. Mike Rennie and Dr. Susan Doka will review primary and grey literature sources as well as canvas for unpublished data (e.g. Golder & Associates 2016) on up to 40 northern species with current fish distributions in lakes of Nunavut and the Northwest Territories.

Meta-analysis and gap analysis: The data extracted from the review will be analyzed using appropriate statistical methods to synthesize the information by life stage (4 stages: spawning, nursery, juvenile and adult habitats) for 40 northern fish species with ranges in Nunavut and the Northwest Territories. Habitat variables of interest include: substrate associations, thermal tolerances and preferends, timing windows, depth associations at different seasons, turbidity tolerances, species-species associations, flows and lake order, cover associations, pH and dissolved oxygen tolerances. Data and information from northern areas will be compared with new and existing information from more southern locales in North America.

Field Sampling: Working with Agnico Eagle Mines – Meadowbank Division to coordinate existing scientific work and travel, the graduate student and DFO support staff will work with consultants to sample up to 6 lakes. Lakes may include Baker Lake (an intended impact site), a proposed offset area, and 4 natural lakes in the vicinity. If possible another impacted lake will be sampled if technically feasible for travel. Techniques used to sample fish distributions will include acoustics (likely BioSonics DTX), trap nets or minnow traps and gill nets, and will link to ongoing e-DNA results (from a separate study) if available. Habitat sampling methods will include bottom acoustics (BioSonics), sediment grabs, longterm logger deployments and multiprobe sonde surveys. We will focus on gap filling if information is already available from the proponent or DFO for certain lakes.

2.3.1.4 Timeline

Initial field assessments will commence in summer 2018, and as currently proposed the study will be conducted over a two- to three-year duration (2018 – 2020).

2.3.1.5 Project Deliverables

The following project deliverables were provided by Dr. Doka.

CSAS or technical document on northern fish species and their habitat associations at northern latitudes to complement Richardson et al 2001.

Also to be included in the above document or separate paper(s):

- Statistical or meta-analysis of data to guide offsetting and restoration in the north as well as updates to tools like HEAT (CSAS SAR 2017, Abdel-Fattah et al 2017a,b and Abdel-Fattah et al 2018, Minns et al 1999).

- Data and knowledge-gap identification to be addressed by future research.

2.3.2 Arctic Grayling Occupancy Modeling

2.3.2.1 Introduction

As a complementary measure for the Whale Tail Pit project offsetting, Agnico is proposing to work with Dr. Heidi Swanson (University of Waterloo) to validate Arctic grayling occupancy

models for use in the Kivalliq region, in follow-up to work she has previously conducted in the Northwest Territories[1]. The following background information on occupancy models was provided by Dr. Swanson.

2.3.2.2 Background

Evaluating the effectiveness of habitat offsetting measures requires robust and accurate data on fish populations both before and after enhancements have taken place. Obtaining these data in northern, remote environments is difficult and expensive. As a result, there is often a great deal of uncertainty around the findings.

All methods of fisheries monitoring have advantages and disadvantages, but obtaining robust and reliable data on fish abundance from standard techniques (such as three-pass depletion surveys) is especially problematic in the Arctic, where studies are expensive, logistics (and thus, often timing of surveys) are constantly changing, and backpack or big boat electrofishing (standard in many abundance three-pass depletion surveys) requires trained and certified operators and specialized equipment (which has to be shipped up from the south). In addition, to meet the required intensity of sampling required for abundance estimates, the spatial scale of abundance surveys is often small.

Occupancy surveys and occupancy models are a relatively new (~15 years) method of monitoring technique for animals. Instead of focusing on the number of animals, occupancy models focus on presence/absence. For each study, the spatial scale is carefully considered and adapted to reflect how far fish are expected to move, the scale at which habitats might be being selected, and the presence of any disturbance (or enhancement). Presence/absence of fish is then related to habitat characteristics, such as water depth, velocity, bank type, substrate, etc. When stakeholders need information about abundance, the models can give broad information about 'high,' 'medium,' and 'low' "states" of occupancy if the study and sampling are set up to achieve this. Also, unlike any other model, occupancy studies also consider the probability of detection – that is, if no fish were captured or observed, what was the chance that the fish were there, but weren't found? The probability of detection can then be related to habitat variables. For example, we might be less likely to find fish in a stretch of stream with large boulders – not because there are less fish, but simply because they are more difficult to catch. Probability of detection can also be related to factors that affect catchability such as the experience of the sampler, the substrate, and the weather. When we explicitly take into account how our ability to catch fish is affected by external factors, we are much better able to model the types of habitats that fish are using.

2.3.2.3 Objectives

Objectives of this work will be the development of occupancy models for Arctic grayling in the Meadowbank region, and a comparison of model fit and Arctic grayling habitat predictors in this area with those observed in the NWT.

2.3.2.4 Methods

[1] Baker, L.F., Artym, K.J., Swanson, H.K., 2017. Optimal sampling methods for modelling the occupancy of Arctic grayling (*Thymallus arcticus*) in the Canadian Barrenlands. Canadian Journal of Fisheries and Aquatic Sciences 74, 1564-1574.

Methods will involve characterizing occupancy of Arctic grayling in relation to habitat characteristics. Specifically this occurs through presence-absence surveys (visual, electrofishing) and assessment of habitat characteristics (stream width, depth, velocity, vegetation cover, bank formation, distance to overwintering habitat) for 30-m stream segments (number of replicates to be determined through initial field surveys). Study sites will include anthropogenically-impacted as well as reference systems in the Meadowbank and Baker Lake area.

As a component of previous No Net Loss Plans, Agnico has constructed habitat enhancement features for Arctic grayling spawning, and has been monitoring the success of these features over a number of years. In addition, Arctic grayling habitat may be impacted by wastewater treatment upgrades in the hamlet of Baker Lake, where changes in nutrient regimes and contaminants could affect use of this system by fish. Both of these habitat manipulations provide interesting opportunities to evaluate the use of occupancy models for the Kivalliq region, in comparison to reference systems.

2.3.2.5 Timeline

Initial reconnaissance and habitat characterizations for this study will begin in 2018, and the project is expected to be complete within three years.

2.3.2.6 Project Deliverables

The development and publication of occupancy models for this region will assist proponents and regulators in future assessments of potential new project impacts and design of offsetting measures for Arctic grayling habitat.

2.3.3 Pit Lake Habitat Assessments

2.3.3.1 Introduction

In recent years, significant uncertainty has arisen regarding the capability of pit lakes to act as fish habitat. While DFO previously accepted reflooded pit areas as habitat in offsetting plans, these areas are no longer considered habitat regardless of connectivity or modeled water quality. As a result, data regarding fish use in pit areas will no longer be regularly documented through standard monitoring programs. However, since multiple pits of various sizes at the Meadowbank site are planned to be reflooded in the relatively near term (2025 – 2029), there is an opportunity to thoroughly characterize fish use of pit lake habitat and population growth in re-flooded lakes through a research program.

Currently, monitoring for general fish presence using underwater camera or angling in lake basin areas adjacent to pits forms a component of Agnico's existing Habitat Compensation Monitoring Plan for the Vault pit. However, the proposed research program could intensify methods to document habitat preferences throughout the re-flooded basin and pit area through techniques such as telemetry and sonar, and further compare movements to reference lakes. This assessment could also be expanded to other pit areas (e.g. Phaser pit, Whale Tail Pit) which are not considered as fish habitat in offsetting plans and thus not planned to be monitored for fish use under compliance programs.

Due to the extended timeframe for this project compared to others (field work 2025+), specific researchers and methods have not been identified at this point. However, following approval of the study topic by DFO as a complementary measure, steps could begin to be taken towards preliminary project objectives to be completed in the years prior to commencement of field work, such as initial literature reviews and methods development.

2.3.3.2 Objectives

Characterize fish use of new pit lake habitat in relation to habitat and water quality variables, and particularly in relation to reference systems.

2.3.3.3 Methods

To be determined in consultation with the identified research team. Likely to include literature review and field assessment in multiple flooded pit areas at the Meadowbank site. Potential to collaborate across sites with other interested industry partners.

2.3.3.4 Timeline

Flooding of pits at the Meadowbank site is currently planned to be complete in between 2027 - 2029 (Phaser, Vault, and Whale Tail Pits), after which time field studies could begin. Initial literature reviews and methods development could occur in the years prior to pit reflooding, or Agnico could collaborate with other industry partners if appropriate sites are available in other locations in the nearer term.

2.3.3.5 Project Deliverables

Since significant uncertainty exists in the literature and between fisheries biologists regarding potential for fish use of habitat in flooded pit lakes, this research would help to provide a better foundation for assessing long-term impacts of development projects in the north on local fish populations.

2.4 EDNA METHODS DEVELOPMENT

2.4.1 Introduction

eDNA methods present a potentially useful tool for rapid and non-invasive assessments of fish communities, but have not been significantly developed or validated for Arctic systems. With their relatively low biodiversity and frequently isolated populations, Arctic lakes present a compelling location for eDNA research.

Since assessments of fish communities are conducted frequently for monitoring, fishout, or research purposes across the Meadowbank site, there are regular opportunities to pair eDNA analyses with data from traditional surveys, or to develop stand-alone research studies. Agnico is very interested in developing tools for estimating fish abundance and biomass, as well as furthering field tests for determining species presence/absence.

As a complementary measure for the Whale Tail Pit project, Agnico is proposing to provide partial support for the University of Manitoba COGRAD group’s project on development and optimization of non-invasive monitoring tools based on DNA metabarcoding technology to measure fish species assemblage in Canada’s Eastern Arctic Kivalliq Region of Nunavut. This

project is currently being supported in part by the KIA, and in 2017 Agnico provided transit and accommodation onsite for two researchers to conduct an initial field reconnaissance and sample collection. The background, preliminary objectives, methods, and deliverables of this project as provided by the COGRAD research group are described below.

2.4.2 Background

It is necessary to efficiently monitor water quality and assess fish species distributions in aquatic ecosystem for their effective management and conservation. Traditional monitoring techniques which rely on physical identification of species remain problematic due to non-standardized sampling methods, cost, labour intensity, and their invasive nature. Traditional methods become even more difficult in remote Arctic areas. Hence, there is an urgent need for alternative, efficient and customized techniques for large-scale monitoring of fish populations.

Recently, the environmental DNA (eDNA) method for the direct detection of specific DNA from water has been recognized as a powerful tool for monitoring aquatic species. eDNA– defined as: genetic material obtained directly from environmental samples without any obvious signs of biological source material – is an efficient, non-invasive and easy-to-standardize sampling approach. Coupled with sensitive, cost/field time-efficient and ever-advancing DNA sequencing technology, it may be an appropriate candidate for the challenge of biodiversity monitoring in remote Arctic areas.

2.4.3 Objectives

The main goal of this project is to develop and optimize monitoring tools based on eDNA metabarcoding technology to assess fish species assemblages in in Canada's Eastern Arctic Kivalliq Region of Nunavut and population changes near the Amaruq mine site.

Objectives are:

1. Development and optimization of the eDNA metabarcoding technique adapted for arctic and mining environment aiming the Amaruq site and utilizing the method as a substitute for current fish species determination approaches.

2. Producing guidelines for handling and analyzing of samples and deliver the method and provide training to the local community.

3. Produce long-term reliable and precise baseline data on the distribution of aquatic associated fish species in the Amaruq mine site lakes using developed eDNA technology.

4. Producing data on the physiochemical properties of the lake water including dissolved mineral content to understand if any changes in stated parameters affect the eDNA/fish assemblage results.

5. Examine the impact of flooding Whale Tail Lake South Basin with the coincident changes in physiochemical properties of the aquatic area (e.g., increase in turbidity, dissolved solids) on the fish population using developed eDNA technique.

6. Collecting baseline eDNA and water quality data on lakes nearby Amaruq mine site outside the mining activity (potential candidates include B3 or DS1) and use them as a control for population changes.

2.4.4 Methods

We are proposing a 5-year plan that would involve development and utilizing eDNA metabarcoding approach in order to measure fish assemblage in the Amaruq areas. Environmental DNA metabarcoding technology will be developed and optimize to detect fish species including Arctic Char, Arctic Grayling, Lake Trout, Cisco, Round Whitefish, Burbot, Slimy Sculpin, Ninespine Stickleback, Hybridized Lake Trout/Arctic Char and analyze their relative abundances. For water quality data, temperature, pressure, dissolve oxygen, pH, salinity, conductivity, and dissolved metals including Cu/ Zn/ Cd/Fe/Hg/Mn will be measured (some metrics may be obtained through regular compliance monitoring programs).

Water samples for all parameters will be collected through three sampling period in each year; at melt, midsummer, and immediately prior to freeze up. First round of sampling was done before mining activity starts (July 2017). The second round of sampling will be done at the start and during mining operation and the final round of sampling will be done after mining operations have ceased. The result will be used to assess the influence of mining activity on changes in fish species populations, as measured through eDNA methods.

2.4.5 Timeline

This project is currently proposed to occur over an additional three year field study period (2017 – 2020), and a five-year total time frame.

2.4.6 Project Deliverables

Once optimized for mining restoration, eDNA metabarcoding could allow industry specialists to identify indicators of successful restoration and evaluate restoration with greater frequency and spatial resolution. In addition, biological recovery may be tracked over multiple mining sites to determine if there is a predictable trajectory. This opens up the possibility of effective adaptive management, informing researchers and industry specialists when intervention may be necessary to achieve restoration goals.

Education and training of the local community on collection, storage, shipment of samples to the U of M is a priority, and will be provided by members of the U of M. COGRAD commits to support, involve, or engage Indigenous organizations in this project. We intend to install a rigorous Field Sampling Protocol and to train and educate local people to assist in the project. In addition, we will establish a team at the U of M composed of fish experts (Department of Biological Science) in conjunction with Analytical Chemists (MCAL) and experts in remote sensing.

2.5 LEVEL OF SUPPORT, STUDY TIMELINES, AND DURATION

For each proposed project, the level of support provided by Agnico may differ. Based on initial consultation with each researcher and the funding available as determined by the cost estimate provided to DFO (March, 2018), the estimated value of Agnico's contributions for each study are shown in **Table *1***.

Table 1. Estimated value of direct monetary and in-kind support to be provided by Agnico Eagle for each complementary measure (research project) proposed as fish habitat offsetting for Whale Tail Pit[2].

Project	Researcher[3]	Type of Support	Study Start Date	Study Duration	Estimated Contribution (rounded) [4]
Changes in Aquatic Productivity	Dr. Heidi Swanson, University of Waterloo	Full funding	Summer 2018	3-4 years	$100,000
Baker Lake Wastewater Assessment	Dr. Rob Jamieson, Dalhousie University (et al.)	Partial funding – industrial partner in NSERC CRD (application to be submitted)	Summer 2018	5 years	$630,000
Lake Fish Habitat Preferences	Dr. Susan Doka, DFO Science (et al.)	Mainly in-kind support	Summer 2018	2 years	$50,000
Arctic Grayling Occupancy Modelling	Dr. Heidi Swanson, University of Waterloo	Full funding	Summer 2018	3 years	$150,000
Pit Lake Habitat Assessment	TBD	TBD	TBD	5 years	$450,000
eDNA Methods Development	University of Manitoba COGRAD group	Partial funding	Summer 2018/2019	3-5 years	$240,000
TOTAL Contributions (as calculated through LOC)					$1,618,046.22

2.6 MFRAG, PLAN REVIEW AND UPDATES

A Meadowbank Fisheries Research Advisory Group (MFRAG) will be established to review and approve any changes to research projects proposed under the Fish Habitat Offsetting Plan for Whale Tail Pit. This group will include DFO, Agnico Eagle, KIA, HTO and a third party research advisor. The MFRAG will meet annually to review project progress reports, propose and approve or reject new projects or project components, and assess whether criteria for success have been met.

[2] The contributions are based on the most current available information and may be subject to change. The total Agnico Eagle contribution will be prescribed by DFO, in accordance with agreed upon LOC calculations

[3] Partnerships with KIA, Baker Lake hamlet and DFO are established for respective projects.

[4] Funding is an estimate. Agnico Eagle expects funding to be leveraged by researchers and their respective institutions through additional grant applications. As a result, based on previous experience, it is possible that total project expenditures could double, benefiting the researchers and research projects.

This plan describing complementary measures for Whale Tail Pit fish habitat offsetting will be updated annually to reflect changes and progress in research projects and to track project funding to date.

Greenhouse Gas Reduction Plan, Version 1



AGNICO EAGLE

Meadowbank Division

Whale Tail Pit – Greenhouse Gas Reduction Plan

MAY 2018
VERSION 1

EXECUTIVE SUMMARY

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is proposing to develop the Whale Tail Pit and Haul Road Project (Project), a satellite deposit located on the Amaruq property, to continue mine operations and milling at the Meadowbank Mine. The proposed Whale Tail open pit will be mined by truck-and-shovel operation.

The impacts of climate change have the potential to affect a wide range of environmental, social and economic systems of value to Inuit, as indicated by the observations and changes experienced by Baker Lake traditional land users. Climate change is a global issue caused by emissions of greenhouse gases (GHG).

This document presents the Greenhouse Gas Reduction Plan as per Nunavut Impact Review Board (NIRB) Project Certificate No.008, Condition 3. It discusses predicted emissions for the Project (including Whale Tail Project and Meadowbank), sources of GHG, as well as monitoring measures and energy reduction initiatives.

Development of the Whale Tail Pit and emissions from traffic along the haul road to Meadowbank Mine are predicted to result in a 14.8% increase in GHG emissions for Nunavut. By adding the Meadowbank mill and camp activities, the emissions for the Project are predicted to result in a 56% increase in GHG emissions for Nunavut. When compared to Canada's national emissions (714,000 kt CO2e/yr), the Project contributes to a less than 0.04% increase in national GHG emissions (Agnico Eagle, 2016). Four (4) main sources of GHG emissions have been identified for the Project; off-road vehicle exhaust, on-road vehicle exhaust, power plant and camp heater.

Emissions of GHG for the Whale Tail Pit Project and Meadowbank Mine will be calculated on a monthly basis and reported annually through Environment Canada's Greenhouse Gas Emissions Reporting Program (GHGRP) and NIRB Annual Report. This report will also include a discussion on the monthly variations of GHG emissions, as well as a comparison with FEIS emission predictions.

A number of initiatives are planned to reduce project-related GHG emissions over the Project lifecycle. Some strategies have already been implemented while others are currently being assessed.

DOCUMENT CONTROL

Version	Date (YM)	Section	Page	Revision
1	May 2018	ALL	-	Comprehensive plan for the Whale Tail Pit Project.

TABLE OF CONTENTS

Executive Summary ..... **i**

Table of Contents ..... **iii**

Acronyms ..... **v**

Units ..... **v**

Section 1 • INTRODUCTION **1**

Section 2 • PROJECT BASELINE EMISSIONS **5**

2.1 Project Baseline Emissions Predictions 5

2.2 Main Sources of Greenhouse Gas for the Project 6

Section 3 • DESCRIPTION OF MONITORING MEASURES **7**

3.1 Greenhouse Gas Emission Monitoring 7

3.2 Data Analysis and Reporting 7

Section 4 • Reduction Initiatives **8**

4.1 Strategies to Reduce Fuel Consumption 8

4.1.1 Heat recovery system – promote cogeneration to increase efficiency and convert to glycol 8

4.1.2 Energy Diagnostic Page 8

4.1.3 Optimization integrated with mining plan 9

4.1.4 Incinerator capacity and alternative 9

4.2 Strategy to Replace Fuel Consumption by Renewable Energy 9

4.3 Strategy Development and Awareness 9

4.3.1 Energy saving staff committee 9

4.3.2 Towards Sustainable Mining flow chart 10

4.3.3 Raising Awareness 10

Section 5 • REFERENCES **11**

List of Figures in Text

Figure 1.1 Location of Whale Tail Pit 3

List of Tables in Text

Table 1.1 Overview of Timeline and General Activities

Table 2.1 Greenhouse Gas Summary for the Project and the Meadowbank Mill (2020)

ACRONYMS

Agnico Eagle	Agnico Eagle Mines Limited – Meadowbank Division
ANFO	Ammonium nitrate/fuel oil
FEIS	Final Environmental Impact Statement
GHGRP	Canada's Greenhouse Gas Emissions Reporting Program
NIRB	Nunavut Impact Review Board
Project	Whale Tail Pit and Haul Road Project
TSM	Towards Sustainable Mining
CO_2	carbon dioxide
CH_4	methane
N_2O	nitrogen dioxide

UNITS

<=	less than
%	percent
CO_2e/yr	carbone dioxide equivalents per year
kt CO_2e	kilotonnes of carbone dioxide equivalents
kt CO_2e/yr	kilotonnes of carbone dioxide equivalents per year
t CO_2e/yr	tonnes of carbone dioxide equivalents per year
L	liters
km	kilometre(s)
km^2	square kilometre(s)
kW	kilowatt

SECTION 1 • INTRODUCTION

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is planning to develop the Whale Tail Pit and Haul Road Project (Project), a satellite deposit located on the Amaruq property, to continue mine operations and milling at the Meadowbank Mine.

The Amaruq property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the Hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq Region of Nunavut. The deposit will be mined as an open pit (i.e., Whale Tail Pit), and ore will be hauled on the Whale Tail haul road to the approved infrastructure at the Meadowbank Mine for milling.

The proposed Whale Tail open pit will be mined by truck-and-shovel operation. As presented in Table 1.1, there are four main phases to the development: 1 year of construction, 4 years of mine operations (2019 to Q1 2022), 8 years of closure, followed by the post-closure period. Pending regulatory approvals, the construction phase is anticipated to start at the beginning of the third quarter of Year -1 (2018) and focus on site preparation and construction of infrastructure to support mine development, along with commencement of open pit development.

The general mine site location for the Project is shown in Figure 1.1. Mine development will include the following major infrastructures:

- industrial area (camp and garage);
- crusher;
- ore stockpiles;
- rock and overburden storage facilities;
- landfill;
- haul and access roads;
- open pit mine; and
- dewatering dikes.

Table 2.1 Overview of Timeline and General Activities

Phase	Year	General Activities
Construction	Year -1	• Construct site infrastructure • Develop open pit mine • Stockpile ore
Operations	Year 1 to 3	• Open pit operations • Transport ore to Meadowbank Mine • Stockpile ore • Discharge Tailings in Meadowbank TSF
	Year 4	• Complete transportation of ore to Meadowbank Mine • Complete tailings discharge in Meadowbank TSF
Closure	Year 4 to 11	• Remove non-essential site infrastructure • Flood mined-out open pit • Re-establish natural Whale Tail Lake level
Post-Closure	Year 11 forwards	• Site and surrounding environment monitoring

TSF = Tailings Storage Facility

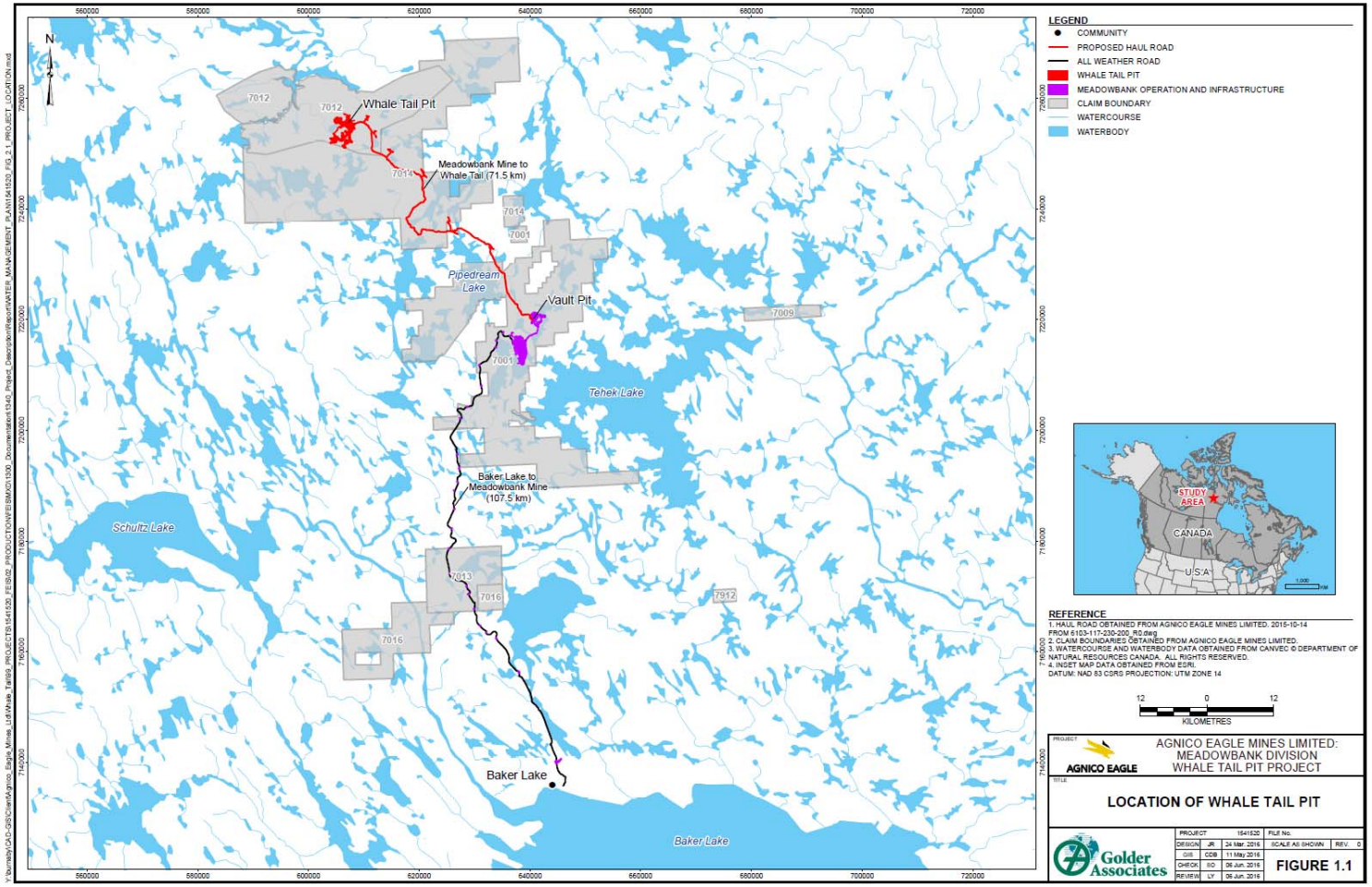


Figure 1.1 Location of Whale Tail Pit

The impacts of climate change have the potential to affect a wide range of environmental, social and economic systems of value to Inuit, as indicated by the observations and changes experienced by Baker Lake traditional land users. Climate change is a global issue caused by emissions of greenhouse gases (GHG). Changes to weather and climate have the potential to affect environmental, social and economic systems of value to the Inuit and other regional stakeholders.

Weather and climate have been identified as valued components (VCs) in the Whale Tail Final Environmental Impact Statement (FEIS) Amendment, Volume 4 – Atmospheric Environment, Section 4.1.2 (Agnico Eagle, 2016). Community elders are concerned about climate change and recent unpredictability in weather (Volume 7, Appendix 7-A) (Agnico Eagle, 2016).

This document presents the Greenhouse Gas Reduction Plan. The purpose of this Plan is to provide consolidated information on the management and monitoring of GHG for the Project, by presenting predicted emissions for the Project (including Whale Tail Project and Meadowbank), sources of GHG, followed by monitoring measures and initiatives taken to reduce emissions.

As per Nunavut Impact Review Board (NIRB) Whale Tail Project Certificate No.008 Condition 3, the Greenhouse Gas Reduction Plan should be submitted to the NIRB within 60 days of the issuance of the Project Certificate, with results submitted annually thereafter or as may otherwise be required by the NIRB. This Plan includes:

- An estimate of the Project's GHG baseline emissions;
- A description of monitoring measures to be undertaken, including the methods, frequency, parameters, and a description the analysis;
- A description of reduction initiatives planned and taken, to reduce project-related GHG emissions over the Project lifecycle.

SECTION 2 • PROJECT BASELINE EMISSIONS

2.1 Project Baseline Emissions Predictions

As presented in the Whale Tail FEIS, Volume 4 – Atmospheric Environment, Section 4.2.3.1 (Agnico Eagle, 2016), an assessment was completed in order to estimate the GHG emissions related to the Project. As part of this assessment, Project-related GHG emissions were calculated using methods consistent with Canada's Greenhouse Gas Emissions Reporting Program (GHGRP).

Table 2.1 presented below summarizes predictions of GHG emissions for the Project for the peak year of production in 2020 (Agnico Eagle, 2016). Mining production will likely be at its highest, meaning that most of the heavy and light equipment will be in operation, and that camp occupancy will be at its maximum. Therefore, the predictions, estimated at 64.2 kilotonnes of carbon dioxide equivalent per year (kt CO_2e/yr), are considered to be the maximum expected for the Project.

Table 2.1 also summarizes predictions from the Project plus those from the existing Meadowbank mill and camp in 2020 (Agnico Eagle, 2016). As the ore material from the Whale Tail Pit Project will be hauled to the approved infrastructures at the Meadowbank Mine for processing and tailings deposition, the predicted emissions for Meadowbank are included with the Whale Tail Pit Project predicted emissions. Total estimated emissions for 2020 are estimated at 244 kt CO_2e/yr.

Since the ore throughput for the Meadowbank mill from the Whale Tail Project is predicted to be 15% to 20% lower than current throughput when processing ore from the Whale Tail Pit, it is estimated that the GHG emissions rate for the mill will be 180 kt CO_2e/yr. This is considered a conservative estimate for the Meadowbank mill processing the Whale Tail Pit ore, as presented in Table 2.1.

There are four (4) main sources of GHG emissions considered for the Project. These sources are described in Section 2.2 below.

Table 2.1 Greenhouse Gas Summary for the Project and the Meadowbank Mill (2020)

Emissions Source	Greenhouse Gas Emissions (kt CO_2e)
Off-road exhaust	52.8
On-road exhaust	4.4
Power plant	4.1
Camp heater	2.9
Whale Tail Project Total [(a)]	64.2
Meadowbank mill	180.0
Whale Tail Project plus Meadowbank Total	244.0

(a) Project Total includes emissions from the Whale Tail Pit and the Haul Road.
kt CO_2e = kilotones of carbon dioxide equivalents; % = percent; <= less than
Source: Modified from Whale Tail FEIS, Volume 4 – Atmospheric Environment (Agnico Eagle, 2016)

2.2 Main Sources of Greenhouse Gas for the Project

As presented in Table 2.1, there are four (4) main sources of GHG identified for the Project predicted emissions:

- Off-road vehicle exhaust emissions which include the heavy and light vehicles not operating on the haul road, but rather in areas of production such as the open pit;
- On-road vehicle exhaust emissions which stand for traffic on the 63 km Whale Tail Haul Road;
- Power plant related GHG emissions, which includes the four (4) expected Caterpillar 3516 generators installed in the power plant to provide power for the mine site - two running and two on standby;
- Camp heater related GHG emissions, including a 500 kW diesel-fired heater expected for the Project.

SECTION 3 • DESCRIPTION OF MONITORING MEASURES

3.1 Greenhouse Gas Emission Monitoring

Emissions of GHG for the Whale Tail Pit Project and Meadowbank Mine will be calculated on a monthly basis. Emissions related to the four (4) main sources described in Section 2 will be calculated. Although considered minimal compared to the other sources, emissions produced by the following activities will also be calculated and compiled:

- aviation (commercial charter planes required for the transportation of employees and cargo freight);
- light truck transportation using gasoline;
- blasting (use of emulsion - ammonium nitrate/fuel oil (ANFO)) ;
- heating using propane.

Quantity of diesel (in liter) used for the generation of electricity and for light and heavy equipment will be recorded on a monthly basis for the Project. The quantities of aviation fuel (liter), propane (liter) and ANFO explosive (tonne) will also be recorded on a monthly basis. From those quantities, the direct emissions based on ``Standard Emissions Factors`` will be calculated. For each sources, carbon dioxide (CO_2) emissions are calculated (in tonnes), as well as methane (CH_4) and nitrogen dioxide (N_2O) in tonnes of carbon dioxide equivalent (CO_2e tonnes). Emissions calculated for each sources are added to obtain a monthly total Project related emissions in tonnes of carbon dioxide equivalents (t CO_2e/yr).

3.2 Data Analysis and Reporting

Estimated GHG emissions for the Project (including Whale Tail Pit and Meadowbank) will be compiled and analysed on a monthly basis. Data will be reviewed and variations will be correlated to factor of causes such as seasonal climate, production activities or other factors of influence identified.

GHG emissions will be reported on an annual basis, as per the requirements of the Whale Tail NIRB Project Certificate No.008, in the Whale Tail Annual Report and to Environment and Climate Change Canada via the GHGRP. The NIRB Annual Report will also include a discussion on GHG emissions monthly variations, as well as a comparison with FEIS emission predictions. Emissions related to aviation, blasting, propane heating, and light truck transportation using gasoline will also be presented and analysed.

SECTION 4 • REDUCTION INITIATIVES

A number of reduction initiatives are planned to reduce project-related GHG emissions over the Project lifecycle. While some have already been implemented others are currently being assessed.

4.1 Strategies to Reduce Fuel Consumption

4.1.1 Heat recovery system – promote cogeneration to increase efficiency and convert to glycol

The main Meadowbank power plant consists of six 4,400 kW generators and a heat recovery system. The heat recovery system was not performing as expected, resulting in additional operating costs, higher GHG emissions, and low comfort level for workers in certain buildings. Cogeneration is recognized as an efficient way of using fossil energy by recovering heat generated from a facility that is usually exhausted into the environment. The optimization of the power plant efficiency was completed in two (2) main phases; increasing cogeneration plant heat production through recovery and synchronizing heat consumption with heat production.

At Meadowbank, the service building heating system was synchronized with the recovered heat (exhaust of generators), further increasing heat production efficiency of the cogeneration plant through heat recovery. The average recovered heat increased by over 50%, replacing the need for auxiliary electric heating at Meadowbank. The power plant consumes now approximately two million (2,000,000) liters less of diesel per year than originally planned, which represents a GHG reduction of approximately 5,600 t CO_2e/yr.

Furthermore, a glycol system, replacing the electric one, was installed in the service building at Meadowbank and is fed by the heat recovery system. This results in diesel consumption reduction and GHG emissions reduction.

A similar cogeneration system and usage of glycol is being evaluated at the Whale Tail Pit Project, resulting in further GHG emissions reduction if implemented.

4.1.2 Energy Diagnostic Page

The implementation of an ``Energy Diagnostic Page`` on the operation screens of the power plant would allow the energy leader staff to monitor the performance of the heating system on a daily basis. This new monitoring tool would also allow the setting of power consumption targets for specific areas of the facilities and of alarms with automated emails when consumption is over the fixed target. This tool would promote rapid identification and diagnostic of problems in the heating system, which is a large contributor to the GHG emissions. The implementation of this device is being evaluated at the moment.

4.1.3 Optimization integrated with mining plan

The Mine and Mill departments are the main energy consumers for the Project, and therefore the main GHG emissions contributors. Both departments are continuously assessing ways to increase their efficiency, whether by reducing the number of trucks or by optimizing cycle time of the fleet. The dispatch system used to monitor the production activities in the open pit and during hauling of the material also contributes to increase the efficiency of the production equipment. Finding optimal rock fragmentation for rock blasting in the pit is also among the ways to reduce rock grinding required at the Mill, reducing energy consumption. These optimizations, along with others, can reduce the energy used for production activities, and therefore reduce GHG emissions and overall costs.

4.1.4 Incinerator capacity and alternative

The optimization of the incinerator cycles to increase capacity with the same energy consumption, while respecting the protocols and procedures to ensure proper operation of the facility, has been completed with success at Meadowbank. The optimization will continue when the incinerator receives waste from the Whale Tail Project.

The potential of food waste composting instead of burning at the incinerator is being evaluated at the moment, to assess its global impact on GHG emissions reduction. This would potentially reduce the amount of waste sent to the incinerator, and therefore reduce the facilities' burning and energy needs, and related GHG emissions. In addition to reducing emissions, composting would consist in an innovative project in the North.

4.2 Strategy to Replace Fuel Consumption by Renewable Energy

Renewable energy alternatives are being assessed and validated on a continuous basis. Historically, trials were conducted in 2015 to assess maintenance needs and reliability of solar panels at Meadowbank. A total of nine (9) solar panels were ordered to assess their performance in a northern environment during the 2015 and 2016 winter months. The trials were successful. At this time, one alternative energy option being assessed is the feasibility of implementing a wind power system.

4.3 Strategy Development and Awareness

4.3.1 Energy saving staff committee

This committee is formed by a group of employees from various departments, who work together to identify areas of improvement for energy consumption savings and to find innovative ideas to improve energy consumption and reduce GHG emissions. For example, the committee initiated the idea of composting food waste on site rather than using the incinerator.

4.3.2 Towards Sustainable Mining flow chart

The Towards Sustainable Mining (TSM) flowchart has been implemented with the Strategic Optimization Group and intends to create a visual approach for employees to understand the energy system and consumption on site, in order to create a venue for discussing energy-savings opportunities.

4.3.3 Raising Awareness

On a regular basis, the Environment and Camp Departments send emails and memos, or install posters to remind employees about the importance of saving energy. For example, the Camp Department staff place individual reminders in rooms during cleaning when the lights are left on by guests. The Environment Department sends regular communications about the ``no idling policy`` for vehicles on site, to avoid having vehicles left on idle mode while not in use. Inspections on site are also completed to raise awareness and enforce this policy.

SECTION 5 • REFERENCES

Agnico Eagle, 2016. Final Environment Impact Statement (FEIS) Volumes 1 to 8, Whale Tail Pit Project, Meadowbank Division. Volume 4 – Atmospheric Environment, Volume 7 – Human Environment.

Groundwater Monitoring Plan, Version 2.1

AGNICO EAGLE

WHALE TAIL PIT PROJECT

Groundwater Monitoring Plan

In Accordance with:
Project Certificate No. 008, T&C 15 and 16

Prepared by:
Agnico Eagle Mines Limited – Meadowbank Division

Version 2

Revision 1
February 2019

EXECUTIVE SUMMARY

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) received a Project Certificate No.008 from the Nunavut Impact Review Board for the development of the Whale Tail Pit, a satellite deposit located on the Amaruq Exploration property.

The deposit will be mined as an open pit (i.e., Whale Tail Pit), and ore will be hauled by truck to the approved infrastructure at Meadowbank Mine for milling. Approximately 8.3 million tonnes (Mt) of ore will be mined from the open pit and processed over a three to four-year mine life. Ore from Whale Tail Pit will be crushed on site after which it will be transported to Meadowbank Mine for milling. The mill rate will be approximately 9,000 to 12,000 tonnes per day.

During mining, groundwater will flow into the open pit. This water is naturally high in total dissolved solids and will not be directly discharged out of the active mine site without treatment. Water management during mine operations will involve a variety of activities, described in detail in the Water Management Plan (WMP) developed for the Project (Agnico Eagle 2018a).

This Groundwater Management Plan (GWMP) reflects the commitments made with respect to submissions provided during the technical review of the FEIS, to comply with Terms and Conditions No. 15 and 16 included in the Project Certificate. This version of the plan includes:

1. Sampling results of the multi-level Westbay well system, that were completed in November 2018;

2. Thermal analyses completed in 2018;

3. Groundwater monitoring plan for horizontal and vertical groundwater flow; and,

4. Threshold and adaptive management plan related to the groundwater management.

Additional modelling efforts were completed in support of the water quality predictions at closure and post-closure. The additional modelling that were completed are: post-closure hydrogeological modelling in combination with the diffusion model; and, the pit lake hydrodynamic model and receiving lake (Mammoth Lake) hydrodynamic model.

The results of these studies indicated that arsenic release from the submerged pit wall (arsenic diffusion) will not affect water quality in the pit lake; and, mass transfer to water is very low even under the conservative assumptions of the calculations. Results from these studies further indicate that the seepage into and out of the pit lake are negligible in volume, particularly compared to surface water exchanged annually during post-closure when flows are re-established based on average climate year watershed runoff. The combination of results corroborates to support that the hydrogeological regime around the pit lake is not critical to pit lake water quality.

Agnico Eagle considers that the uncertainty related to the arsenic-related water quality issues emanate from the Water Rock Storage Facility and the fill water in the proposed pit lake created after the excavation of the ore body, are addressed, and the NIRB Project Certificate No. 008 terms and conditions No. 15 and 16 has been fulfilled.

The GWMP was updated to include additional monitoring of the horizontal and vertical groundwater flow to validate the prediction of these studies during the operation of the Whale Tail pit.

Agnico Eagle would like to clarify the monitoring requirements related to the Waste Rock Storage Facility (WRSF) are addressed in the approved ARD-ML monitoring plan, Water Quality and Flow Monitoring Plan, Water Management Plan and Waste Management Plan, as any seepage emanating from the WRSF is considered as a surface water management issue. The groundwater monitoring plan focus on the definition of the groundwater quality and flow reporting to the pit lake created before, during and after the excavation of the ore body.

DISTRIBUTION LIST

AEM – Geology Superintendent

AEM – Engineering Superintendent

AEM – Geotechnical Coordinator

AEM – Environment Superintendent

AEM – Environmental Coordinator

DOCUMENT CONTROL

Version	Date (YMD)	Section	Revision
1	2018-05-30	All	To address Project Certificate No. 008. T&C 15 and 16
2	2018/11/8	1.1, 2.4, 2.5	To address ECCC and CIRNAC recommendations issued in October 2018
2 Rev. 1	2019/02/19	All	To address NWB and CIRNAC comments discussed on February 13, 2019

Prepared by:
Golder Associates & Agnico Eagle Mines Limited - Meadowbank Division

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **II**

DISTRIBUTION LIST ..... **IV**

DOCUMENT CONTROL ..... **V**

LIST OF FIGURES ..... **VII**

LIST OF TABLES ..... **VII**

1 INTRODUCTION **1**

1.1 Concordance 1
1.2 Objectives 2

2 BACKGROUND **4**

2.1 Site Conditions 4
2.2 Hydrogeology Setting 4
2.2.1 Conceptual Model 4
2.2.2 Post-Closure Hydrogeological and Thermal Analysis 9
2.2.3 Groundwater Volumes and Quality 11
2.3 Additional Data Collection 13
2.3.1 Groundwater Quality 13
2.3.2 Hydraulic Conductivity Testing 13
2.3.3 Verification of Horizontal and Vertical Groundwater Flow Direction 14

3 GROUNDWATER MONITORING PLAN **15**

3.1 Horizontal and Vertical Groundwater Flow Monitoring 15
3.2 GroundWater Quantity and Quality Monitoring 16
3.2.1 Water Quantity 16
3.2.2 Water Quality 17
3.3 Data Compilation and Updates to Groundwater Model 17

4 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES **21**

4.1 Quality Assurance 21
4.1.1 Field Staff Training and Operations 21
4.1.2 Laboratory 21
4.1.3 Office Operations 21
4.2 Quality Control 22

5 REFERENCES **24**

APPENDIX A – WHALE TAIL PIT POST-CLOSURE PIT LAKE THERMAL ASSESSMENT 25

APPENDIX B –2018 WESTBAY SYSTEM GROUNDWATER MONITRORING INVESTIGATION ...27

LIST OF FIGURES

FIGURE 1: SITE LOCATION.....3

FIGURE 2: HYDROGEOLOGY BASELINE STUDY AREA 6

FIGURE 3: CONCEPTUAL MODEL OF PRE-MINING DEEP GROUNDWATER FLOW REGIME - CROSS-SECTION VIEW.....7

FIGURE 4: CONCEPTUAL MODEL OF DEEP GROUNDWATER FLOW REGIME DURING MINING - CROSS-SECTION VIEW.....8

FIGURE 5: CONCEPTUAL MODEL OF DEEP GROUNDWATER FLOW REGIME IN LONG-TERM POST-CLOSURE - CROSS-SECTION VIEW.....9

LIST OF TABLES

TABLE 1: 2015 PREDICTED GROUNDWATER INFLOW TO THE OPEN PIT DURING OPERATIONS AND CLOSURE.....11

TABLE 2: 2015 PREDICTED GROUNDWATER INFLOW TO THE ATTENUATION POND DURING OPERATIONS AND CLOSURE.....12

TABLE 3: PREDICTED GROUNDWATER INFLOW AND GROUNDWATER QUALITY – POST-CLOSURE.....12

TABLE 4: GROUNDWATER ADAPTIVE MANAGEMENT PLAN 19

1 INTRODUCTION

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) received Project Certificate No.008 from the Nunavut Impact Review Board (NIRB) for the development of the Whale Tail Pit (the Project), a satellite deposit located on the Amaruq Exploration property. The Amaruq Exploration property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq region of Nunavut (Figure 1). The deposit will be mined as an open pit, and ore will be hauled by truck to the approved infrastructure at Meadowbank Mine for milling.

This document presents Groundwater Monitoring Plan (GWMP) for the Whale Tail Pit. Overall water management for operations, closure, and post-closure is described in the Agnico Eagle Water Management Plan (WMP) (Agnico Eagle 2018a). The WMP provides descriptions of the water control structures and associated design criteria.

1.1 CONCORDANCE

Meadowbank Mine is an approved mining operation and Agnico Eagle is planning to extend the life of the mine by constructing and operating the Project. The Project was subject to an environmental review established by Article 12, Part 5 of the Nunavut Agreement. In June 2016, Agnico Eagle submitted a Final Environmental Impact Statement (FEIS) seeking a reconsideration of the Meadowbank Mine Project Certificate (No. 004/File No. 03MN107) and Type A Water Licence Amendment (No. 2AM-MEA1525) from the NIRB.

On July 2016, the NIRB determined that the proposed Project required a separate screening assessment under the Nunavut Agreement and the *Nunavut Planning and Project Assessment Act* (NuPPAA). A separate Project Certificate (NIRB Project Certificate No. 008) was issued for the Project on March 15, 2018 by the NIRB. This GWMP reflects the commitments made with respect to submissions provided during the technical review of the FEIS, to comply with Terms and Conditions No. 15 and 16 included in the Project Certificate.

This version of the plan includes:

1. Sampling results of the multi-level Westbay well system, that were completed in November 2018;

2. Thermal analyses completed in 2018;

3. Groundwater monitoring plan for horizontal and vertical groundwater flow; and,

4. Threshold and adaptive management plan related to the groundwater management.

Additional modelling efforts were completed in support of the water quality predictions at closure and post-closure. The additional modelling that were completed are: post-closure hydrogeological modelling in combination with the diffusion model; and, the pit lake hydrodynamic model and receiving lake (Mammoth Lake) hydrodynamic model.

The results of these studies indicated that arsenic release from the submerged pit wall (arsenic diffusion) will not affect water quality in the pit lake; and, mass transfer to water is very low even under the conservative assumptions of the calculations. Results from these studies further indicate that the seepage into and out of the pit lake are negligible in volume, particularly compared to surface water exchanged annually during post-closure when flows are re-established based on average climate year watershed runoff. The combination of results corroborates to support that the hydrogeological regime around the pit lake is not critical to pit lake water quality.

Agnico Eagle considers that the uncertainty related to the arsenic-related water quality issues emanate from the Water Rock Storage Facility and the fill water in the proposed pit lake created after the excavation of the ore body, are addressed, and the NIRB Project Certificate No. 008 terms and conditions No. 15 and 16 has been fulfilled.

The GWMP was updated to include additional monitoring of the horizontal and vertical groundwater flow to validate the prediction of these studies during the operation of the Whale Tail pit.

Agnico Eagle would like to clarify the monitoring requirements related to the Waste Rock Storage Facility (WRSF) are addressed in the approved ARD-ML monitoring plan, Water Quality and Flow Monitoring Plan, Water Management Plan and Waste Management Plan, as any seepage emanating from the WRSF is considered as a surface water management issue. The groundwater monitoring plan focus on the definition of the groundwater quality and flow reporting to the pit lake created before, during and after the excavation of the ore body.

1.2 OBJECTIVES

The objective of the GWMP is to provide consolidated information on groundwater management for the Project. The GWMP is divided into the following components:

- Introductory section (Section 1)
- A brief summary of the physical and hydrogeological setting at the mine site, the mine development plan and FEIS pit inflow predictions (Section 2)
- A description of the groundwater monitoring program (Section 3)
- A summary of procedures for quality assurance and quality control (QA/QC) (Section 4)

Whale Tail Pit

Meadowbank Mine to Whale Tail (71.5 km)

Baker Lake to Meadowbank Mine (107.5 km)

Pipedream Lake

Vault Pit

Tehek Lake

Schultz Lake

Baker Lake

7012
7014
7001
7009
7013
7016
7912

560000 580000 600000 620000 640000 660000 680000 700000 720000

7260000 7240000 7220000 7200000 7180000 7160000 7140000

N

LEGEND

- COMMUNITY
- PROPOSED HAUL ROAD
- ALL WEATHER ROAD
- WHALE TAIL PIT
- MEADOWBANK OPERATION AND INFRASTRUCTURE
- CLAIM BOUNDARY
- WATERCOURSE
- WATERBODY



REFERENCE

1. HAUL ROAD OBTAINED FROM AGNICO EAGLE MINES LIMITED. 2015-10-14 FROM 6103-117-230-200_R0.dwg
2. CLAIM BOUNDARIES OBTAINED FROM AGNICO EAGLE MINES LIMITED.
3. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
4. INSET MAP DATA OBTAINED FROM ESRI.

DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

12 0 12
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

LOCATION OF THE PROJECT

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	JR	24 Mar. 2016	SCALE AS SHOWN	REV. 0
GIS	CDB	24 Mar. 2016		
CHECK	JR	09 May 2016		
REVIEW	LY	09 May 2016		

FIGURE 1

Y:\burnaby\CAD-GIS\Client\Agnico_Eagle_Mines_Ltd\Whale_Tail\99_PROJECTS\1541520_FEIS\02_PRODUCTION\FEIS\MXD\1300_Documentation\1340_Project_Description\Report\1541520_FIG_1.1-1_PROJECT_LOCATION.mxd

2 BACKGROUND

2.1 SITE CONDITIONS

The Project is located in Canada's Northern Arctic ecozone. This region includes most of Canada's Arctic Archipelago and northern regions of continental Nunavut and the Northwest Territories. This ecoregion is classified as a polar desert and is characterized by long cold winters and short cool summers. The mean air temperatures in June to September is approximately 7 degrees Celsius (°C) and -20.6 °C in October to May.

Average annual precipitation at Meadowbank Mine is 142.6 mm (1998 to 2004). The annual precipitation at site generally falls as rain between June and September, and snow between October and May. However, snowfall can occur at any time of the year.

Based on data for Baker Lake (120 km to the south), and from experience ice auguring within the Meadowbank Mine lakes in the winter, the mean maximum lake ice thickness over Whale Tail Lake is expected to be 2.25 m. During the winter collection of water quality baseline data in Whale Tail Lake in April 2016, ice thickness was confirmed to be 2 m.

The surficial geology of the Project area shows strong evidence of glacial activity and is dominated by veneers and blankets of till overlying undulating bedrock. Bedrock frequently outcrops in isolated exposures, elevated plateaus and elongated ridges. Lakes and ponds are abundant, occupying approximately 16% of the area.

The local overburden consists of till with a silty sand matrix and clasts that range from granule gravel to large boulders in size. Glaciofluvial deposits in the form of eskers and terraces are found in the northeast section of the satellite deposit and they continue in a southeast direction intersecting the haul road in several locations.

The bedrock geology in the Project area consists of Archean and Proterozoic supercrustal sequences and plutonic rocks.

2.2 HYDROGEOLOGY SETTING

2.2.1 Conceptual Model

The Project is in an area of continuous permafrost. In this region, the layer of permanently frozen subsoil and rock is generally deep and overlain by an active layer that thaws during summer. The depth of the active layer is typically expected to range between one and three metres. Depending on lake size, depth, and thermal storage capacity, the talik (unfrozen ground surrounded by permafrost) beneath lakes may fully penetrate the permafrost layer resulting in an open talik. Circular lakes with a radius greater than 300 m, or elongated lakes with a half-width of at least 150 m, are assumed to be connected to the deep groundwater flow regime through open taliks. The thickness of the permanently frozen permafrost was estimated to be on the order of 427 to 495 m.

In areas of continuous permafrost, there are two groundwater flow regimes: a deep groundwater flow regime beneath permafrost, and a shallow groundwater flow regime located in the active (seasonally thawed) layer near the ground surface. With the exception of areas of taliks beneath lakes, the two groundwater regimes are isolated from one another by thick permafrost.

The shallow groundwater regime is active only seasonally during the summer months, and the magnitude of the flow in this layer is expected to be several times less than runoff from snowmelt. Groundwater in the active layer primarily flows to local depressions and ponds that drain to larger lakes; therefore, the total travel distance would generally extend only to the nearest pond, lake, or stream. Water in the active layer is stored in ground ice during the cold season and is then released with the ice thaws in late spring or early summer, thus providing flow to surface. During the warm season, groundwater in the active layer is recharged primarily by precipitation.

Permafrost reduces the hydraulic conductivity of the bedrock by several orders of magnitude (Burt and Williams 1976; McCauley et al. 2002). Consequently, the permafrost in the rock would be virtually impermeable to groundwater flow. The shallow groundwater flow regime, therefore, has little to no hydraulic connection with the deep groundwater regime which is overlain by massive and continuous permafrost.

Groundwater flow within the deep groundwater flow regime is limited to the sub-permafrost zone. This deep groundwater flow regime is connected to the ground surface by open taliks underlying larger lakes. Talik exist beneath lakes that have enough depth so that they do not freeze to the bottom over the winter. If the lake is sufficiently large and deep, the talik can extend down to the deep groundwater regime. These taliks are referred to as open talik. If the talik does not extend down to the deep groundwater, it is referred to as a closed or an isolated talik. The width and shape of lakes in the Hydrogeology Baseline Study area were reviewed to estimate if open taliks could be present below the lakes (FEIS Volume 6 Appendix 6.A). Based on 1-D analytical solutions presented in Burn (2002), Golder estimated that open taliks could be present for circular lakes with a radius of approximately 300 m and for elongated lakes with a half-width of approximately 150 m. Beneath smaller lakes that do not free to the bottom over the winter, a talik bulb may form; however, the talik bulb is not expected to extend to the deep groundwater flow system.

Generally, deep groundwater will flow from higher elevation lakes with open taliks to lower elevation lakes with open taliks. To a lesser degree, groundwater beneath the permafrost is influenced by density differences due to saline water conditions (density driven flow).

Below the active layer, permafrost underlies the land surrounding the lakes, which restricts the lateral or horizontal flow of groundwater and restricts the recharge of the sub-permafrost groundwater flow system by precipitation. Multiple thermistors in the land surrounding Whale Tail Lake, in combination with thermal modelling, indicate the permafrost extends to 425 m to 495 m below ground surface. In particular, thermistor data recorded at AMQ15-452, AMQ17-1233, AMQ17-1337 and AMQ17-1277A (Golder 2018b) indicates the presence of permafrost

between Whale Tail Lake and Nemo lake, and therefore the absence of horizontal groundwater flow in the upper 425 to 495 m of bedrock.

Groundwater flow is controlled by surface water elevations in lakes with open talik; water moves vertically through the open talik to the underlying sub-permafrost groundwater flow system. The elevations of the lakes with expected talik in the baseline study area indicate that Whale Tail Lake is likely a groundwater discharge zone at the south end of the Lake (upward vertical hydraulic gradient), with flow from Lake A60 to Whale Tail Lake, and a groundwater recharge zone at the north end of the Lake (downward hydraulic gradient), with groundwater flow from Whale Tail Lake to Lake DS1 as presented on the Figure 2 showing the hydrogeology baseline study area. Whale Tail Pit is located in the north basin and therefore a downward vertical hydraulic gradient is expected (Figure 3). This was verified by hydraulic head monitoring at the Westbay Well system, which had a measured downward hydraulic gradient of 0.008 m/m, which is equivalent to what would be expected based on the relative lake elevation of Whale Tail Lake and Lake DS1 (Golder 2019).

Figure 2: Hydrogeology Baseline Study Area

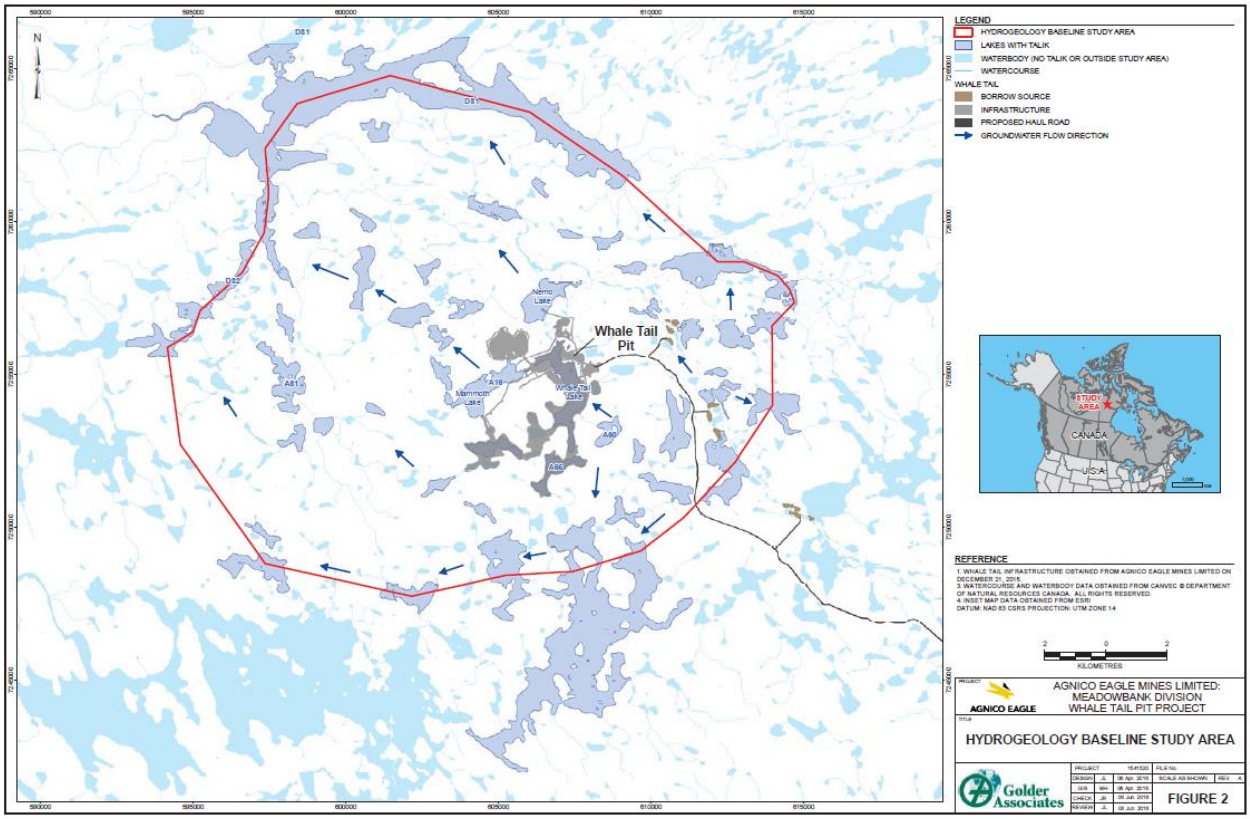
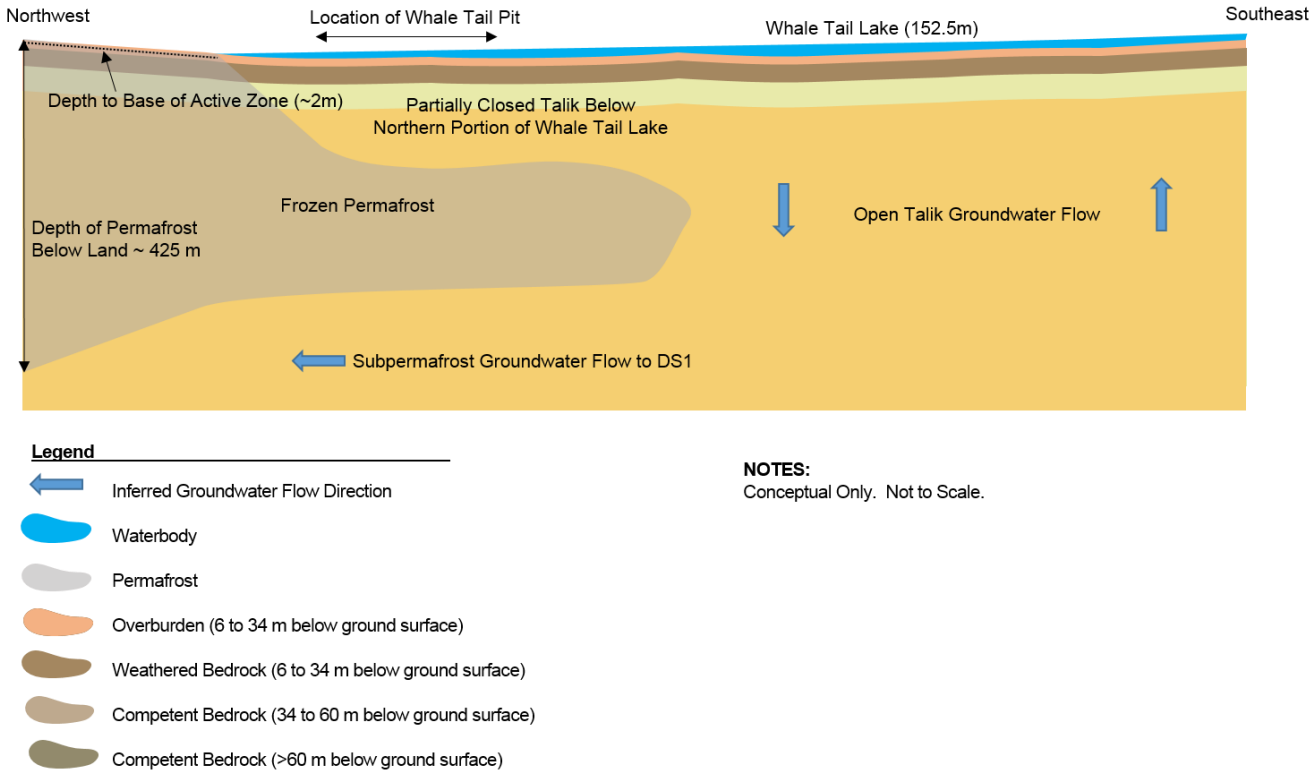
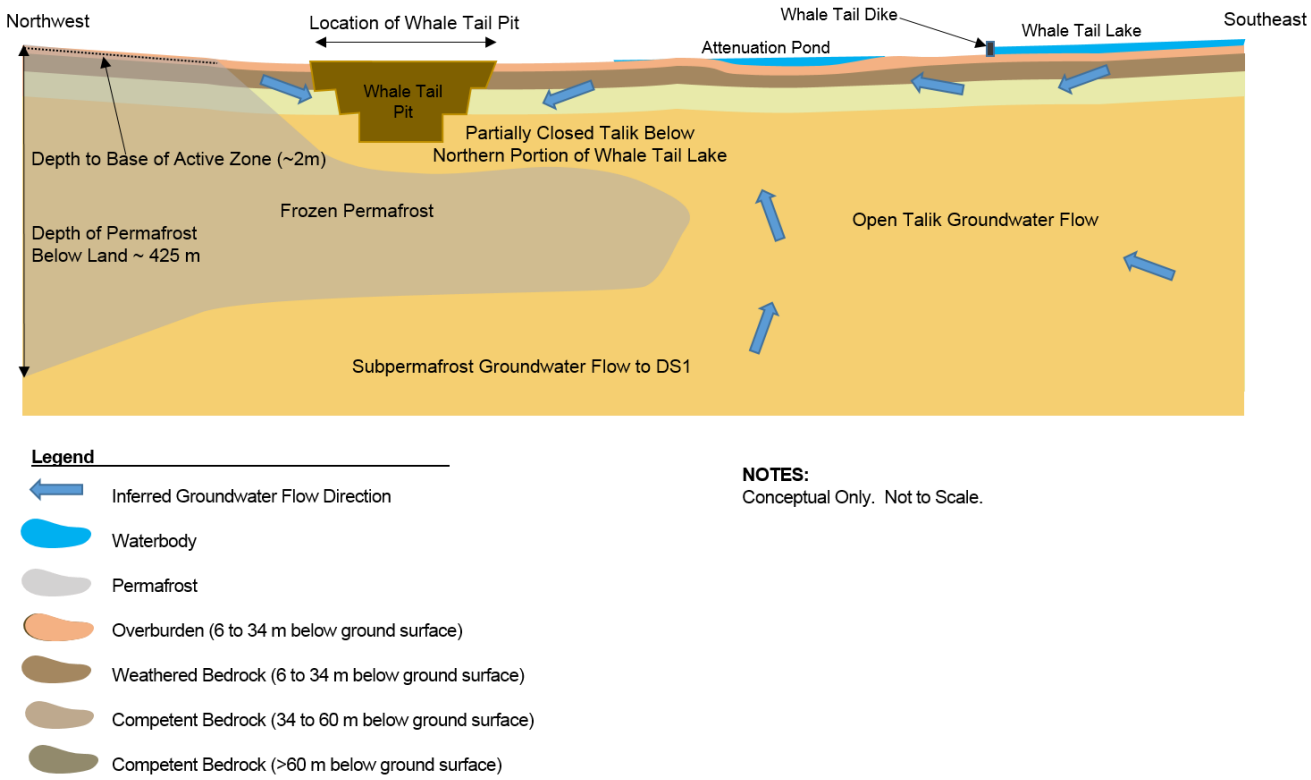


Figure 3: Conceptual Model of Pre-Mining Deep Groundwater Flow Regime - Cross-Section View



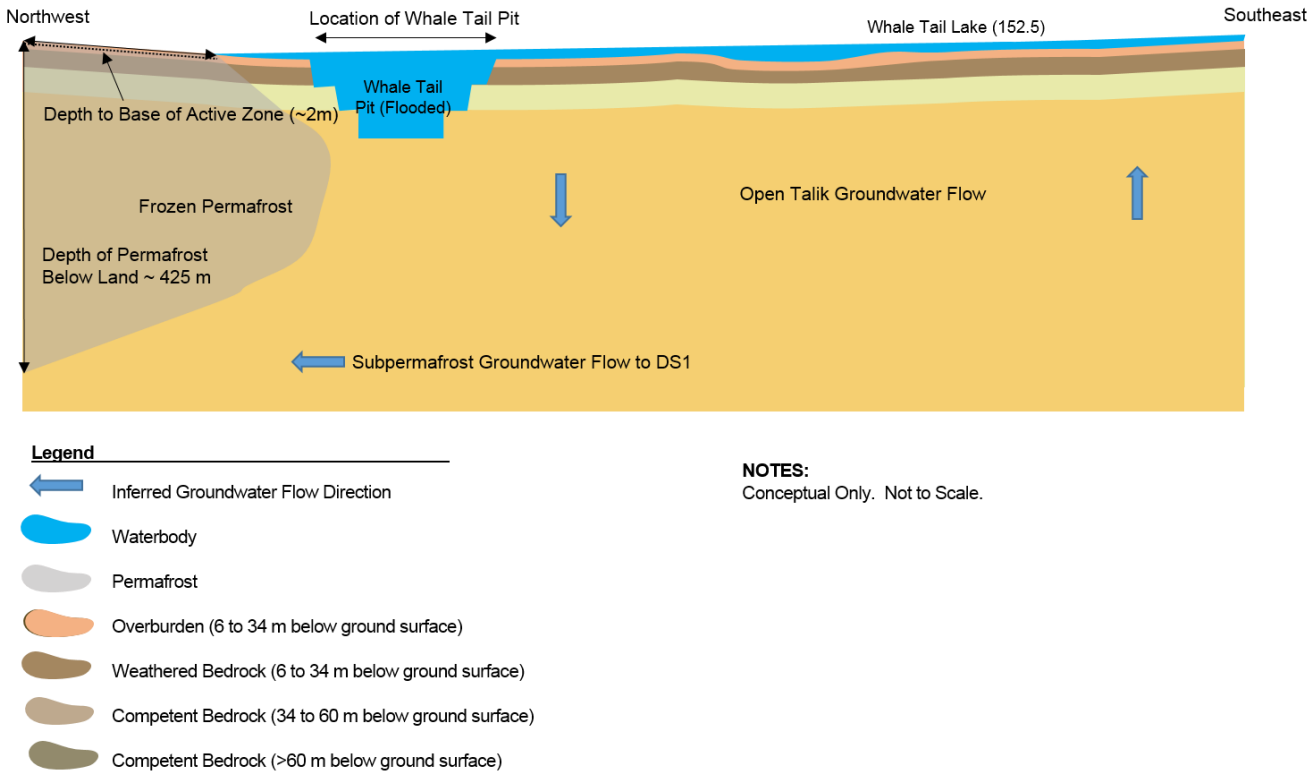
Below Whale Tail Lake, a talik is expected to form a continuous channel that is closed in the northern portion of Whale Tail Lake below the open pit and becomes open towards the south and central portion of the lake. As shown in Figure 4, during mining the open pit will act as a sink for groundwater flow, with seepage faces developing along the pit walls. In response to mining of the open pit, groundwater will be induced to flow through bedrock to the open pit. Mine inflow will primarily originate from Whale Tail Lake, the attenuation pond between the pit and Whale Tail dike, and deep bedrock. The quality of mine inflow will be a result of the mixing from each of these sources.

Figure 4: Conceptual Model of Deep Groundwater Flow Regime during Mining - Cross-Section View



During closure (Figure 5), the open pit will be flooded with water from a variety of sources including: water pumped from the flooded South Whale Tail watershed until the original Whale Tail Lake level is reached (152.5 m), the north-east watershed following the breach of the North-East dike, groundwater originating from nearby lakes underlain by open taliks, connate water and water pumped from the attenuation pond. This process will dissipate the large hydraulic head differences established during mine operations in the vicinity of the mine workings. The rate of groundwater inflow will decrease as the water level in the open pit rises. From the start of closure and following the formation of the pit lake in post-closure, permafrost below the pit is expected to thaw slowly. The thermal regime in the vicinity of the pit will be monitored, as outlined in the Thermal Monitoring Plan for the Project (Agnico Eagle 2018b).

Figure 5: Conceptual Model of Deep Groundwater Flow Regime in Long-Term Post-Closure - Cross-Section View



2.2.2 Post-Closure Hydrogeological and Thermal Analysis

Hydrogeological analysis was conducted to assess the post-closure groundwater regime in the vicinity of the Whale Tail Pit (Golder 2018a). The intent of the study was to consider post-closure changes in the groundwater regime once the pit lake reaches its ultimate elevation and the influence, if any, that these changes may have on water quality in the flooded pit. As part of the analysis, the predicted changes in the permafrost regime, based on a post-closure thermal assessment, were incorporated in to the hydrogeological model. The results of the hydrogeological assessment provided input into a concurrent study that assessed water quality in the flooded pit (Golder 2018c). Overall, groundwater was found to be a minor component of the flooded pit lake water quality due to the small predicted seepage rates from the pit in relation to typical surface water exchanges.

Results of the post-closure thermal assessment (Golder, 2018b) included:

- During pit flooding, the warm pit lake temperature impacts mostly the upper portion of the permafrost under the pit, and a talik starts to form around the pit wall and floor.

- The permafrost under the pit lake continues to thaw during the long-term post-closure stage, and the open talik expands towards the northern edge of the pit lake (land side). The majority of the permafrost under the pit lake is thawed 300 years after closure.

- The steady-state model indicates the pit lake would thaw the permafrost in the long-term, and eventually somewhat reduce the permafrost depth to the northwest of the pit. A significantly longer time (in the order of 10,000 years) is likely required for the pit lake to reach the steady-state thermal conditions**.** Permafrost is still predicted to the north of the pit, restricting the horizontal flow of groundwater to towards Nemo Lake where the permafrost is present.

Result of the Post-closure hydrogeological model (Golder, 2018a) included:

- Initially, once the hydraulic heads return to near equilibrium shortly after mine flooding, groundwater inflow into the pit is greater than pit lake discharge into surrounding bedrock. This groundwater discharge to the pit lake decrease gradually over 100 years, at which time it reverses and the pit lake discharge into the bedrock is greater than the groundwater inflow. The relative difference in flow increases with time and as the permafrost layer beneath the pit lake thaws.

- Long-term, the pit lake establishes as a source of groundwater recharge, which is consistent with the current pre-development groundwater flow condition.

As summarized above, with the exception of deep sub-permafrost groundwater flow, groundwater flow during closure will be similar to pre-development conditions and limited to the area of talik below Whale Tail Lake and the developed pit lake during closure. Horizontal flow beneath land will be restricted by the presence of permafrost below the active layer. Thermal analysis indicates that although permafrost degradation below the pit footprint will occur, permafrost will be present below the land outside of the pit lake and other lakes with talik (i.e., including between the pit and Nemo Lake).

Predictions from the hydrogeological modelling were an input into a concurrent study that assesses overall water quality in the flooded pit (Golder, 2018c). Arsenic loading rate from the Whale Tail pit north wall has been determined from the completion of the Arsenic diffusion model (Golder, 2018d) and integrated to the Whale Tail Pit hydrodynamic model (Golder, 2018c). Result of the hydrodynamic model are:

- The concentration of TDS will remain below site specific water quality objectives at all times. TDS will peak at just below 25mg/L in year 2025, and thereafter decrease over time. Concentration of TDS will stabilize at approximately 11mg/L by 2055.

- The concentration of arsenic will remain below site specific water quality objectives at all times. Arsenic will peak at just below 0.025mg/L in year 2025, and thereafter decrease over time. Concentration of arsenic will stabilize at approximately 0.0025mg/L by 2055.

- The concentration of total phosphorous will remain below site specific water quality objectives at all times. Total phosphorus will peak at just above 0.007mg/L in year 2025, and thereafter decrease over time. Concentration of total phosphorus will stabilize at approximately 0.0025 mg/L by 2055.

The pit lake in the long-term is expected to be a source of groundwater recharge, with a seepage loss rates to groundwater of approximately 1.7 m^3/day (620 m^3/year), which is negligible relative to the 3,000,000+ m^3 of surface water exchanged annually post-closure when surface water flows are re-established, based on average climate year watershed runoff. This groundwater loss rate is representing 0.02% of the total surface water exchanged annually. This indicates that uncertainty in the hydraulic gradient and groundwater flow is not critical to the long-term assessment of pit lake water quality. As presented in Golder (2018) recent monitoring of the hydraulic gradient, and calculated fluxes based on this gradient suggest that the predicted post-closure seepage rates are reasonable based on the measured data.

2.2.3 Groundwater Volumes and Quality

Potential groundwater inflow quantity and quality with respect to total dissolved solids was predicted in the FEIS using a groundwater numerical model (FEIS Volume 6, Appendix 6.B). A summary of these predictions is presented on Table 1 and Table 2.

Table 1: 2015 Predicted Groundwater Inflow to the Open Pit during Operations and Closure

Phase	Period	Groundwater Inflow (m^3/day)	TDS Concentration (mg/L)
Dewatering	Mar 2019 to Oct 2019	-	-
Mining	Q4 2019 to 2020	275	415
	2021	100	410
Filling	2022	65	370
	2023	55	365
	2024	30	370
	Jan to Oct 2025	15	370
	Nov 2025 to Oct 2028	1	370

Note: Mining prior to Q4 2019 is within permafrost and groundwater inflow will be negligible.

TDS = total dissolved solids; m^3/day = cubic metres per day; mg/L = milligrams per litre

Table 2: 2015 Predicted Groundwater Inflow to the Attenuation Pond during Operations and Closure

Phase	Period	Net Groundwater Inflow (m^3/day)	TDS Concentration (mg/L)
Dewatering	Mar 2019 to Oct 2019	-	-
Mining	Q4 2019 to 2020	2	160
	2021	1	170
Filling	2022	1	195
	2023	1	175
	2024	1	175
	Jan to Oct 2025	1	175
	Nov 2025 to Oct 2028	-	-

TDS = total dissolved solids; m^3/day = cubic metres per day; mg/L = milligrams per litre

In accordance with Project Certificate Term and Condition No. 16b and 16c, Golder conducted a supplemental hydrogeological assessment to predict the post-closure groundwater regime in the vicinity of the Whale Tail Pit (Golder 2018a). The purpose of the model simulations was to evaluate the effects of higher TDS groundwater beneath the open pit on the groundwater flow system after closure and to evaluate the influence of solute transport by density–driven flow on the movement of solutes from the bedrock into the flooded pit.

Table 3 presents the predicted groundwater inflow quantity and quality to the Whale Tail Pit during post-closure. The results of the post-closure hydrogeological assessment provided input into a concurrent study that was assessing overall water quality in the flooded pit (Golder 2018b). The post-closure model results show that, initially, once the hydraulic heads return to near equilibrium shortly after mine flooding, groundwater inflow into the pit lake is greater than pit lake discharge into surrounding bedrock. Over time, pit lake water is drawn downwards from the bottom part of the flooded pit into bedrock. Approximately 100 years after closure, pit lake water discharge into bedrock becomes greater than groundwater inflow into the pit lake. The relative difference in flow increases with time and as the permafrost layer beneath the pit lake is predicted to thaw.

Table 3: Predicted Groundwater Inflow and Groundwater Quality – Post-Closure

Years Following Closure	Groundwater Inflow to Pit Lake (m^3/day)	Average TDS Concentration into pit (mg/l)	Pit Lake Outflow to Groundwater (m^3/day)
1	2.2	650	1.1
10	1.1	540	0.8
100	0.2	440	0.8
500	0.1	77	1.7

2.3 ADDITIONAL DATA COLLECTION

Project Certificate Term and Condition No. 15 indicates the need to collect additional site-specific hydraulic data in key areas of the Project during the pre-development, construction and operational phases. Agnico Eagle has commenced with the collection and documentation of this data, and a summary of the results is presented below.

2.3.1 Groundwater Quality

At the time of the FEIS, a representative sample of deep groundwater had not been collected and data collected at the Meadowbank Mine was used to infer the TDS profile at the project. A Westbay well system was installed on site between March and April in 2016. The borehole was drilled to a depth of 499 m. The well was installed to monitor hydraulic heads, test hydraulic conductivity, and collect groundwater samples from multiple intervals (Golder 2016c). The groundwater samples collected from the Westbay system at depths from 276 m to 392 m indicate that the TDS content in the groundwater was between 3,198 mg/L and 4,042 mg/L. This range is slightly higher than the groundwater TDS measured at Meadowbank from shallower depths (less than 200m vertical depth).

Groundwater samples were also collected from the Westbay in November 2018, along with the measurement of vertical hydraulic gradient (Golder 2018). The 2018 program estimated groundwater quality were in the same range as previously estimated. The calculated groundwater TDS were slightly higher in 2018 which was attributed to the higher proportion of residual drilling water in the sample. The concentrations of metals and arsenic were low. Given that the arsenic concentrations are similar to the assumptions adopted in the geochemical models (low arsenic in formation groundwater), groundwater arsenic content is still not likely to have a significant effect on mine surface water quality.

Data collected from the Westbay will be used in future updates to the water quality forecast in support of the Project. At this time, it is expected that the water treatment system planned for the project can handle groundwater with the measured water quality observed in 2016 and 2018.

2.3.2 Hydraulic Conductivity Testing

Supplemental hydrogeological investigations have been undertaken between 2015 and 2017 to further characterize the hydraulic conductivity of the bedrock in the vicinity of the Whale Tail Pit. These investigations have been documented in reports by Knight Piesold (2016), Golder (2016a, 2017), and SNC (2017). These investigations included the completion of 49 packer tests in unfrozen areas of bedrock (i.e., within the talik or below the regional permafrost).

Data collected from these four supplemental investigations indicate the bulk hydraulic conductivity of the bedrock ranges on the order of 1×10^{-5} m/s near surface (i.e., up to depths of 40 m) to approximately 1×10^{-9} m/s at greater depths. As part of the FEIS, the hydraulic conductivity was estimated to be between 1×10^{-8} and 2×10^{-7} m/s. Evaluation of the refined estimates of hydraulic conductivity from the supplemental testing with respect to groundwater

flows indicate that the inflow to the pit could be up to five times higher (up to 1,400 m^3/day) during mining due to the groundwater flow rates to the pit being controlled by the shallow bedrock hydraulic conductivity (connection of the pit to the south whale tail basin). This higher flow rate is within the limits of the water treatment system and water management infrastructure and adaptive management of these flows is not required at this time.

The lower hydraulic conductivity of the bedrock at depth indicate that the seepage rates from the pit are likely to be lower than predicted in the post closure hydrogeological assessment. This indicates that the predicted seepage rates were conservatively high, and that actual seepage rates from the pit lake will be slightly lower due to the lower bedrock hydraulic conductivity expected to be present near the base of the pit. Based on the lower estimated hydraulic conductivity near the base of the pit (1×10^{-9} m/s), the measured vertical hydraulic gradient in the Westbay (0.008 m/m), and an approximately flooded pit lake area of approximately 0.5 Km3, the long-term predicted discharge from the pit lake at post-closure would be approximately 0.3 m^3/day). Overall, the estimated flux is similar to the long-term predicted discharge from the pit lake at post-closure (1.7 m^3/day) and supports the conclusion in the FEIS that long-term predicted flows from the pit lake to the groundwater flow system will be negligible relative to the surface water exchange into the pit lake (Golder 2018c).

2.3.3 Verification of Horizontal and Vertical Groundwater Flow Direction

Thermal data continues to be collected at the Project to verify assumptions in the permafrost conditions. Thermistors have been installed at ten locations, of which four are located to the north of the Whale Tail Pit, between Nemo Lake and Whale Tail Pit (Golder 2018b). These thermistors verify the presence of permafrost below the active layer and that the deep-sub permafrost groundwater flow system will only be connected/recharged by vertical flow through talik present below lakes of sufficient size, such as Whale Tail lake. The four thermistors between Nemo Lake and Whale Tail Pit (AMQ17-1337, AMQ17-1233, AMQ17-1277A and AMQ15-452) each indicate permafrost below the land and that horizontal flow below the active layer is restricted by permafrost in the upper 425 to 495 m of bedrock.

The vertical movement of groundwater flow through the open talik is being monitored using the Westbay Well system (AMQ16-626) to measure the vertical hydraulic gradient. This monitoring verified the direction of groundwater flow and can be used in combination with the measured bedrock hydraulic conductivity to estimate the groundwater flux near Whale Tail Pit.

The data collected at AMQ16-626 (Golder 2018), indicates the presence of a downward hydraulic gradient. Assuming the measured hydraulic head is representative of the midpoint of the measurement interval, the downward gradient is 0.008 m/m. This gradient is consistent with the estimated gradient derived from looking at the relative elevation of Whale Tail Lake and DS1 (0.008 m/m), as reported in Agnico Eagles response to TC15 (Agnico Eagle 2018). DS1 is the predicted receptor from water in the area of Whale Tail Pit and Underground (Golder 2016c). Figure 2 is presenting location of Whale Tail Lake and DS1 Lake.

For the depth interval over which the hydraulic head was measured (326 to 456 mbgs), the estimated hydraulic conductivity of the bedrock for the FEIS for the Whale Tail Pit Project was 1 $x10^{-8}$ to 3 x 10^{-8} m/s (Golder 2016c). As discussed, in support of TC15 and the development of the Project, additional packer testing was conducted subsequent to the FEIS and the data indicate the hydraulic conductivity of bedrock over this depth interval is likely lower (1 x 10^{-9} m/s based on the geometric average of the test data) (Golder 2018a). Considering the measured gradient (0.008), the historical range of bedrock hydraulic conductivity adopted in the FEIS (1 $x10^{-8}$ to 3 x 10^{-8}) and the now refined hydraulic conductivity (1 x 10^{-9} m/s) and an assumed effective porosity of 0.001 (Maidment 1992; Stober and Bucher 2007), the estimated downward groundwater flow velocity is between approximately 0.25 m/yr and 8 m/yr. The lower bound of this range is considered more reasonable, as it uses the refined hydraulic conductivity data discussed above, which is based on the geometric mean of all the packer test measurements (pre- and post-FEIS).

Gradients measured during this monitoring program are considered a reasonable interpretation of what long-term gradients could be post-closure following the formation of the pit lake. Recharge and discharge from the base of Whale Tail Lake or a flooded pit lake will be controlled by the vertical hydraulic gradients and the bedrock hydraulic conductivity near the base of the permafrost. Considering the approximate area of the Whale Tail Pit (0.5 km^2), the range in bedrock hydraulic conductivity (1 x 10^{-9} to 3 x 10^{-8} m/s), and the measured downward gradient (0.008), the data would indicate long-term groundwater flux would be approximately 0.3 m^3/day to 11 m3/day. Similar to the estimated groundwater velocity, the lower bound of this range is considered more reasonable, as it uses the refined estimate of hydraulic conductivity. Overall, the estimated flux is similar to the long-term predicted discharge from the pit lake at post-closure (1.7 m3/day; Golder 2016c) and supports the conclusion in the FEIS that long-term predicted flows from the pit lake to the groundwater flow system will be negligible relative to the surface water exchange into the pit lake (Golder 2018c).

3 GROUNDWATER MONITORING PLAN

Water quantity and quality monitoring data will be used to verify the predicted water quality and quantity trends and to conduct adaptive management should differing trends be observed. Monitoring will be initiated at the start of mining and continue during operations and closure.

The GWMP will be further defined as the open pit is developed and will be conducted in agreement with the WMP for the Project.

3.1 HORIZONTAL AND VERTICAL GROUNDWATER FLOW MONITORING

Thermal monitoring will continue at each of the installed thermistors to monitor the presence of permafrost below the active layer during construction and operations phases. The monitoring will continue until such time as a thermistor is destroyed by active mining. Two thermistors, AMQ17-1233 and AMQ17-337, are located outside of the pit footprint and will be used to

monitor permafrost conditions between Nemo Lake and Whale Tail Pit. The thermistor data will be used to verify the presence of permafrost and the restricted horizontal movement of groundwater below the active layer due to permafrost in the upper 425 to 495 m of bedrock.

As part of the Whale Tail Dike Operation Maintenance and Surveillance manual, performance of the Whale Tail dike will be monitored with different instruments (e.g. piezometers) located in the principal horizontal groundwater flow pathway between Whale Tail South Basin and the Whale Tail pit. Piezometer readings and water level in the Whale Tail South Basin and the Attenuation Pond will be available to calibrate the hydrogeological model during operation if deemed necessary.

Vertical groundwater flow conditions in the area of Whale Tail Pit will be monitored by the Westbay Well system. Agnico Eagle will be sampling the Westbay Well system commencing in March 2019 and will continue to sample and report on an annual basis during the Construction and Operations Phases. The monitoring will include the measurement of the vertical hydraulic gradient and the collection of groundwater samples. During operations, this data will be supplemented by the direct measurement of groundwater quality in the seepage inflow to the pit (Section 3.2). Water sampling parameters will be consistent with the sump sampling and seepage surface parameters planned for the pit (Section 3.2.2).

Data collected during construction and operations phases will be used to develop an appropriate monitoring for closure and will be documented in the Interim Closure and Reclamation Plan.

3.2 GROUNDWATER QUANTITY AND QUALITY MONITORING

3.2.1 Water Quantity

Groundwater inflow to the open pit will be collected in sumps prior to being pumped to surface. Water collected in the sumps represents the bulk, or combined inflow to the open pit, and may include other sources of water, such as precipitation. During construction and operations, groundwater inflow to the pit will be evaluated four time per calendar year as per Water Licence 2AM-WTP1826 requirements. Management of the pumped-out water is described in the WMP.

The above flow monitoring will be supplemented by periodic seepage surveys to be conducted twice during the first year of mining and once a year thereafter. In the first year of pit development, one of the seepage surveys will be conducted in early summer, following snow melt and thawing of any ice in the pit walls, and then again in late August. In the following years of mining, one survey will be conducted in August of each year. The objective of the seepage surveys is to identify preferential groundwater flow paths in the walls of the open pit, if present, and to determine their relative contribution to the groundwater inflow to the pit with respect to water quantity and quality.

3.2.2 Water Quality

During the operations phase, the quality of water from the sumps (either at the sump or at end of pipe at the surface) will be monitored four time per calendar year as per Water Licence 2AM-WTP1826 requirements.

Water samples will also be collected from seeps in the pit walls if there is sufficient water for analysis and if access to the seep is possible.

For each sample, field parameters will be recorded (pH, turbidity, salinity and electrical conductivity). Analytical parameters will include:

- Total and Dissolved Metals: aluminium, antimony, arsenic, boron, barium, beryllium, cadmium, copper, chromium, iron, lithium, manganese, mercury, molybdenum, nickel, lead, selenium, tin, strontium, titanium, thallium, uranium, vanadium and zinc.

- Nutrients: ammonia-nitrogen, total kjeldahl nitrogen, nitrate nitrogen, nitrite-nitrogen, ortho-phosphate, total phosphorous, total organic carbon, total dissolved organic carbon and reactive silica.

- Conventional Parameters: bicarbonate alkalinity, chloride, carbonate alkalinity, conductivity, hardness, calcium, potassium, magnesium, sodium, sulphte, pH, total alkalinity, total dissolved solids, total suspended solids and turbidity.

- Total cyanide and free cyanide. If total cyanide is detected above 0.05 mg/L at a monitoring station in receiving environment; further analysis of Weak Acid Dissociable Cyanide will be triggered.

Additional chemical analyses may be required to more completely characterize the chemical loading from the mine water. The additional analyses will be dependent on monitoring results.

3.3 DATA COMPILATION AND UPDATES TO GROUNDWATER MODEL

Groundwater monitoring data will be compiled into a Project-specific database and evaluated for trends in groundwater data with respect to pit and underground inflow quantity and quality.

Measured groundwater inflow rates will be compared to model predictions on an annual basis. If significant variations from model predictions are observed, the assumptions behind the data will be reviewed and the analysis updated if required. In addition, updates to the groundwater model will be made if operational changes occur as the open pit advances which could significantly alter groundwater inflow or quality.

Variations that would be considered significant and would be triggers for review of the data include:

- Groundwater inflow quantity to the mine, based on rolling monthly average of inflow over six consecutive months, is 20% higher than predicted groundwater inflow. The six-month averaging period of observation is based on observed seasonal variations in inflow quantities in mines situated in continuous permafrost regions, where half the year there is virtually no surface water component of flow to the pit.

- Collected water samples that indicate that the TDS is more than 25% higher than the estimated water quality, based on a 6-month rolling average.

- Temperature profiles observed in the sentinel thermistors (AMQ17-1233 and AMQ17-337) located between Nemo Lake and Whale Tail Lake are showing sign of permafrost degradation below the active layer.

- Observed inflow quantity and quality is lower than expected would not be of concern and/or effect water management plans on-site. Model updates or analysis would therefore not be conducted if predicted inflow quantity and quality is higher than observed conditions.

If the first three variations are triggered, the groundwater and/ or permafrost data would be assessed to evaluate trends, the potential causes of the triggers and the potential for long-term effects associated with the variation. If for example, the greater than predicted inflows were correlated to a short-term effect such as freezing in the pit walls, changes in mining rate, freshet or transient drainage of a high storage feature, then further reassessment of groundwater inflows may not be required, and the adaptive management of these short-term effects would be evaluated under the Water Management Plan (WMP). However, if the effects of these variations is found to be potentially long term, this may warrant review of the model and/or permafrost calibration and predictions.

Table 4 presents the adaptive management plan with respect to groundwater monitoring. The design of the water management infrastructure includes contingencies in case of unplanned events. The Whale Tail attenuation pond can handle higher groundwater inflows and the Operation Water Treatment Plan (O-WTP) is designed to handle total flow rates 60% higher than planned (including surface and groundwater inflows reporting to the Attenuation Pond). O-WTP has the capacity to treat more than a five times increase in groundwater inflows from the one predicted during operation. Moreover, if the inflows are greater than this then there is the capacity to store water within the pit and adjust the mining plan to deal with extra inflows. In any case, all contact water will be managed within the pit area.

The groundwater management strategies: the ponds, sumps and water conveyance strategies around the pit can be modified to mitigate the effect of additional groundwater volume or salinity prior to treatment and discharge. The water conveyance strategy will be evaluated and optimized during operations and closure to maintain post-closure commitments. Other engineering solutions such as depressurization wells, grouting and thermosiphons may be considered, if warranted.

If one of the thresholds in Table 4 is triggered and it is found to be a potentially long-term effect, then hydrogeological and thermal analyses will be required to define the best solution to address the exceedance. Agnico Eagle considers that adaptive management must be based on well informed decisions and may include re-calibration of the thermal and hydrogeological models, predictions based on these re-calibrations, and revised Site-Wide water balance and Site-Wide water quality forecasts.

Table 4: Groundwater Adaptive Management Plan

Threshold	Consequence	Likelihood	Adaptive Management
Groundwater inflows to the mine, based on rolling monthly average of inflow over six consecutive months, is 20% higher than predicted groundwater inflow	• Higher water volume to treat during operation • Potential to compromise storage capacity of the attenuation pond • Impact on mining sequence	Low	O-WTP have 60% contingency to manage higher inflow to attenuation pond (forecasted peak operation flow in the water balance is 1,300m^3/h during 12h a day vs treatment capacity of 1,800 m^3/h during 24h per day); O-WTP have the capacity to treat more than five times increase in groundwater inflows from the one predicted during operation; Attenuation pond has 50% contingency to manage higher groundwater inflow; Assess situation by performing additional inspection, monitoring and field investigation; Review hydrogeological model, Site-wide water balance and Site-wide water quality forecast with updated data; Review water management strategy (e.g. temporary storing water in the pit); Evaluate potential long-term mitigations (e.g., grouting); Review water management strategy.
Collected groundwater samples that indicate that the TDS is more than 25% higher than the estimated groundwater quality, Based on rolling monthly average over 6 consecutive months	• Higher TDS water quality to treat during operation • Compromise storage capacity of the attenuation pond • Potential to reduce water treatment efficiency and management plan if not meeting Metal and Diamond Mining Effluent Regulations • Impact on mining sequence	Low	O-WTP have 60% contingency to manage higher inflow to attenuation (forecasted peak operation flow in the water balance is 1,300m3/h during 12h a day vs treatment capacity of 1,800m3/h during 24h per day); O-WTP have the capacity to treat more than five times increase in groundwater inflows from the one predicted during operation; Flow to the pit is dominated by seepage loss from the Attenuation Pond and seepage from the South Basin of Whale Tail Lake. As the groundwater inflow to the pit is representing a small ratio of the overall water inflows in the attenuation pond, water treatment efficiency should not be impacted significantly by uncertainty in the groundwater

			TDS; Assess situation by performing additional inspection, monitoring and field investigation; Review hydrogeological model, Site-wide water balance and site-wide water quality forecast with updated data; Evaluate additional treatment and storage capacity required to manage flow in operation (e.g. storing water in the pit); Evaluate potential long term mitigations (e.g. grouting, thermosiphon); Review water management strategy.
Temperature profile observed in the sentinel thermistors (AMQ17-1233 and AMQ17-337) located between Nemo Lake and Whale Tail Lake are showing sign of permafrost degradation below the active layer.	• Horizontal groundwater flow observed between Whale Tail Pit north wall and Nemo Lake. • Potential for groundwater seepage to pit sump/pit lake. • Increased water treatment requirement.	Unlikely	Assess situation by performing additional inspection, monitoring and field investigation; Review thermal model, hydrogeological model, Site-wide water balance and site-wide water quality forecast with updated data; Install new thermistor(s) to evaluate the extent of the permafrost degradation; Evaluate additional treatment and storage capacity required to manage flow in operation (e.g. storing water in the pit); Evaluate potential long-term mitigations as depressurization wells, grouting, thermosiphon Review water management strategy.

4 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Quality Assurance (QA) refers to plans or programs that encompass a wide range of internal and external management and technical practices designed to ensure the collection of data of known quality that matches the intended use of the data. Quality Control (QC) is a specific aspect of QA that refers to the internal techniques used to measure and assess data quality. Specific QA and QC procedures that will be followed during sampling performed for the GWMP are described in Section 4.1 and 4.2.

4.1 QUALITY ASSURANCE

Quality assurance protocols will be diligently followed so data are of known, acceptable, and defensible quality. There are three areas of internal and external management, which are outlined in more detail below.

4.1.1 Field Staff Training and Operations

To make certain that field data collected are of known, acceptable, and defensible quality, field staff will be trained to be proficient in standardized field groundwater sampling procedures, data recording, and equipment operations applicable to the GWMP. All field work will be completed according to specified instructions and established technical procedures for standard sample collection, preservation, handling, storage and shipping protocols.

4.1.2 Laboratory

To make sure that high quality data are generated, accredited laboratories that will be selected for sample analysis. Accreditation programs are utilised by the laboratories so that performance evaluation assessments are conducted routinely for laboratory procedures, methods, and internal quality control.

4.1.3 Office Operations

A data management system will be utilized so that an organized consistent system of data control, data analysis, and filing will be applied to the GWMP. Relevant elements will include, but are not limited to the following:

- all required samples are collected;
- chain-of-custody and analytical request forms are completed and correct;
- proper labelling and documentation procedures are followed, and samples will be delivered to the appropriate locations in a timely manner;
- laboratory data will be promptly reviewed once they are received to validate data quality;
- sample data entered into a Mine-specific groundwater quality database will be compared to final laboratory reports to confirm data accuracy; and
- appropriate logic checks will be completed to ensure the accuracy of the calculations.

4.2 QUALITY CONTROL

The QC component will consist of applicable field and sample handling procedures, and the preparation and submission of two types of QC samples to the various laboratories involved in the program. The QC samples include blanks (e.g., travel, field, equipment) and duplicate/split samples.

Sample bottle preparation, field measurement and sampling handling QC procedures include the following:

- Sample bottles will be kept in a clean environment, capped at all times, and stored in clean shipping containers. Samplers will keep their hands clean, wear gloves, and refrain from eating or smoking while sampling.
- Where sampling equipment must be reused at multiple sampling locations, sampling equipment will be cleaned appropriately between locations.
- Temperature, pH, and specific conductivity will be measured in the field using hand held meters (e.g., YSI water quality sondes).
- Samples will be cooled to between 4°C and 10˚C as soon as possible after collection. Care will be taken when packaging samples for transport to the laboratory to maintain the appropriate temperature (between 4°C and 10˚C) and minimize the possibility of rupture. Where appropriate, samples will be treated with preservatives to minimize physical, chemical, biological processes that may alter the chemistry of the sample between sample collection and analysis.
- Samples will be shipped to the laboratory as soon as reasonably possible to minimize sample hold times. If for any reason, samples do not reach the laboratory within the maximum sample hold time for individual parameters, the results of the specific parameters will be qualified, or the samples will not be analysed for the specific parameters.
- Chain of custody sample submission forms will be completed by field sampling staff and will be submitted with the samples to the laboratory.
- Only staff with the appropriate training in the applicable sampling techniques will conduct water sampling.

Quality control procedures implemented will consist of the preparation and submission of QA/QC samples, such as field blanks, trip blanks, and split/duplicate water samples. These are defined as follows:

- Field Blank: A sample will be prepared in the field using laboratory-provided deionized water to fill a set of sample containers, which will then be submitted to the laboratory for the same analysis as the field water samples. Field blanks will be used to detect potential sample contamination during collection, shipping and analysis.
- Travel Blank: A sample will be prepared and preserved at the analytical laboratory prior to the sampling trip using laboratory-provided deionized water. The sample will remain unopened throughout the duration of the sampling trip. Travel blanks will be used to detect potential sample contamination during transport and storage.

- Duplicate Sample: Two samples will be collected from a sampling location using identical sampling procedures. They will be labelled, preserved individually and submitted for identical analyses. Duplicate samples will be used to assess variability in water quality at the sampling site. Duplicate will be collected and submitted for analyses at approximately, 10% of sampling locations. For smaller batches of samples (less than 10), at least one duplicate will be collected and submitted for analysis.

Additional QA/QC procedures that will be applied to the seepage survey component of the GWMP will include:

- Location – Universal Transverse Mercator (UTM) coordinates of seepage will be defined through the use of a hand-held Global Positioning System (GPS) unit and will be recorded in the field log book with a photograph of each pit wall.
- Sample Labels – appropriate sample nomenclature will be assigned to the sample labels that will define sample locations, sample type, year, and designation. These labels will distinguish between samples collected from seeps versus samples collected from sumps.

5 REFERENCES

Agnico Eagle (Agnico Eagle Mines Limited). 2017. Whale Tail Pit Water Management Plan. Version 1. January 2017.

Agnico Eagle. 2018. Whale Tail Pit Thermal Monitoring Plan. Version 1. May 2018.

Burn, C.R. 2002. Tundra lakes and permafrost, Richards Island, western Arctic coast, Canada. Can J Earth Sci 39: 1281-1298.

Burt, T.P. and Williams, P.J. 1976. Hydraulic Conductivity in Frozen Soils, Earth Surface Processes, Volume 1, John Wiley, pp. 349-360.

Golder (Golder Associates Ltd.). 2016a. Westbay System Installation Summary – Whale Tail Pit Project, Nunavut. Dated 7 July 2016.

Golder. 2016b. Groundwater Quality Investigation, Amaruq, Nunavut. Dated 31 November 2016.

Golder. 2017. Hydrogeological and Permafrost Field Investigation, Amaruq Project 2017 Factual Report. 31 July 2017.

Golder. 2018a. Whale Tail Pit Project, Post-closure Hydrogeological Assessment for the Whale Tail Open Pit. Reference No. 1789310-180-TM. 27 June 2018.

Golder. 2018b. Whale Tail Pit Post Closure Pit Lake Thermal Assessment. 30 July 2018.

Golder. 2018c, in preparation. Whale Tail Pit Project, Hydrodynamic Modelling of Whale Tail Pit Lake. Reference No. 1789310-181-TM.

Golder. 2019. 2018 Westbay System Groundwater Monitoring Investigation. 8 February 2019.

Knight Piesold Ltd. 2016. Geomechanical Site Investigation Summary, 12 December 2016.

McCauley, C.A, White, D.M, Lilly, M.R., and Nyman, DM. 2002. A comparison of hydraulic conductivities, permeabilities and infiltration rates in frozen and unfrozen soils. Cold Regions Science and Technology 34(2002). PP. 117-125.

SNC Lavalin. 2017. Preliminary Studies for the Water Management and Geotechnical Infrastructures at Amaruq, 2017 Geotechnical Investigation Factual Report. Dated 25 May 2017.

APPENDIX A – WHALE TAIL PIT POST-CLOSURE PIT LAKE THERMAL ASSESSMENT

GOLDER

TECHNICAL MEMORANDUM

DATE 30 July 2018 1789310-174-TM-Rev0

TO Jamie Quesnel
Agnico Eagle Mines Limited

CC Michel Groleau, Valérie Bertrand

FROM Colin McGrath, Jianfeng Chen, Don Chorley, and Serge Ouellet **EMAIL** Jianfeng_Chen@golder.com

WHALE TAIL PIT
POST-CLOSURE PIT LAKE THERMAL ASSESSMENT

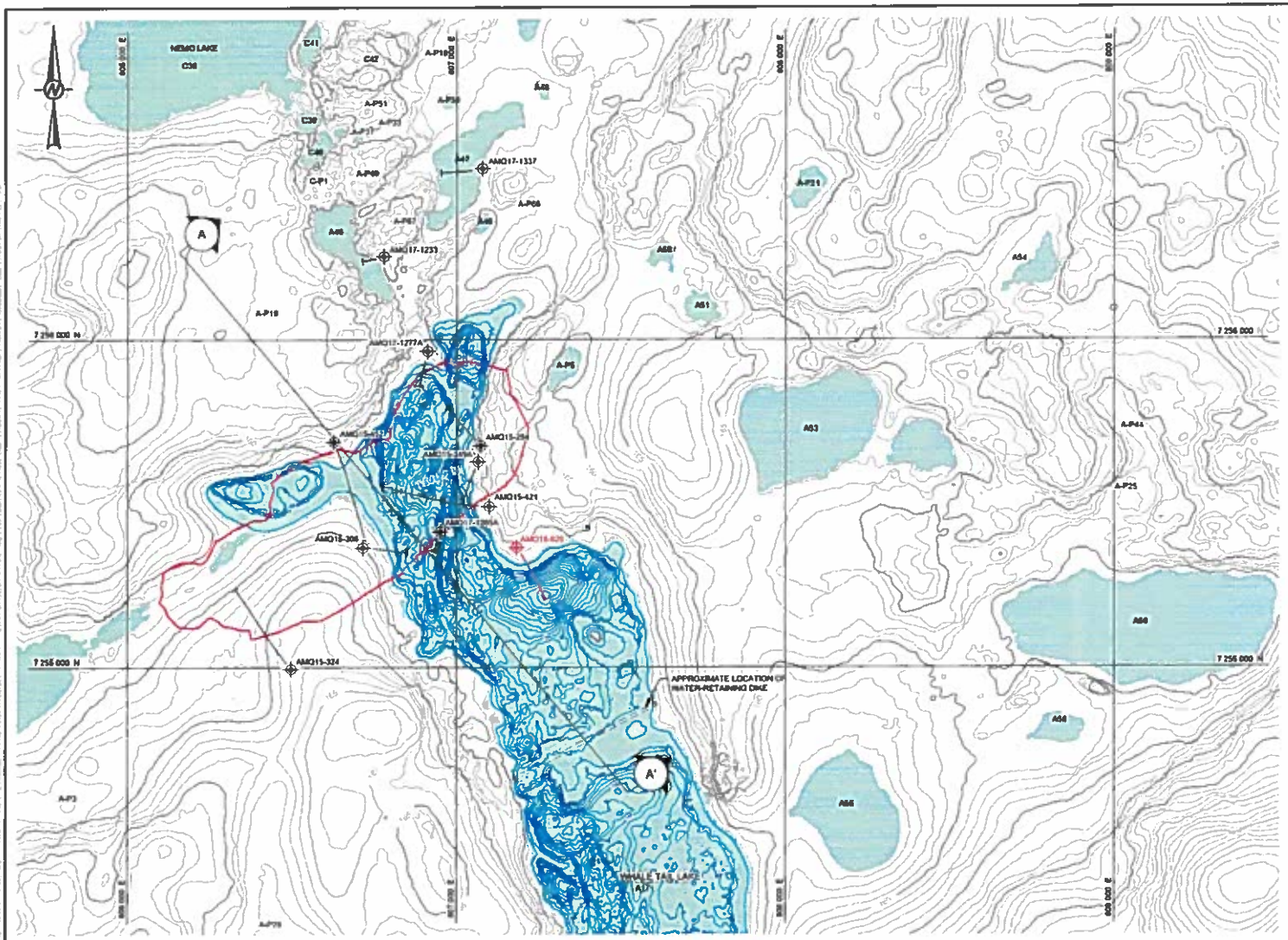
1.0 INTRODUCTION

Agnico Eagle Mines Limited (Agnico Eagle) is currently evaluating the potential development for mining the Whale Tail Pit Project (Project), a satellite deposit located on the Amaruq exploration property in Nunavut. The Amaruq property is a 408 km^2 site located in Inuit Owned Land approximately 150 km north of the hamlet of Baker Lake and approximately 50 km northwest of Agnico Eagle's operating Meadowbank Mine.

The following technical memorandum presents the assumptions and results of two-dimensional (2D) thermal analysis that was conducted in support of post-closure hydrogeological modelling for the Whale Tail Pit (Golder 2018a). The thermal analysis was conducted to evaluate how quickly the permafrost below Whale Tail Pit could melt following the formation of the Whale Tail Pit Lake during closure. The location of Whale Tail Pit is presented on Figure 1.

The thermal assessment included a review of the original Whale Tail Lake talik formation estimation based on available thermistor data at the time of the FEIS, the previous assessment completed by Golder (2017a), the current ground thermal conditions in the Whale Tail Lake area, and thermal changes during and after flooding the Whale Tail Pit.

This technical memorandum presents a summary of the updated evaluation of permafrost conditions based on the available thermistor data to October 2017, and the numerical modelling results of predicted thermal conditions under the Whale Tail Pit Lake post-closure.


MEMO LAKE
C38
C41
C42
A-P18
A-P19
A-P20
A-P21
A-P22
A-P23
C39
C40
A-P24
C-P1
A-P25
A-P26
A-P27
A-P28
A-P29
A-P30
A-P31
A-P32
A-P33
A-P34
A-P35
A-P36
A-P37
A-P38
A-P39
A-P40
A-P41
A-P42
A-P43
A-P44
A-P45
A-P46
A-P47
A-P48
A-P49
A-P50
A-P51
A-P52
A-P53
A-P54
A-P55
A-P56
A-P57
A-P58
A-P59
A-P60
A-P61
A-P62
A-P63
A-P64

2.0 BACKGROUND

The Project is located in the zone of continuous permafrost. The land surface of the Project is underlain by permafrost except under the lake where water is too deep to freeze to the bottom during winter. Taliks (areas of unfrozen ground) are expected beneath a water body where the water depth is greater than the ice thickness. Closed talik formations consist of a depression in the permafrost table below relatively shallower and smaller lakes. Open talik formations that penetrate through the permafrost and connect the lake waterbody with the sub-permafrost hydrogeological regime are to be expected for relatively deeper and larger lakes in the Project area.

A previous site investigation on the Project completed by Knight Piésold (Knight Piésold 2015) between June and October of 2015 included the installation of six thermistors in the vicinity of the proposed development of Whale Tail Lake to collect ground temperature data.

The project site permafrost conditions were initially assessed by Knight Piésold (2015). A further review on site thermistor data was carried out by Golder during the thermal assessment for the Whale Tail Lake, with a summary of the thermal conditions presented in Golder (2017a). An additional four thermistors were installed within the vicinity of Whale Tail Lake in 2017 by Golder.

Based on site investigation data, soils in the project area are typically medium to coarse grained glacial till and colluvium with high coarse fragment content overlying bedrock at shallow depths. The six thermistor boreholes drilled in 2015 indicated soil thicknesses varying from 6.1 to 12.4 m. Review of existing data indicates the soil thicknesses varying from about 1 m to 12 m in the proposed waste rock storage facility area located northwest of the proposed pit. Underlying the soil, bedrock in the area generally consists of a stratigraphic sequence of greywacke, komatiite, and ultramafics, with varying thicknesses.

A mean annual air temperature for the site is of -11.3 °C, based on climate data provided by Agnico Eagle (Golder 2016a, Agnico Eagle 2016). Climate normal for Baker Lake between 1981 and 2000 shows a mean annual air temperature of -11.2 °C (Golder 2017b). Table 1 presents a summary of average air temperature at the site and at the Baker Lake climate station. The mean monthly temperatures of the two sets of data are similar. Mean monthly temperatures from Meadowbank site based on camp site data from 1997 to 2003 is included in the table for comparison (Golder 2003). The Meadowbank data gives a similar annual average of -11.1 °C.

Table 1: Mean Monthly Air Temperatures

	Whale Tail Project (Golder 2016a, Agnico Eagle 2016)	Meadowbank Project (1997 - 2003) (Golder 2003)	Baker Lake Climate Normal (1981 to 2000)
Unit	**°C**	**°C**	**°C**
January	-31.3	-31.6	-31.2
February	-31.1	-31.7	-31.0
March	-26.3	-25.5	-26.2
April	-17.0	-17.2	-17.0
May	-6.4	-5.6	-6.3
June	4.9	3.8	4.8
July	11.6	12.4	11.6
August	9.8	9.9	9.8
September	3.1	3.3	3.1
October	-6.5	-7.6	-6.4
November	-19.3	-18.0	-19.3
December	-26.8	-25.6	-26.5
Average	**-11.3**	**-11.1**	**-11.2**

3.0 SITE PERMAFROST CONDITIONS

The following sections present a summary of site-specific permafrost conditions based on the available thermistor data.

3.1 Thermistor Installation

The locations of the existing thermistors are shown in Figure 1; Table 2 presents a summary of thermistor data obtained to date.

Table 2: Thermistor Location and Installation Summary

Borehole	Collar Coordinates					Drilled Length (m)	Thermistor	Status[c]
	Northing	Easting	Elevation	Inclination (deg)	Azimuth (deg)		Depth Below Ground Surface (m)	
AMQ15-294	607,073.2	7,255,676.1	155.9	-45.18	322.7	220.5	144.4	Functioning
AMQ15-306	606,714.8	7,255,363.8	154.9	-45.41	96.3	201.0	141.5	Functioning[b]
AMQ15-324	606,496.8	7,254,995.2	161.8	-55.46	325.5	505.0	317.4	Functioning
AMQ15-349A	607,064.9	7,255,627.5	155.3	-45.32	204.4	202.5	140.6	Not functioning
AMQ15-421	607,098.3	7,255,490.8	155.1	-51.31	273.9	501.0	388.3	Not functioning
AMQ15-452	606,627.2	7,255,687.9	156.2	-49.98	159.5	501.0	382.3	Functioning
AMQ17-1265A	606,950.1	7,255,413.6	152.5	-80.0	196.0	425.0	349.6[a]	Functioning
AMQ17-1233	606,777.7	7,256,253.8	161.9	-59.06	252.7	156.0	132.4	Functioning
AMQ17-1337	607,078.4	7,256,522.0	155.2	-59.62	260.4	250.0	218.0	Functioning
AMQ17-1277A	606,911.1	7,255,963.6	153.2	-60.17	193.1	250.0	217.4	Functioning

a) Depth below lake water (ice) level.
b) Only the top node is functioning.
c) Based on information provided by Agnico Eagle in April 2018

3.2 Thermistor Data Summary

Table 3 presents a summary of the permafrost information estimated from the ten thermistors on site. The parameters were estimated using average values from September 2015 to October 2017. Ground temperature plots for the thermistor data is presented in Attachment 1.

Based on the thermistor data, the findings on the permafrost characteristics in the project area remain similar to those presented in Golder (2017a), with following updates:

- The thermistor AMQ17-1337 suggested deeper permafrost in the area away from deep lakes of up to 495 m, compared to the 427 m depth from the thermistor AMQ15-324
- The temperatures at the depths of zero amplitude changed slightly, they are now in the range of -3.0 °C to -8.4 °C (-3.1 °C to -8.6 °C reported in Golder 2017a)
- The thermistor AMQ17-1265A installed within the lake suggests the talik depth at this location is about 112 m from the lake water level

No additional groundwater quality and freezing point depression data were provided during this assessment; these are assumed to remain unchanged since the last assessment (Golder 2016b).

Table 3: Summary of Permafrost Conditions from Site Thermistors

Hole ID	Approx. Collar Distance to Lake (m)	Thermistor Location	Zero Annual Amplitude		Mean Annual Ground Temperature (°C)[a]	Geothermal Gradient (°C/m)	Estimated Permafrost Depth (metres below ground or lake surface)
			Approximate Depth (m)	Approximate Temperature (°C)			
AMQ15-294	31	Beneath Whale Tail Lake	19	-3.0	-3.5	Insufficient depth	Insufficient depth
AMQ15-306	55	Beneath Whale Tail Lake	20	-7.4	-8.1	Insufficient depth	Insufficient depth
AMQ15-324	370	On land	35	-8.4	-9.9	0.025[b]	427
AMQ15-349A	40	Beneath Whale Tail Lake	18	-5.2	-5.2	Insufficient depth	Insufficient depth
AMQ15-421	40	Beneath Whale Tail Lake	24	-3.6	-3.9	0.005[c]	445
AMQ15-452	50	Beneath Whale Tail Lake	23	-3.6	-3.4	0.011[d]	468
AMQ17-1265A	0 (within Whale Tail Lake)	Beneath Whale Tail Lake	N/A	N/A	N/A	0.016[e]	343 (including 112 m lake talik)
AMQ17-1233	21	Beneath A49 Lake	Insufficient depth	Insufficient depth	Insufficient depth	Insufficient depth	Insufficient depth
AMQ17-1337	12	Beneath A47 Lake	Insufficient depth	Insufficient depth	-9.5	0.019[f]	495
AMQ17-1277A	29	Beneath Whale Tail Lake	Insufficient depth	Insufficient depth	Insufficient depth	Insufficient depth	Insufficient depth

a) Estimated by projecting best fit line to surface.
b) Based on thermistor data from 105.1 to 282.1 m depth.
c) Based on thermistor data below 271.8 m depth.
d) Based on thermistor data below 248.4 m depth.
e) Based on thermistor data below 290.5 m depth.
f) Based on thermistor data below 166.2 m depth.

4.0 PIT LAKE THERMAL MODEL

Two-dimensional thermal modelling was carried out using the finite element program, TEMP/W, of GeoStudio 2007 (Ver. 7.23), developed by GEO-SLOPE International Ltd. This section presents the model scenarios, input parameters, and assumptions.

Golder previously conducted thermal modelling to evaluate the permafrost and talik conditions in the Whale Tail Lake and project area (Golder 2017a), and conducted thermal modelling for the cover of the Whale Tail waste rock storage facility (Golder 2017b, 2018b). A number of model parameters used in these assessments were adopted for this pit lake thermal modelling.

For the purpose of providing input to the pit hydrogeological modelling, the section A shown in Figure 1 was selected for thermal modelling of the post-closure pit lake. The modelling included the following steps.

- Evaluate the current condition of permafrost regime under Whale Tail Lake by reviewing of the existing thermistor data and the 2017 Whale Tail Lake thermal assessment results (Golder 2017a).
- Estimate the ground thermal conditions when the Whale Tail Pit is mined out, for use as the initial condition.
- Run a transient thermal model with the pit being flooded based on the proposed flooding schedule, to estimate the evolution of the permafrost regime during flooding at closure. The model stops when most of the permafrost under the pit lake thaws.
- Continue running the model to evaluate long-term permafrost regime, after the water-retaining dike is breached, and the Whale Tail Lake (South Basin) and the fully flooded Whale Tail Pit Lake are merged.
- Run a steady-state thermal model for the pit lake to estimate the ultimate permafrost regime.

4.1 Material Properties

Consistent with Golder (2017a), for the purposes of this thermal assessment, each model assumed a uniform thickness of 12 m of till overlying bedrock both on land and under the lake, except the pit lake. No lake bed sediment or weathered bedrock materials were included in the models. It is expected that the material properties of the bedrock will have a more significant effect on the thermal conditions than the soil due to the relative thickness of the soil compared to the bedrock. Material properties and depths used in the thermal models are summarized in Table 4. The material thermal properties were referenced from typical values presented in Andersland and Ladanyi (2004) and are consistent with Golder (2017a and b).

Table 4: Material Thermal Properties Used in the Models

Material	Assumed Volumetric Water Content	Thermal Conductivity (W/m-°C)		Volumetric Heat Capacity (MJ/m^3-°C)		Assumed Depth Below Ground surface (m)
		Frozen	Unfrozen	Frozen	Unfrozen	
Till	30%	1.8	1.5	2.0	2.5	0 to 12
Bedrock	1%	3.0	3.0	2.0	2.0	>12

The thermal models were solved considering groundwater with a phase change temperature of 0 °C. The addition of salinity in the groundwater would result in a freezing point depression and could lower the phase change temperature to below 0 °C if salinity is high enough. The freezing point depression was not modelled directly. A Westbay well system is installed in borehole AMQ16-626. Groundwater samples collected from the Westbay system at depths from 276 m to 392 m indicated a salinity range of 0.3% to 0.4% (Golder 2016b). This salinity level indicates an approximate 0.2 °C of freezing point depression and is considered to have minor impact to the evolution of the thermal regime around the pit lake.

4.2 Boundary Conditions

4.2.1 Ground Surface Temperature

The monthly ground surface temperature function was estimated through numerical modelling using daily climate data from Baker Lake, and review of existing thermistor data from the Whale Tail site (Golder 2017b). Ground surface temperatures are often observed to be warmer than the air temperatures in permafrost regions. Figure 2 shows the ground surface temperature function used in the model, as well as the Baker Lake normal air temperatures from 1981 to 2010. The mean annual ground temperature is about -7.3 °C, which lies in the range of -3.4 to -9.9 °C, projected from the thermistor data (Table 3) and is considered to be reasonable for use in the transient model.

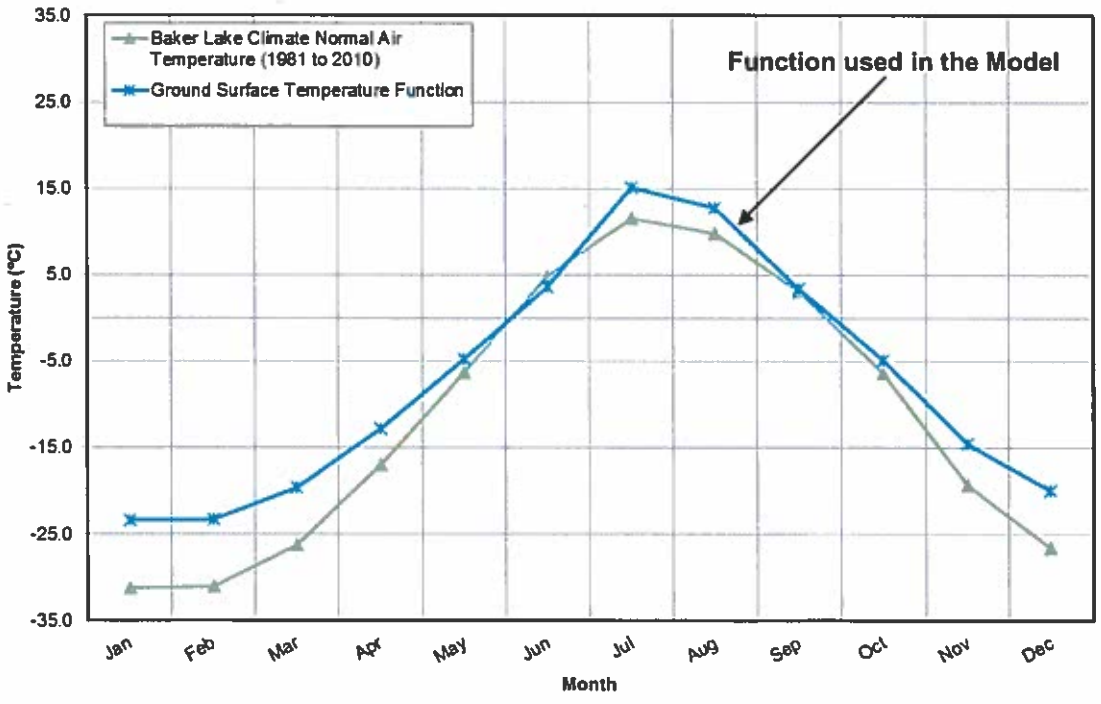


Figure 2: Monthly Air and Ground Surface Temperature Functions

4.2.2 Geothermal Gradient

A geothermal heat flux of 0.048 J/sec was applied to the models as the lower boundary condition based on the assumed bedrock thermal conductivity of 3.0 W/m-°C and a geothermal gradient of 0.016°C/m (Golder 2017a). This thermal gradient is consistent with the one estimated during the Meadowbank Project baseline study (Golder 2003).

4.2.3 Pit Lake Bottom Temperature

Typically, a mean annual lake bottom temperature is related to water depth in a permafrost region: the deeper the lake, the higher the expected mean annual lake bottom temperature. The mean annual lake bottom temperature is typically higher than the mean annual ground surface temperature in a permafrost region.

Deep pit lake temperatures tend to stabilize near +4°C at which the maximum water density typically occurs for fresh water and low salinity water. An assessment of the variation of the pit lake temperature was not carried out at this stage. A review of measured pit lake bottom temperatures from Pieters and Lawrence (2014) and Crusius et al. (2002) indicates the following:

- +3.5°C at about 110 m depth for Zone 2 Pit Lake at Colomac Mine located 250 km north of Yellowknife, NWT
- +5°C at about 90 m depth for Faro Pit Lake at Faro Mine near Faro, Yukon
- +4.5°C at about 60 m depth for Grum Pit Lake at Faro Mine near Faro, Yukon
- +4.2°C at about 50 m depth for Vangorda Pit Lake at Faro Mine near Faro, Yukon
- +5.2°C at about 120 m depth at Main Zone Pit Lake at Equity Mine near Houston, BC
- +5.5°C at about 40 m depth at Waterline Pit Lake at Equity Mine near Houston, BC

For the purpose of the modelling, the Whale Tail Pit Lake was assumed to have a constant mean annual bottom temperature of +4°C in all models based on the above review. Due to the depth of the proposed Whale Tail Pit Lake, meromictic conditions are expected to develop. When meromictic conditions are present, mixing of the surface and deep water is inhibited (stratification) which results in a stable bottom temperature.

For the relatively shallow lake area near the proposed water-retaining dike (Whale Tail Dike), a constant temperature of +2°C was assumed for the lake bottom.

4.3 Model Scenario and Assumptions

Pit flooding was adopted according to the mine schedule adopted in the 3D hydrogeological model at the time of the FEIS (Appendix 6-B of the FEIS). This 3D hydrogeological model also forms the basis of the post-closure prediction of groundwater inflows to the flooded pit lake. This thermal model was designed to provide reasonable assumptions for a conservative approach to melting of permafrost for the groundwater modelling. Since the FEIS, some changes in filling schedule have been potentially identified; however, for the scale of analysis being adopted and evaluated in the post-closure hydrogeological analysis, these changes will not significantly affect predictions of groundwater inflow quantity and quality to the pit lake. Pit flooding was assumed in the FEIS to commence in 2022 and was expected to reach the top of the pit / base of Whale Tail Lake (138 masl) in 2025. Subsequent re-flooding of Whale Tail Lake (North Basin) will continue until 2028. The assumed yearly water elevations during flooding is shown in Figure 3, and Table 5.

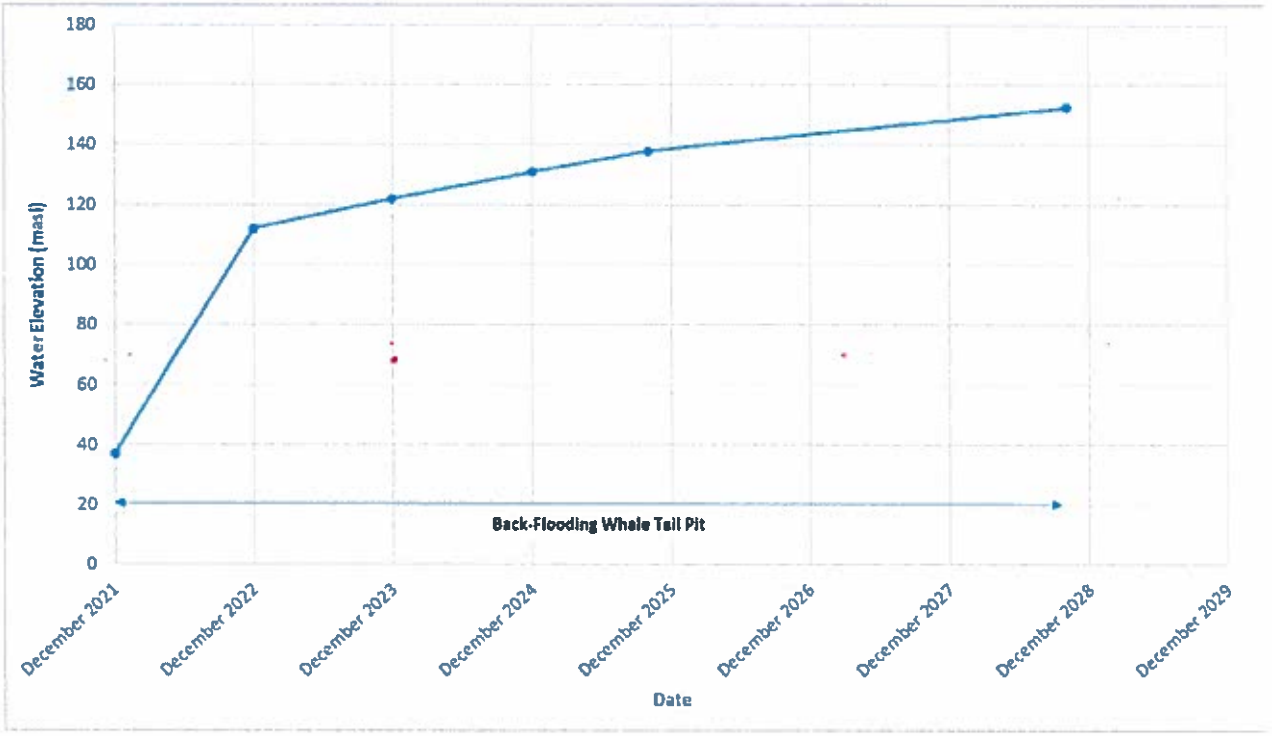


Figure 3: Whale Tail Pit Flooding Schedule from FEIS

The modelling scenario was developed to simulate the proposed Whale Tail Pit flooding elevations from years 1 to 7 as presented in Table 5.

Table 5: Thermal Model Back-Flooding Elevations

Year	Whale Tail Pit Back-Flooding Elevation (masl)
1	112
2	122
3	131
4	138
7	152.5

The post-closure pit lake and Whale Tail Lake are assumed to maintain the elevation of 152.5 masl.

The modelling was completed up to 300 years from start of flooding for the section through the centreline of the ultimate pit configuration. The model used the ground surface temperature function and a daily time step without consideration for any climate change. This hypothetical scenario assumed climatic conditions in 300 years remain similar to current site conditions.

The thermal modelling was completed to support the post-closure groundwater modelling in which the time to penetrate through the permafrost beneath the proposed Whale Tail Pit Lake was required. Climate change may accelerate slightly the warming progress of the upper ground thermal regime. This is considered to be insignificant for the purpose of supporting the hydrogeological study and therefore consideration for climate change was not included in the thermal model.

4.4 Thermal Conditions Prior to Flooding

Section A is located within Whale Tail Lake, in the longitudinal direction. Modelling the entire section is not expected to be appropriate to estimate the initial thermal conditions before pit flooding, as the lateral thermal impacts from surrounding colder ground cannot be accounted for in two dimensions. Instead, the initial thermal regime along section A was interpolated by modelling a steady-state condition of the northern terrace at the proposed Whale Tail Pit, the ground temperature data from thermistor AMQ17-1265A, and previous thermal analysis of the Whale Tail Lake completed by Golder (2017a). Based on the ground temperature profile from AMQ17-1265A, the extent of permafrost is expected to occur from El. 40.8 masl to -191 masl at the southeast side of the pit on section A. The assumed initial conditions are presented on Figure 2-1 of Attachment 2.

For the purpose of this assessment, the majority of the thermal regime prior to mining was assumed to be the same as when the mining is complete due to the short duration of mining. Some freeze-back during the pit mining is expected and was estimated to form a part of the initial thermal condition for the post-closure period.

5.0 SUMMARY OF MODEL RESULTS FOR THE POST-CLOSURE PERIOD

Post closure thermal modelling and hydrogeological analysis was not completed as part of the FEIS. In response to an information request regarding post closure groundwater flow, thermal modelling has been carried out to provide input to the hydrogeological study for post closure. The modelling was specifically conducted to evaluate how quickly the permafrost below Whale Tail Pit could melt following the formation of the Whale Tail Pit Lake during closure.

Several assumptions were made for the thermal modelling to evaluate when the permafrost below the pit could melt. The model results are presented in Figures 2-1 to 2-6 of Attachment 2 including:

- The assumed initial thermal conditions prior to pit flooding.
- Thermal conditions during the pit flooding in closure.
- Zero degree isolines at select years of post-closure, up to year 300.
- Steady-state thermal conditions for the post-closure pit lake.

The following findings are based on the model results:

- During pit flooding, the warm pit lake temperature impacts mostly the upper portion of the permafrost under the pit, and talik zones starts to occur around the pit wall and floor.
- The permafrost under the pit lake continues to thaw during the long term post-closure stage, and the open talik expands from the lake side (south) to the land side (north). The majority of the permafrost under the pit lake is thawed 300 years after closure.

- The steady-state model indicates the pit lake would thaw the permafrost in the long-term, and eventually reduce the permafrost depth under the ground northwest of the pit. A significantly longer time (in the order of 10,000 years) is likely required for the pit lake to reach the steady-state thermal conditions.

6.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this technical memorandum.

We trust this document satisfies you current requirements. If you have any questions or require further assistance, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

REGISTERED PROFESSIONAL ENGINEER
30/Jul/2018
J.F. CHEN
LICENSEE
NT/NU

Colin McGrath
Junior Geotechnical Specialist

Jianfeng Chen, M.Sc., P.Eng. (NT/NU)
Geotechnical Engineer

Don Chorley, M.Sc., P.Geo.
Senior Hydrogeologist

Serge Ouellet, Ph.D., P.Eng. (NT/NU)
Senior Environmental Engineer

CM/JFC/DC/VJB/jr

Attachments: Study Limitations
Attachment 1: Thermistor Readings
Attachment 2: Thermal Model Results

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature
Date 31 July 2018
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

https://golderassociates.sharepoint.com/sites/19830g/1000_phase1commitments/reports_all subphases/thermal modelling/rev0/1789310-174-tm-rev0-phase1whaletailpit post-closure thermal.docx

REFERENCES

Agnico Eagle (Agnico Eagle Mines Limited). 2016. Meadowbank Mine – Amendment/Reconsideration of the Project Certificate (No.004/File No. 03MN107) and Amendment to the type A Water Licence (No. 2AM-MEA1525). Volume 8, Appendix 8-B.2. Submitted to the Nunavut Impact Review Board, 30 June 2016.

Andersland, O.B. and Ladanyi, B. 2004. Frozen Ground Engineering. 2nd edition, John Wiley & Sons, Inc.

Crusius J, Pieters R, Leung A, Whittle P, Pedersen T, Lawrence GA, McNee JJ. 2002. A Tale of Two Pit Lake: Initial Results of a Three-Year Study of the Main Zone and Waterline Pit Lakes Near Houston, BC. 2002 SME Annual Meeting, Feb. 25 – 27, Phoenix Arizona, USA.

Golder (Golder Associates Ltd.). 2003. Report on Permafrost Thermal Regime Baseline Studies, Meadowbank Project, Nunavut. Golder Project No. 03-1413-078. Prepared for Cumberland Resources Ltd. Submitted 18 December 2003.

Golder. 2016a. Water Management and Water Balance Related to Amaruq Exploration Portal/Ramp Program, Quarry and Advanced Underground Exploration and Bulk Sample, Amaruq Exploration Site, Nunavut. Golder Doc. No. 069-1665859 Ver 0. Prepared for Agnico Eagle Mines Ltd. Submitted 15 November 2016.

Golder. 2016b. Groundwater Quality Investigation, Amaruq, Nunavut. Golder Document No. 080-1649355. Prepared for Agnico Eagle Mines Ltd. Submitted 15 November 2016.

Golder. 2017a. Whale Tail Lake Thermal Assessment. Golder Reference No. 1665859-085-TM-Rev0-5100. Prepared for Agnico Eagle Mines Ltd. Submitted 22 February 2017.

Golder. 2017b. Commitment 39: Whale Tail Pit Project Waste Rock Storage Facility Cover Thermal Assessment. Golder Reference No. 1774579-124-TM-Rev0-2500. Prepared for Agnico Eagle Mines Ltd. Submitted 10 July 2017.

Golder. 2018a. Whale Tail Pit Post-closure Hydrogeological Assessment for the Whale Tail Open Pit. Reference No. 1789310-180-TM. June 2018.

Golder. 2018b. Whale Tail Pit Project Waste Rock Storage Facility Cover Thermal Assessment. Reference No. 1789310_177_TM_Rev0. June 2018

Knight Piésold. 2015. Agnico Eagle Mines Ltd.: Meadowbank Division – Whale Tail Pit – Permafrost and Hydrogeological Characterization. Submitted 24 November 2015.

Pieters R, Lawrence GA. 2014. Physical Processes and Meromixis in Pit Lakes Subject to Ice Cover. Canadian Journal of Civil Engineering. 41(6):569-578.

STUDY LIMITATIONS

Golder Associates Ltd. (Golder) has prepared this document in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this document. No warranty, express or implied, is made.

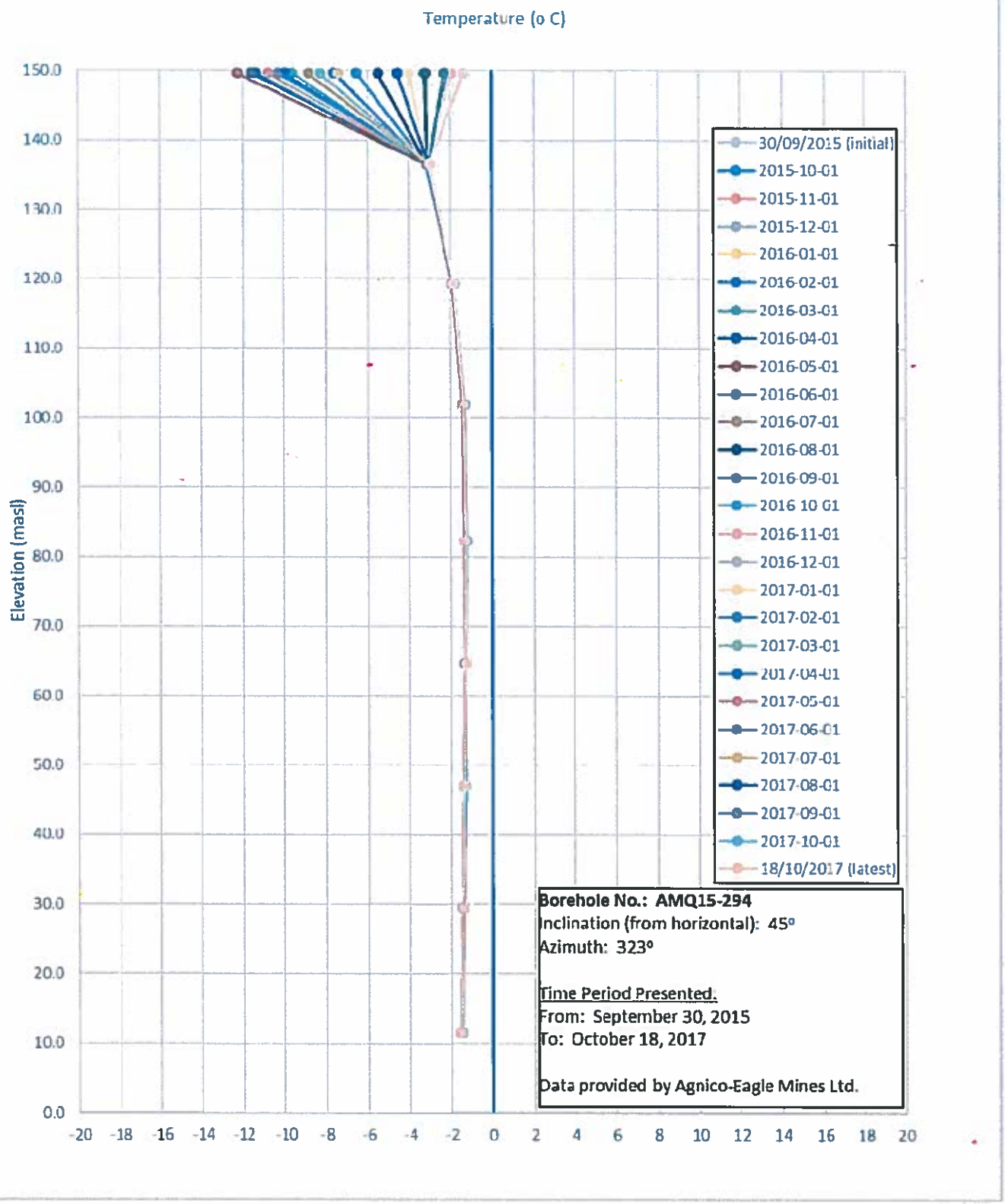
This document, including all text, data, tables, plans, figures, drawings and other documents contained herein, has been prepared by Golder for the sole benefit of Agnico Eagle Mines Limited It represents Golder's professional judgement based on the knowledge and information available at the time of completion. Golder is not responsible for any unauthorized use or modification of this document. All third parties relying on this document do so at their own risk.

The factual data, interpretations, suggestions, recommendations and opinions expressed in this document pertain to the specific project, site conditions, design objective, development and purpose described to Golder by Agnico Eagle Mines Limited, and are not applicable to any other project or site location. In order to properly understand the factual data, interpretations, suggestions, recommendations and opinions expressed in this document, reference must be made to the entire document.

This document, including all text, data, tables, plans, figures, drawings and other documents contained herein, as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder. Agnico Eagle Mines Limited. may make copies of the document in such quantities as are reasonably necessary for those parties conducting business specifically related to the subject of this document or in support of or in response to regulatory inquiries and proceedings. Electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore no party can rely solely on the electronic media versions of this document.

ATTACHMENT 1

Thermistor Readings



NOTE: Readings are shown once per month for clarity.

CLIENT
AGNICO EAGLE MINES LTD.

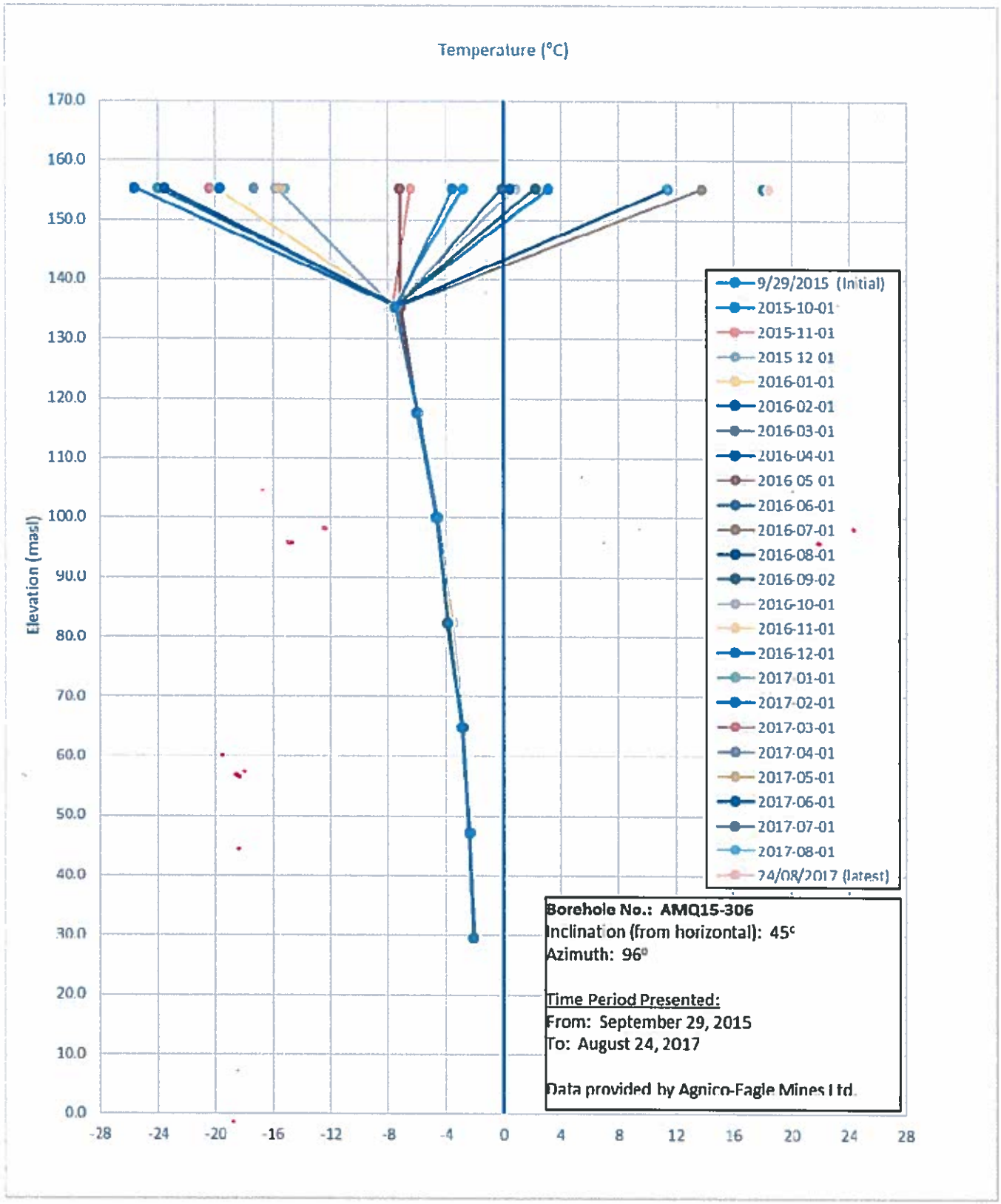
PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

TITLE
THERMISTOR AMQ15-294 2015/2017 READINGS

PROJECT No	PHASE/TASK	Rev	FIGURE
1789310	1000/12020	0	1-1



NOTE: Readings are shown once per month for clarity.

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

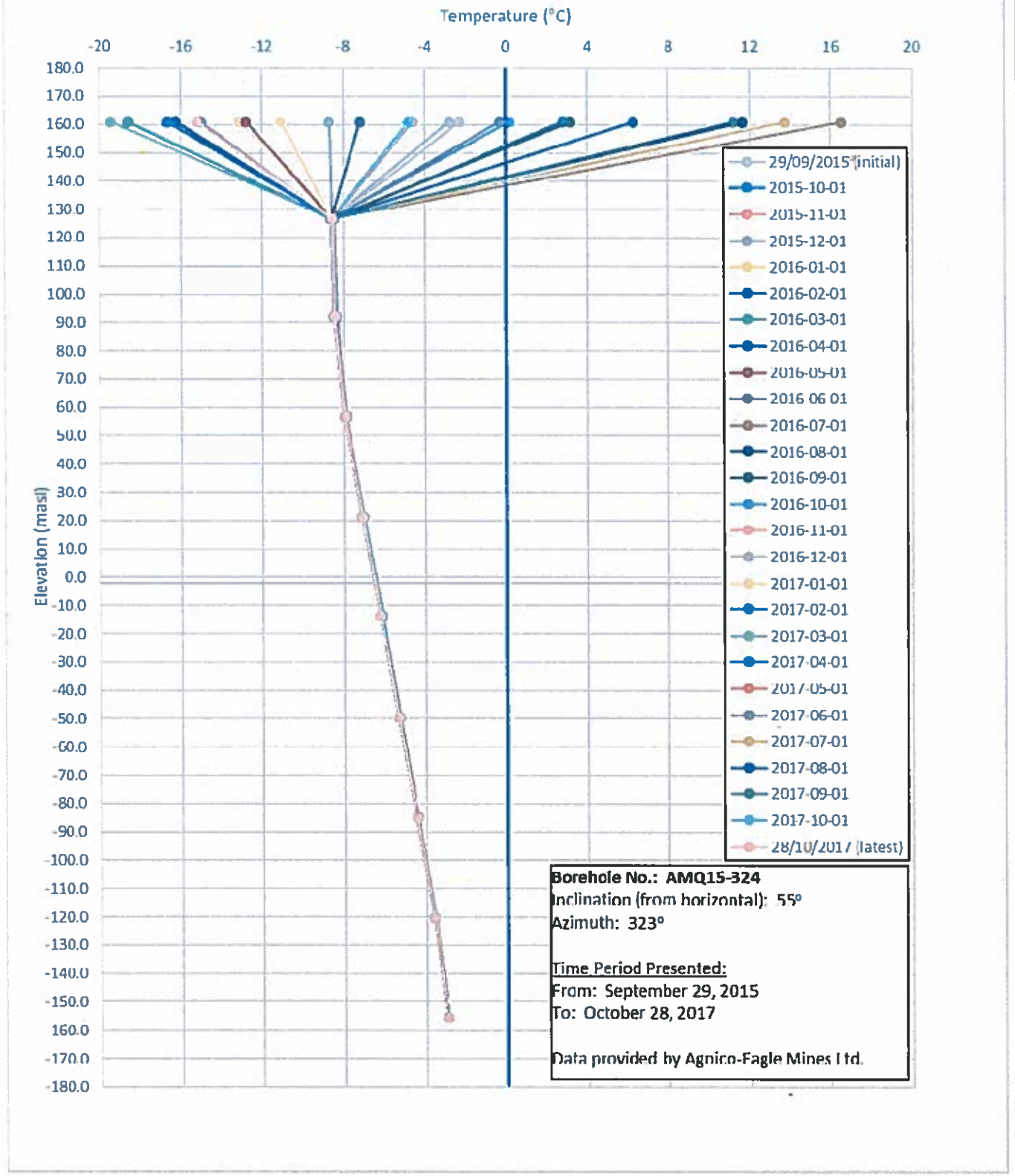
YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

TITLE
THERMISTOR AMQ15-306 2015/2017 READINGS

PROJECT No.	PHASE/TASK	Rev.	FIGURE
1789310	1000/12020	0	1-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



NOTE: Readings are shown once per month for clarity.

CLIENT
AGNICO EAGLE MINES LTD.

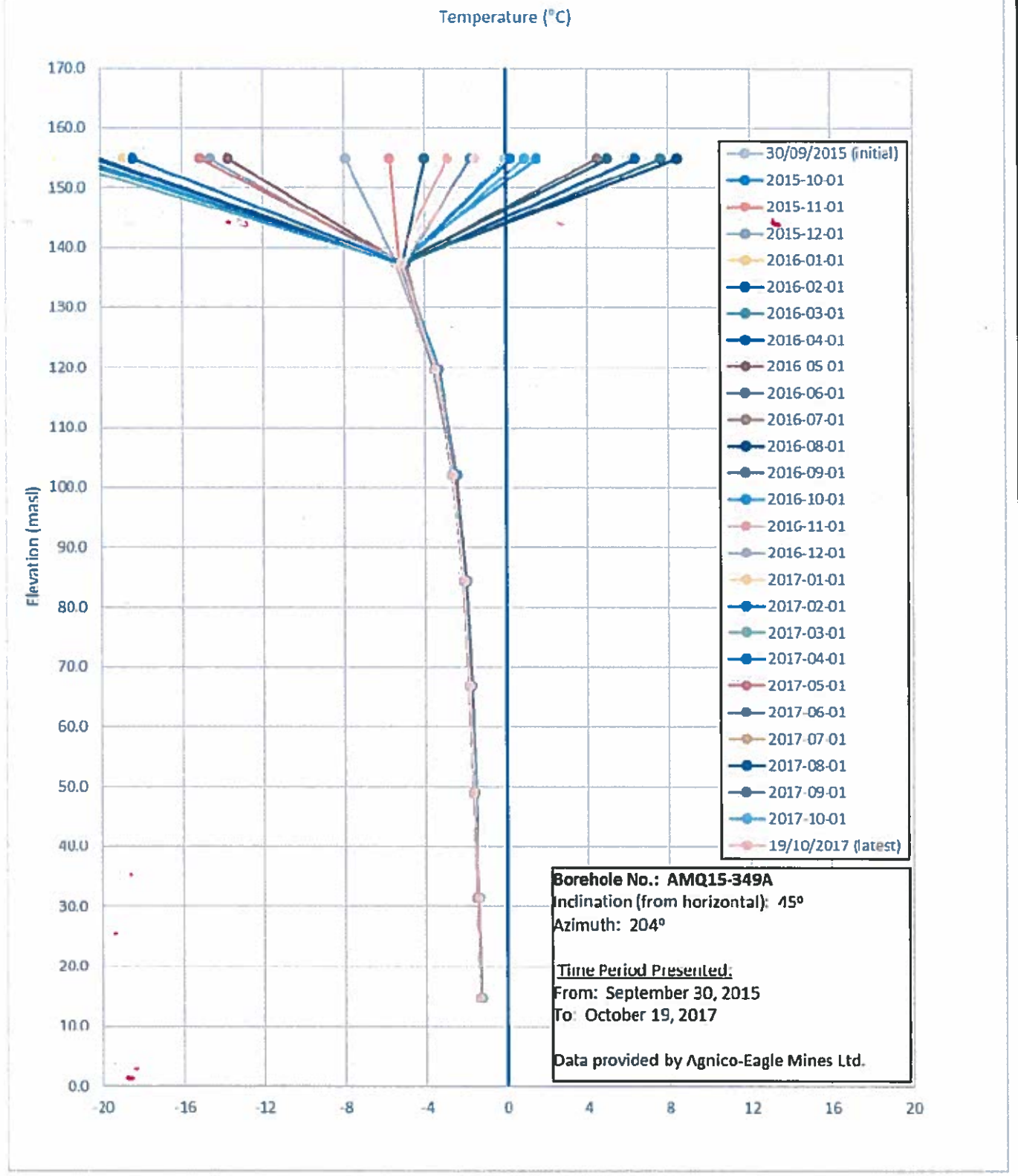
CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

TITLE
THERMISTOR AMQ15-324 2015/2017 READINGS

PROJECT No.	PHASE/TASK	Rev.	FIGURE
1789310	1000/12020	0	1-3



NOTE: Readings are shown once per month for clarity.

CLIENT
AGNICO EAGLE MINES LTD.

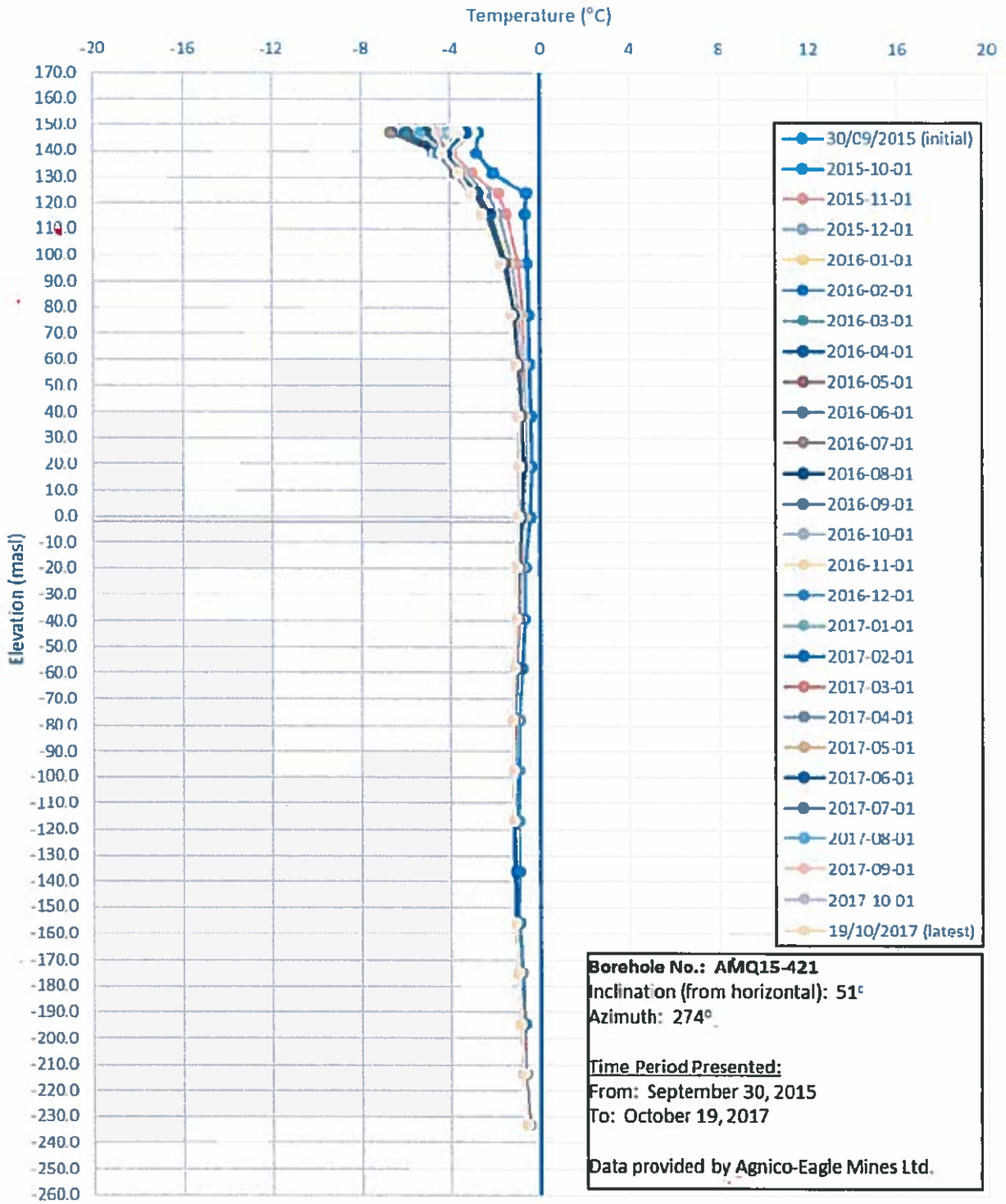
CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

TITLE
THERMISTOR AMQ15-349A 2015/2017 READINGS

PROJECT No	PHASE/TASK	Rev	FIGURE
1789310	1000/12020	0	1-4



Borehole No.: AMQ15-421
Inclination (from horizontal): 51°
Azimuth: 274°

Time Period Presented:
From: September 30, 2015
To: October 19, 2017

Data provided by Agnico-Eagle Mines Ltd.

NOTE: Readings are shown once per month for clarity.

CLIENT
AGNICO EAGLE MINES LTD.

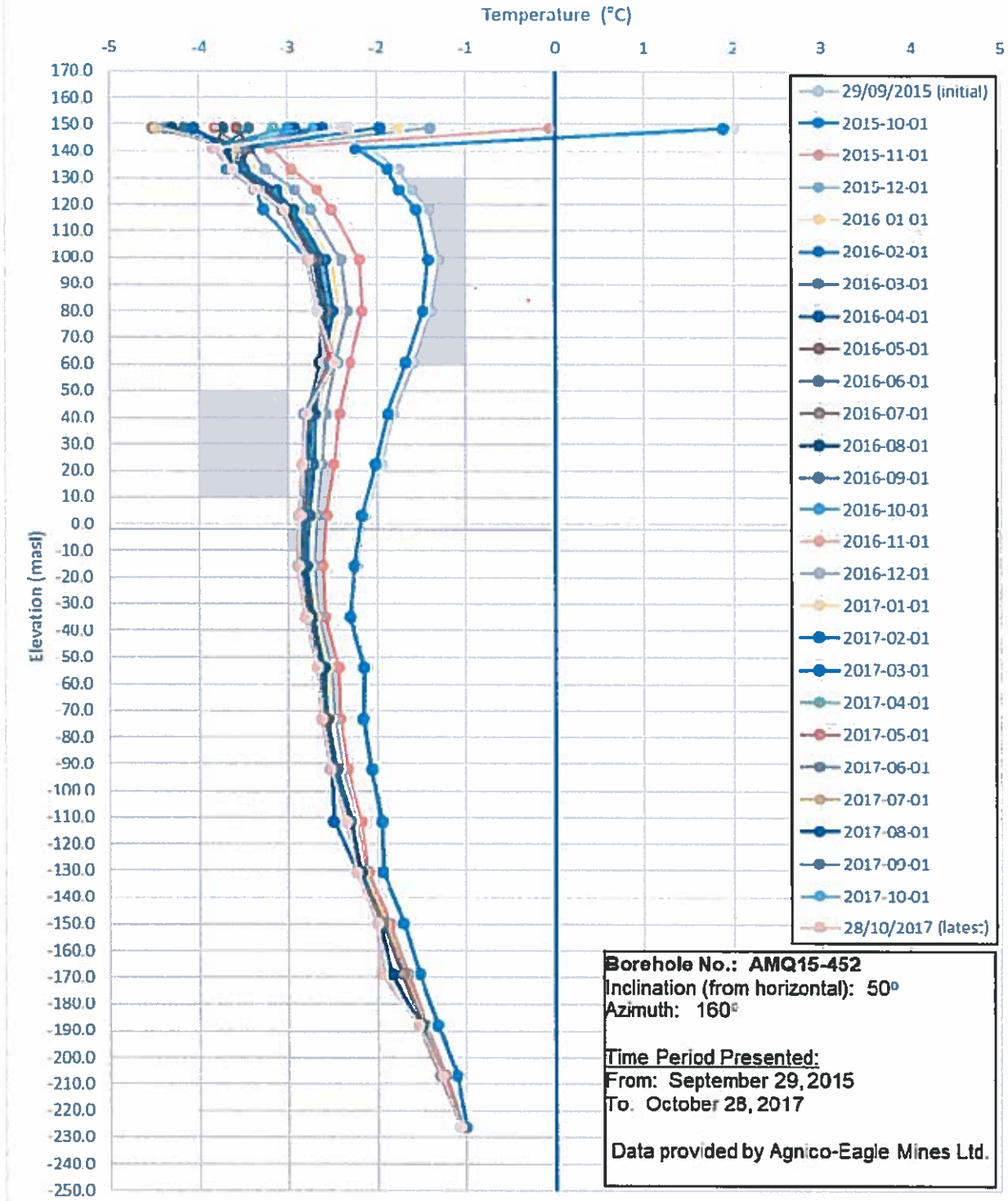
PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

TITLE
THERMISTOR AMQ15-421 2015/2017 READINGS

PROJECT No	PHASE/TASK	Rev	FIGURE
1789310	1000/12020	0	1-5



NOTE: Readings are shown once per month for clarity.

CLIENT
AGNICO EAGLE MINES LTD.

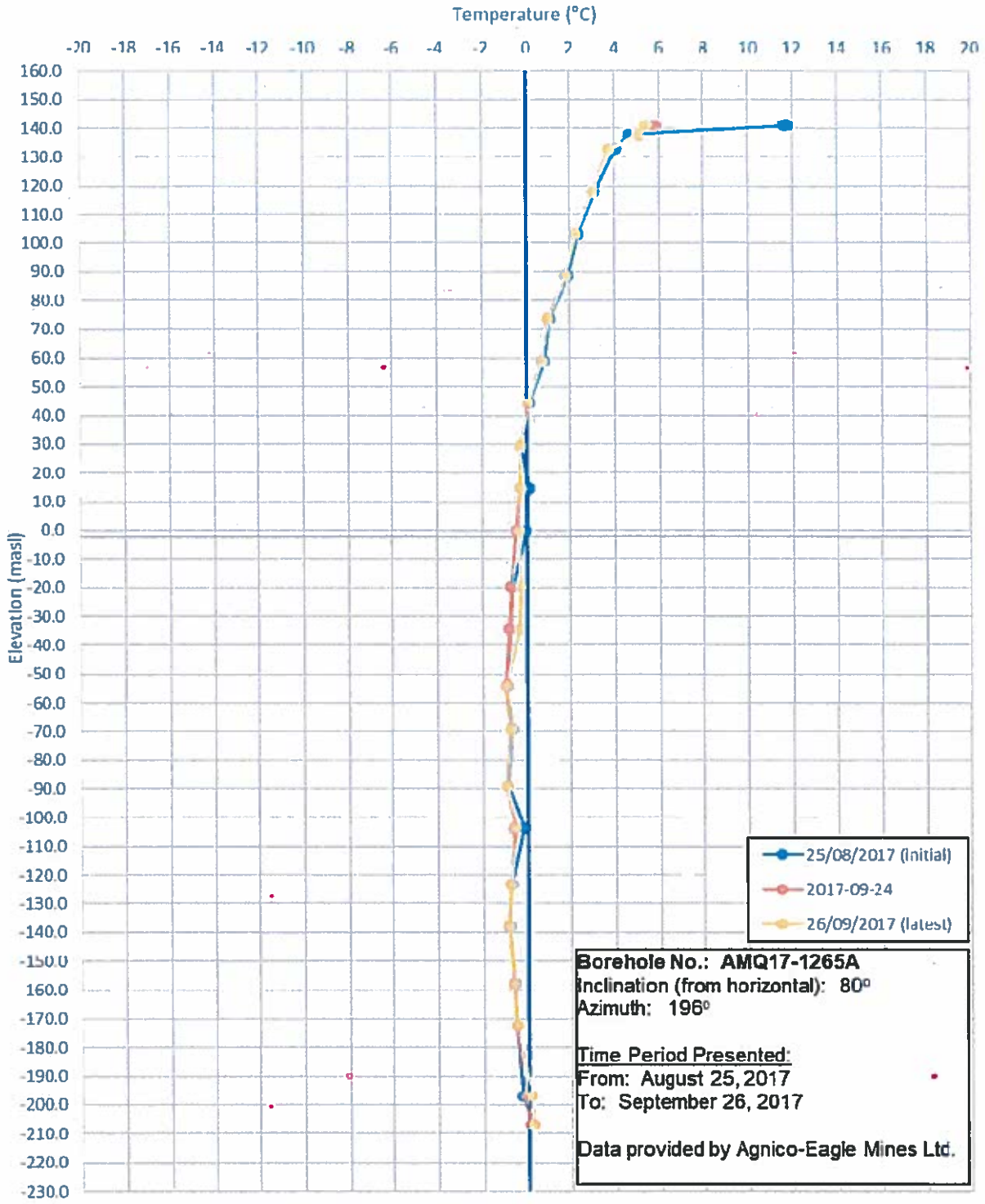
CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

TITLE
THERMISTOR AMQ15-452 2015/2017 READINGS

PROJECT No	PHASE/TASK	Rev	FIGURE
1789310	1000/12020	0	1-6



CLIENT
AGNICO EAGLE MINES LTD.

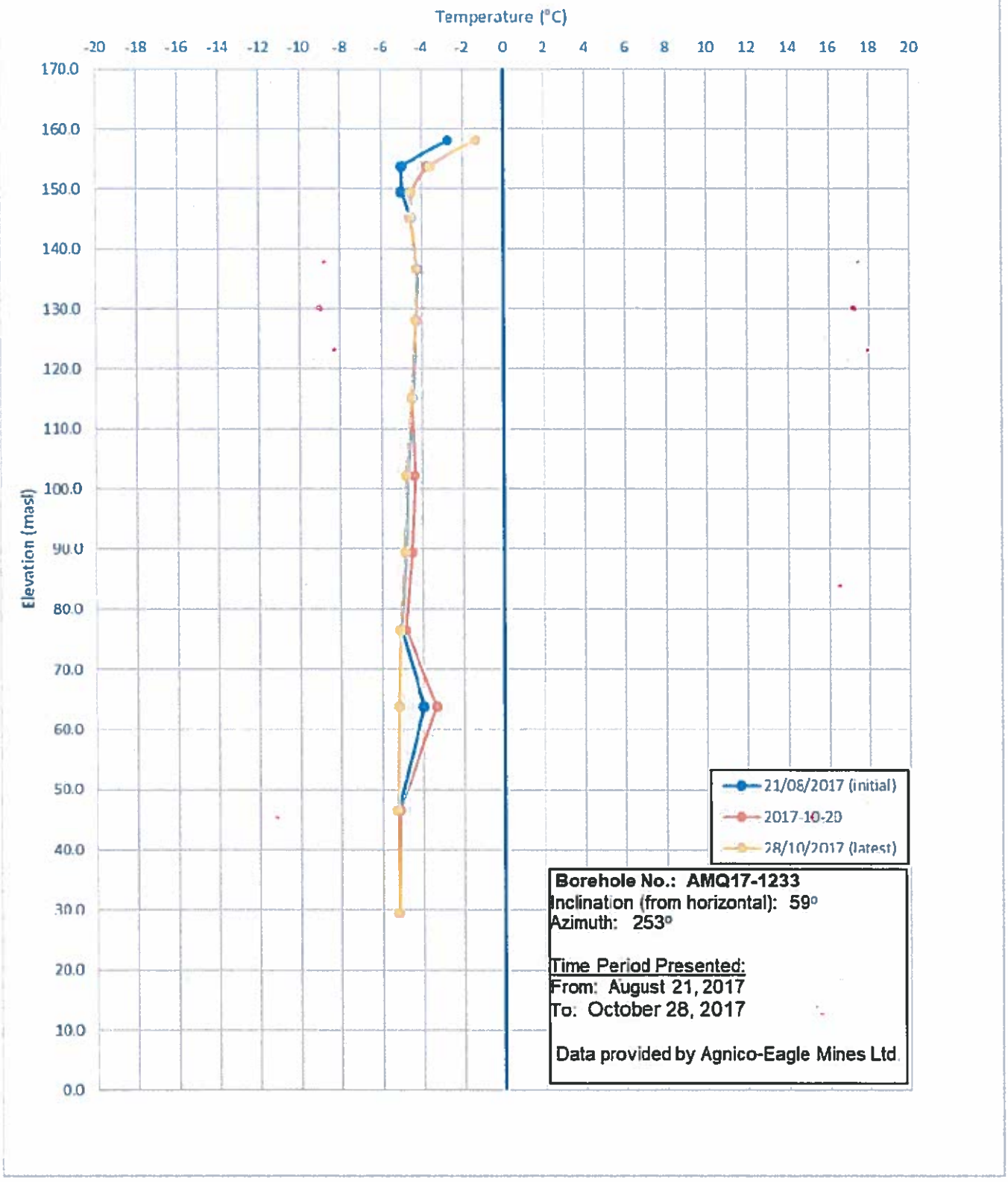
CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

TITLE
THERMISTOR AMQ17-1265A 2017 READINGS

PROJECT No	PHASE/TASK	Rev	FIGURE
1789310	1000/12020	0	1-7



CLIENT
AGNICO EAGLE MINES LTD.

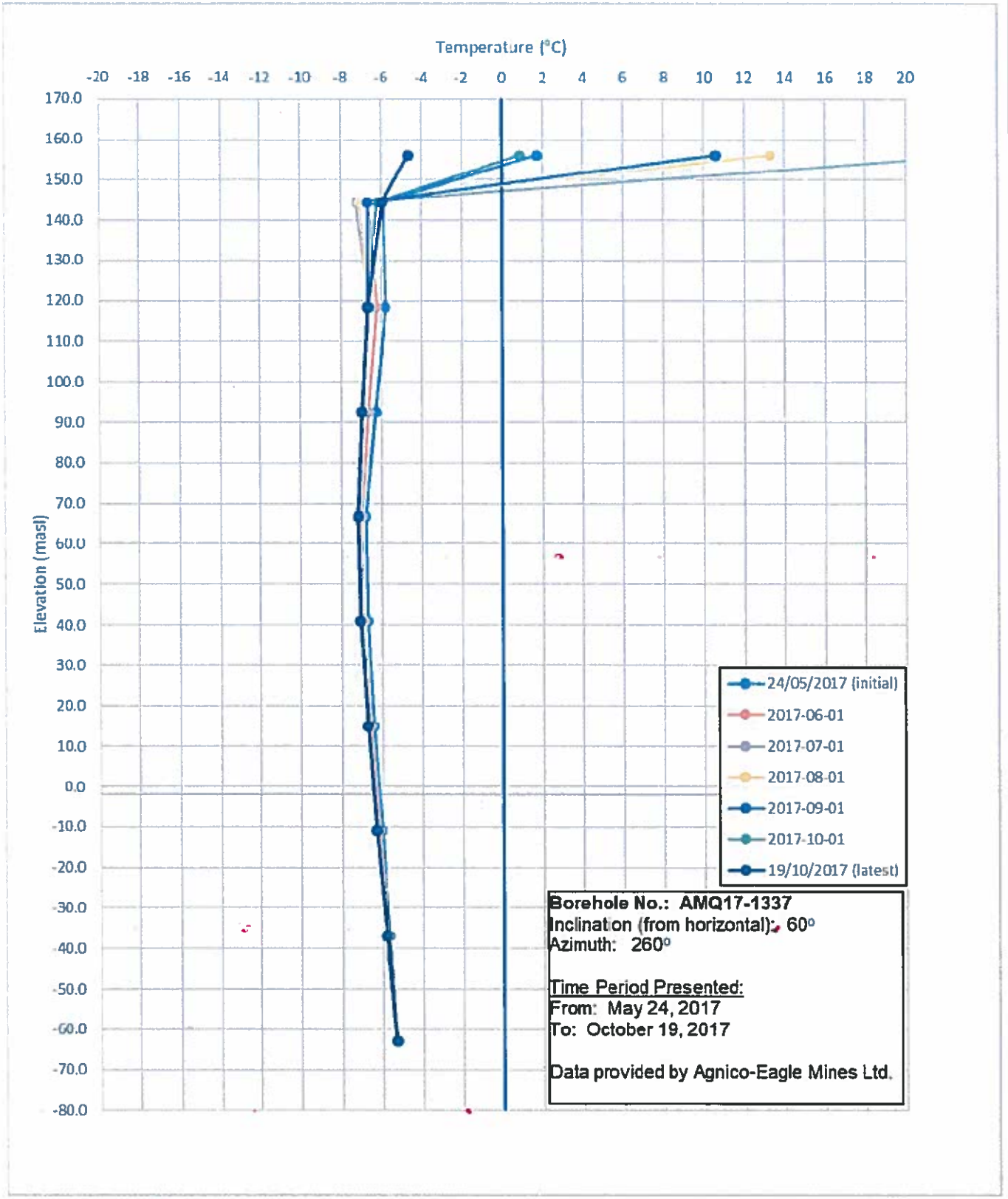
CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

TITLE
THERMISTOR AMQ17-1233 2017 READINGS

PROJECT No	PHASE/TASK	Rev	FIGURE
1789310	1000/12020	0	1-8



NOTE: Readings are shown once per month for clarity.

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

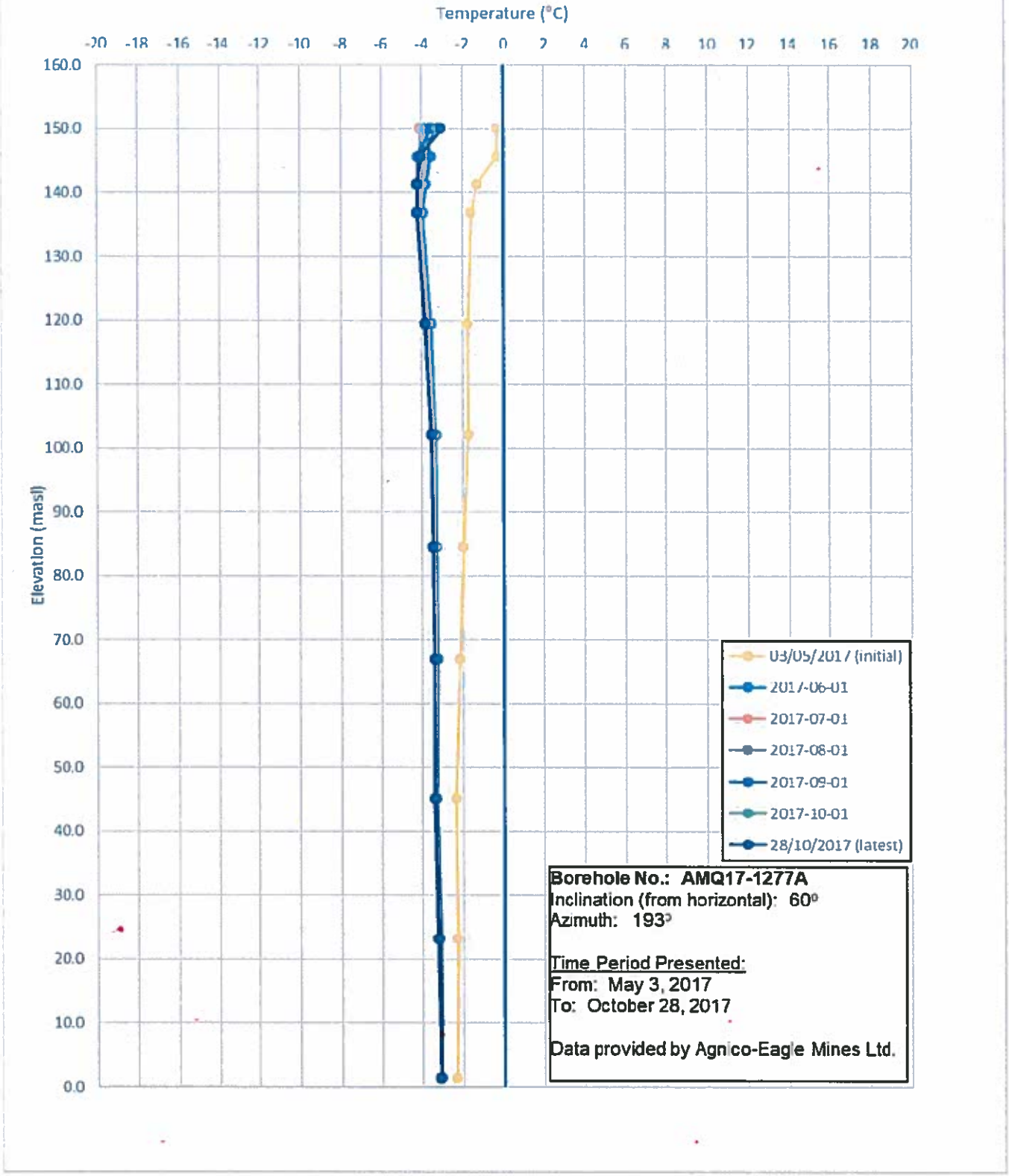
YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

TITLE
THERMISTOR AMQ17-1337 2017 READINGS

PROJECT No	PHASE/TASK	Rev	FIGURE
1789310	1000/12020	0	1-9

© THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



NOTE: Readings are shown once per month for clarity.

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-19
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
WHALE TAIL LAKE THERMAL ASSESSMENT
NUNAVUT

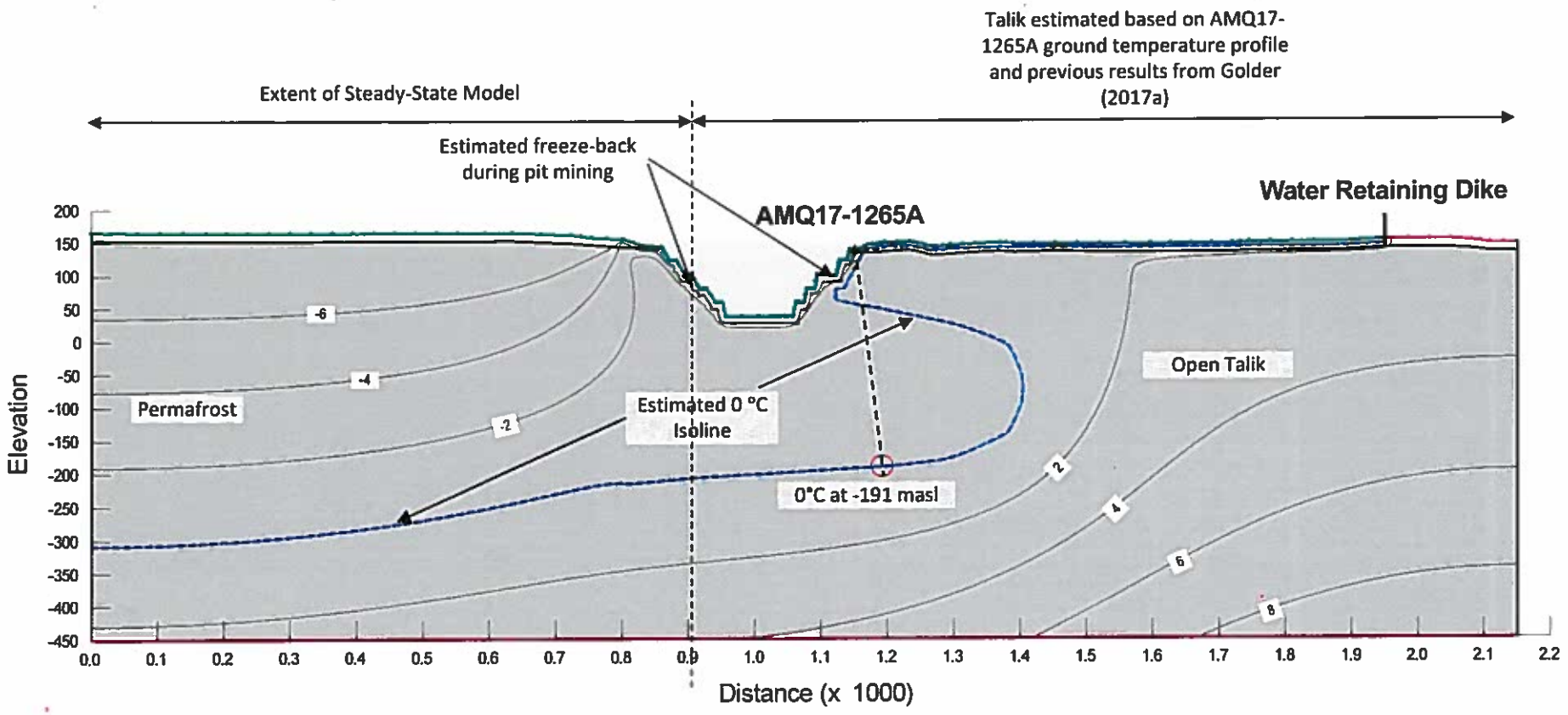
TITLE
THERMISTOR AMQ17-1277A 2017 READINGS

PROJECT No.	PHASE/TASK	Rev.	FIGURE
1789310	1000/12020	0	1-10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

ATTACHMENT 2

Thermal Model Results



File Name: Phase 1 Section.gsz

Notes

1. Location of thermistor AMQ17-1265A is approximate.
2. Temperature contour interval 2 °C.

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

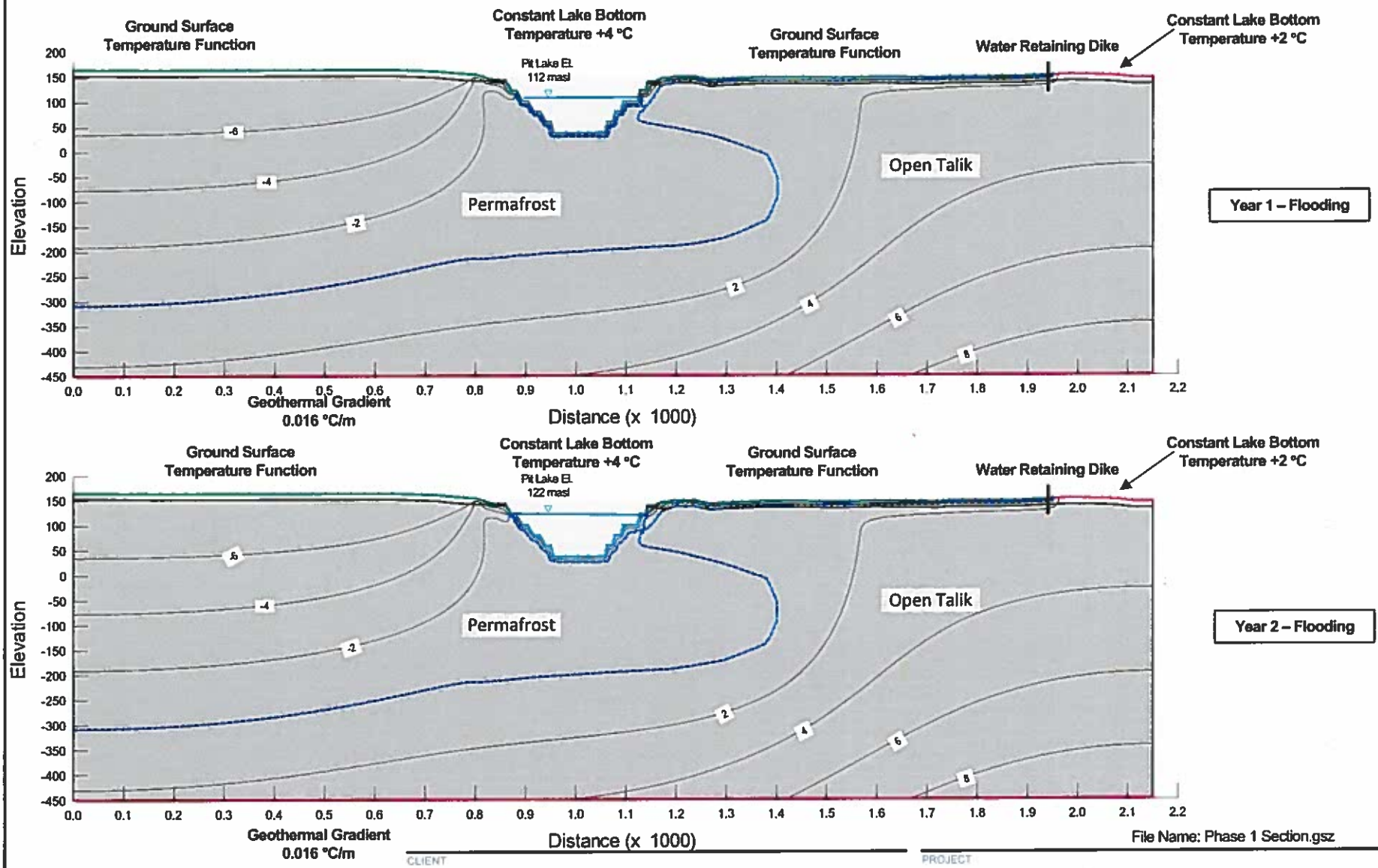
YYYY-MM-DD	2018-04-03
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
POST-CLOSURE PIT LAKE THERMAL ANALYSIS
NUNAVUT

TITLE
TRANSIENT THERMAL MODELLING
ASSUMED INITIAL CONDITION
BEFORE PIT FLOODING

PROJECT No	Phase/Task	Rev	Figure
1789310	1000/12020	0	2-1

Path: D:\Active\20163 Proj\1685859 Agnico Eagle_Water Mgmt_Whale Tail\1789310_ThermalThermal Analysis



File Name: Phase 1 Section.gsz

Notes

1. Location of thermistor AMQ17-1265A is approximate.
2. Temperature contour interval 2 °C.

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

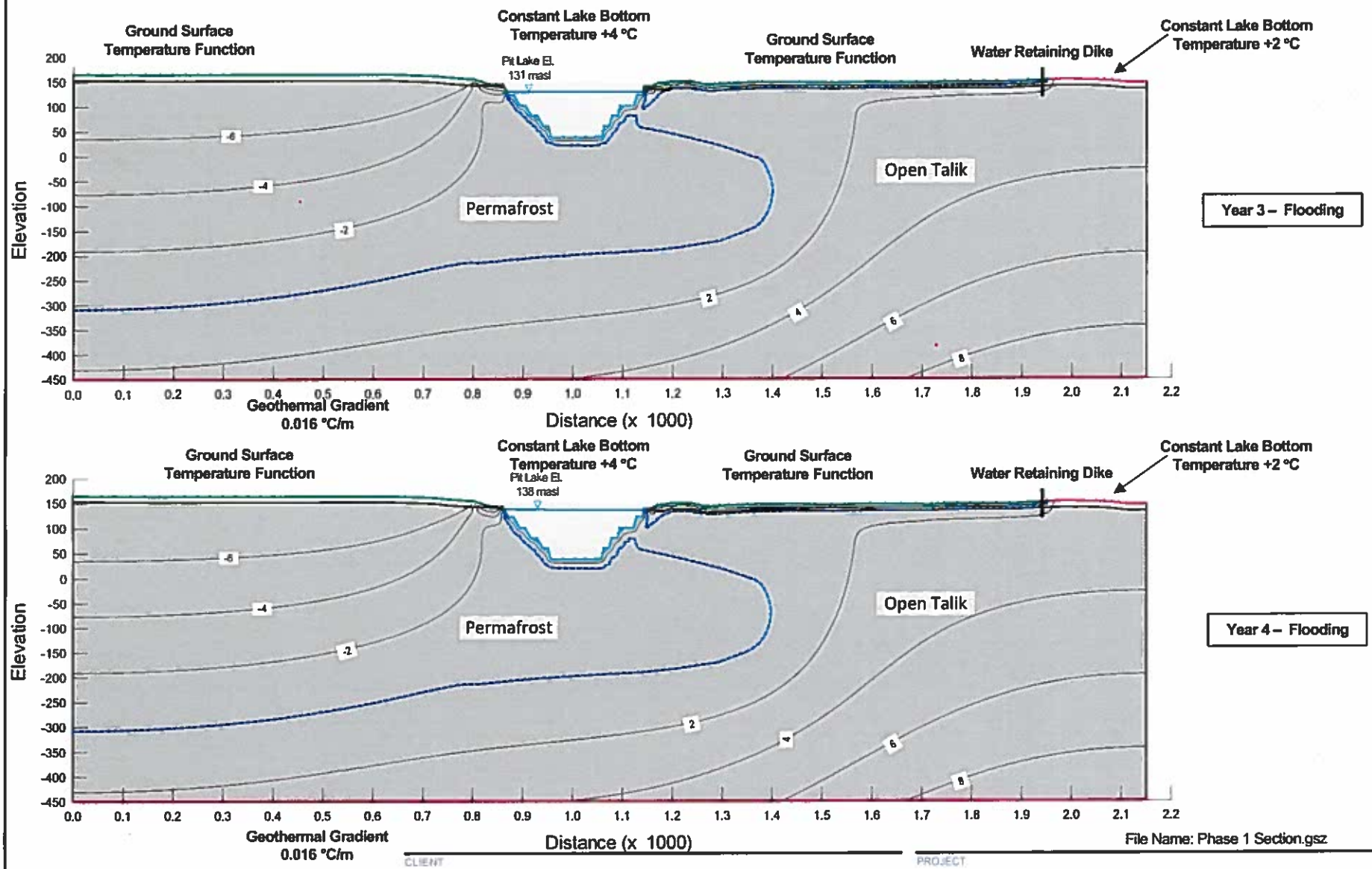
YYYY-MM-DD	2018-04-03
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
POST-CLOSURE PIT LAKE THERMAL ANALYSIS
NUNAVUT

TITLE
TRANSIENT THERMAL MODELLING
PIT FLOODING
YEARS 1 & 2

PROJECT No	Phase/Task	Rev	Figure
1789310	1000/12020	0	2-2

Path: O:\Active\2016\3 Proj\1665859 Agnico Eagle_Water Mgmt_Whale Tail\1789310_Thermal\Thermal Analysis



File Name: Phase 1 Section.gsz

Notes

1. Location of thermistor AMQ17-1265A is approximate.
2. Temperature contour interval 2 °C.

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

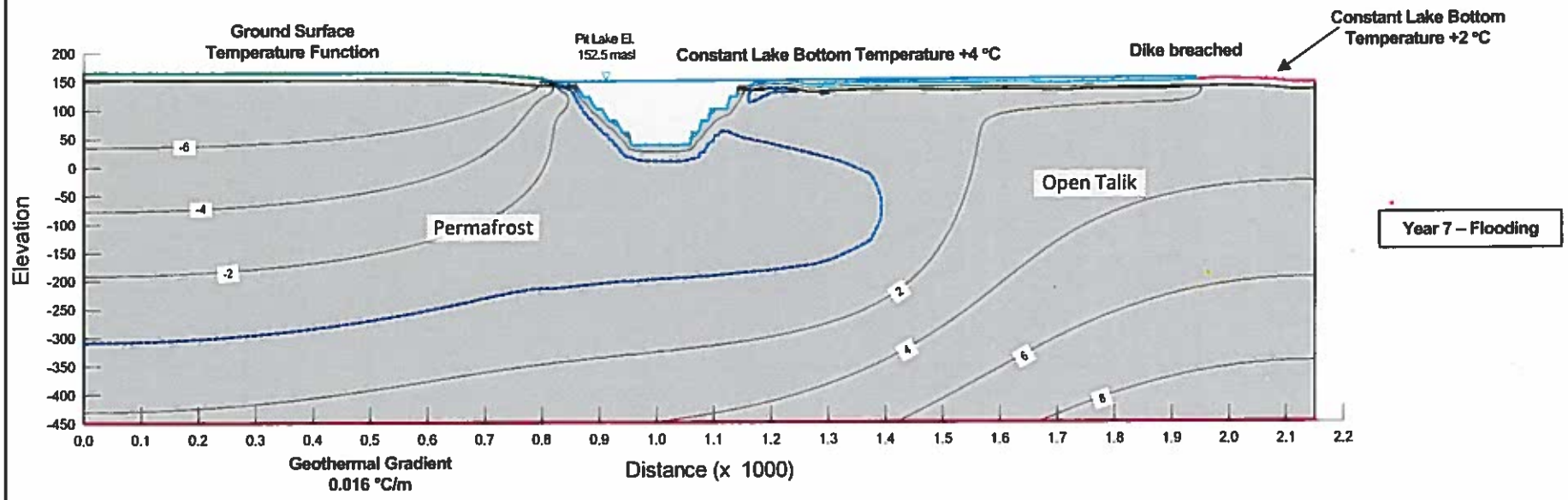
YYYY-MM-DD	2018-04-03
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
POST-CLOSURE PIT LAKE THERMAL ANALYSIS
NUNAVUT

TITLE
TRANSIENT THERMAL MODELLING
PIT FLOODING
YEARS 3 & 4

PROJECT No.	Phase/Task	Rev.	Figure
1789310	1000/12020	0	2-3

Path: O:\Active\20183 Proj\1665859 Agnico Eagle_Water Mgmt_Whale Tail\1789310_ThermalThermal Analysis



Notes

1. Location of thermistor AMQ17-1265A is approximate.
2. Temperature contour interval 2 °C.

File Name: Phase 1 Section.gsz

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

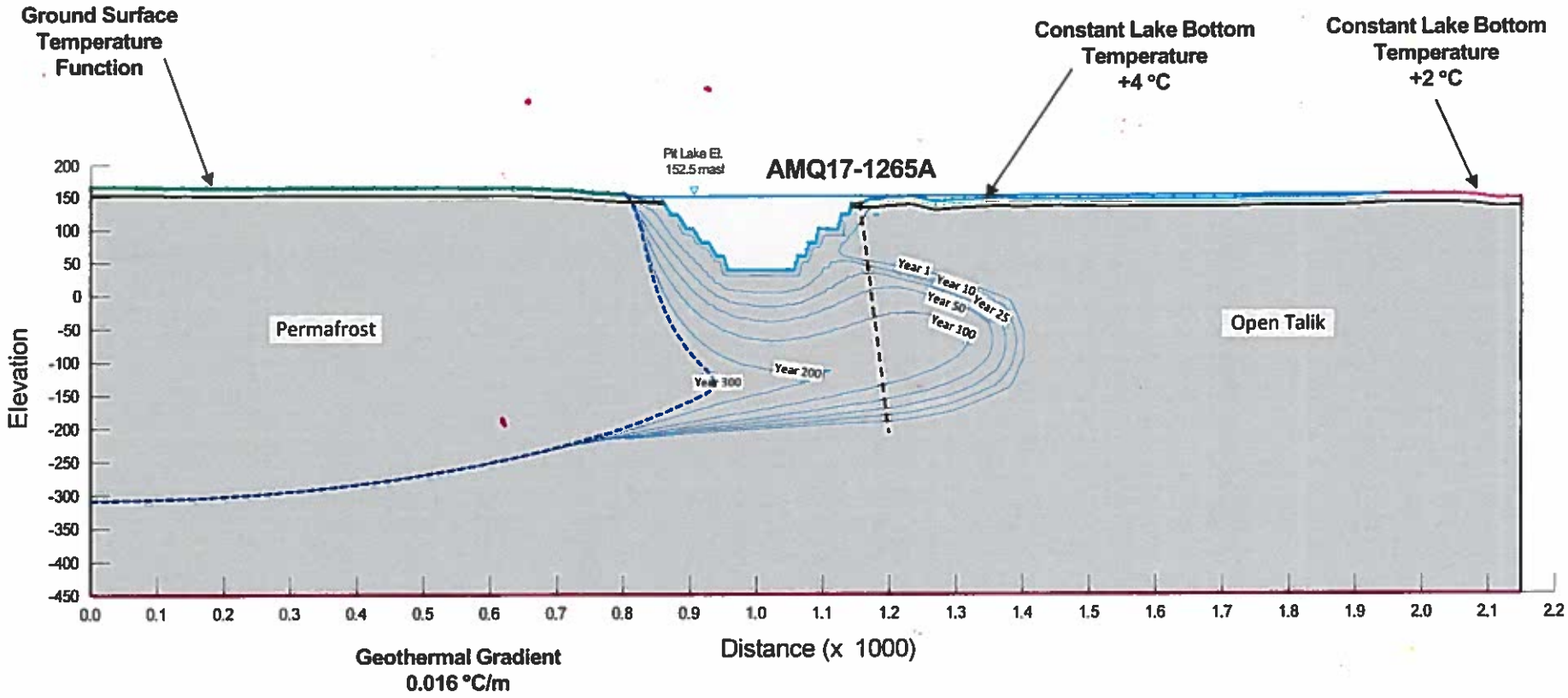
YYYY-MM-DD	2016-04-03
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
POST-CLOSURE PIT LAKE THERMAL ANALYSIS
NUNAVUT

TITLE
TRANSIENT THERMAL MODELLING
PIT FLOODING
YEAR 7

PROJECT No	Phase/Task	Rev	Figure
1789310	1000/12020	0	2-4

Path: O:\Active\2018\3 Proj\1865859 Agnico Eagle_Water Mgmt_Whale Tail\1789310_Thermal\Thermal Analysis



File Name: Phase 1 Section.gsz

Notes

1. Location of thermistor AMQ17-1265A is approximate.
2. The 300 year isotherm includes the 7 years of back-flooding.

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

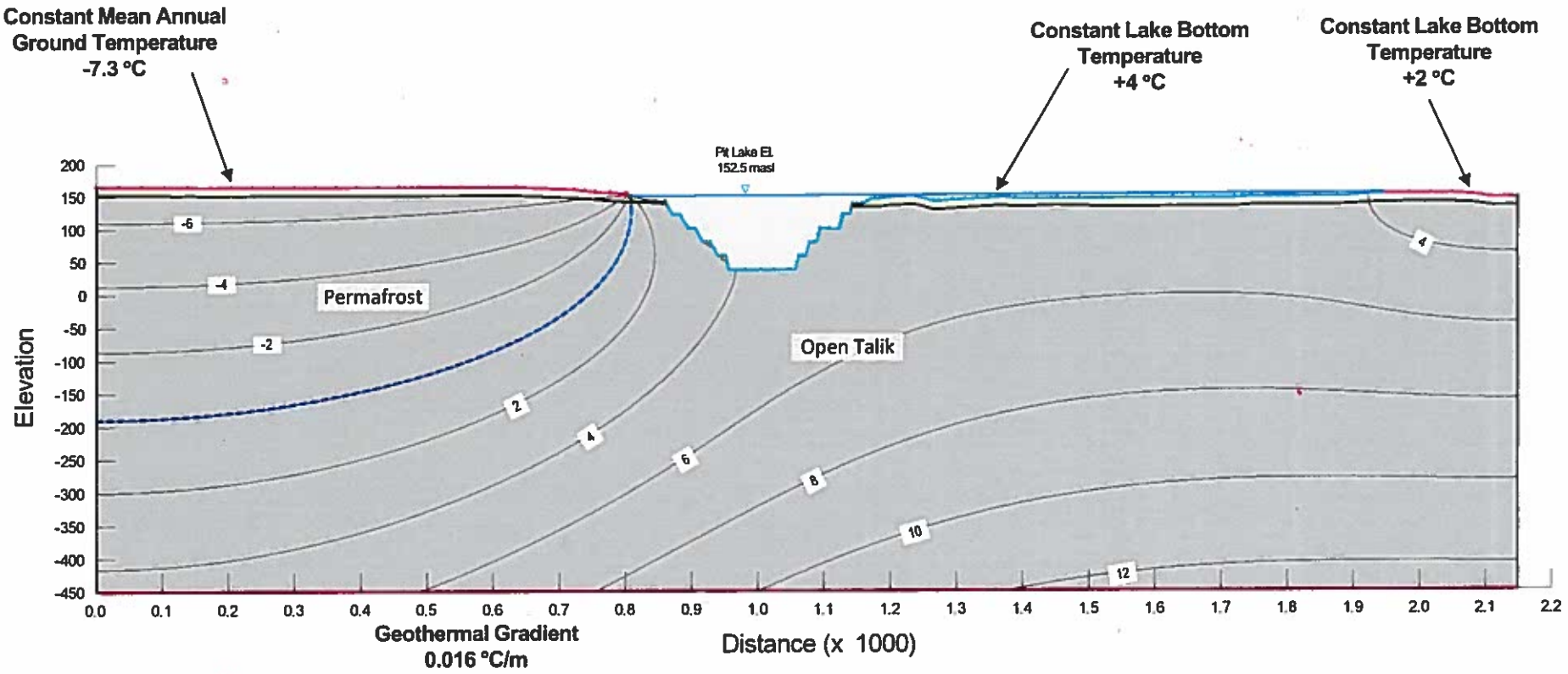
YYYY-MM-DD	2018-04-03
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
POST-CLOSURE PIT LAKE THERMAL ANALYSIS
NUNAVUT

TITLE
TRANSIENT THERMAL MODELLING
POST-CLOSURE PIT LAKE
ZERO DEGREE ISOTHERMS AT SELECT YEARS

PROJECT No.	Phase/Task	Rev	Figure
1789310	1000/12020	0	2-5

Path: O:\Active\201663 Proj\1665859 Agnico Eagle_Water Mgmt_Whale Tail\1789310_Thermal\Thermal Analysis



Notes

1. Location of thermistor AMQ17-1265A is approximate.
2. Temperature contour interval 2 °C.

File Name: Phase 1 Section.gsz

CLIENT
AGNICO EAGLE MINES LTD.

CONSULTANT
GOLDER

YYYY-MM-DD	2018-04-03
PREPARED	CTM
DESIGN	CTM
REVIEW	SO
APPROVED	JFC

PROJECT
WHALE TAIL PIT PROJECT
POST-CLOSURE PIT LAKE THERMAL ANALYSIS
NUNAVUT

TITLE
STEADY-STATE THERMAL MODELLING
POST-CLOSURE PIT LAKE
THERMAL REGIME

PROJECT No	Phase/Task	Rev	Figure
1789310	1000/12020	0	2-6

APPENDIX B –2018 WESTBAY SYSTEM GROUNDWATER MONITRORING INVESTIGATION

GOLDER

TECHNICAL MEMORANDUM

DATE February 8, 2019

Project No. 1789310-244-TM-Rev0

TO Michel Groleau
Agnico-Eagle Mines Ltd.

FROM Valerie Bertrand, Dale Holtze, Jennifer Levenick

EMAIL vbertrand@golder.com

2018 WESTBAY SYSTEM GROUNDWATER MONITORING INVESTIGATION

1.0 INTRODUCTION

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is developing the Whale Tail Pit Project that was approved by the Nunavut Impact Review Board (NIRB). The property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq Region of Nunavut.

As part of the Approved Project baseline studies, groundwater samples were collected from a Westbay monitoring well installed in borehole AMQ16-626, drilled in March and April 2016 targeting the area of the talik zone below Whale Tail Lake near future mine developments. Agnico Eagle retained Nuqsana Golder Engineering and Environmental Inc. (Nuqsana Golder) to complete a groundwater monitoring program in November 2018. The objective of the program was to obtain additional pre-development hydraulic head and groundwater quality data in support of the Whale Tail Pit Project Certificate No. 008, Term and Condition No. 15 (TC15) (NIRB 2018).

This technical memorandum provides an interpretation of the data collected from AMQ16-626 in November 2018 with respect to hydraulic gradients and groundwater quality. The collected data was reviewed in the context of conceptual and numerical model predictions for the Whale Tail Pit Project to evaluate if follow-up assessment is required (i.e., if significant differences in the model assumptions or predictions was indicated by the collected data).

2.0 BACKGROUND

2.1 Westbay Well Installation

A Westbay groundwater well system was installed on site between March and April in 2016 to obtain groundwater quality and verify the vertical hydraulic gradient within the talik zone of Whale Tail Lake, in the area of future mine development, to define future effects of the mine workings on the groundwater flow regime and overall site water quality from development to post-closure.

The well was installed in the purpose-specific borehole (AMQ16-626) which was drilled at an inclination of -69 degrees, an azimuth of 152.6 degrees and advanced to a depth of 499 m along the borehole, through massive diorite throughout the borehole. The Westbay well was designed to tap discrete zones of unfrozen bedrock and, if encountered, zones of higher hydraulic conductivity that were observed during drilling and well testing conducted prior to well installation. Six sampling ports were installed at and below the depth of anticipated ramp development (0 to 385 metres below ground surface [mbgs]), listed in Table 1. Borehole drilling, packer test results along the borehole and well installation details are documented in another report (Golder 2016b). A schematic of the Westbay well instrument that was installed in borehole AMQ160626 is included in Appendix A for reference.

Golder Associates Ltd.
1931 Robertson Road Ottawa, Ontario, K2H 5B7 Canada

T: +1 613 592 9600 +1 613 592 9601

Golder and the G logo are trademarks of Golder Associates Corporation

golder.com

Table 1: Borehole AMQ16-626 Westbay System Zones

Sampling Interval	Depth Along Borehole			Interval Depth Vertical Depth		
	From	To	Length	From	To	Thickness
	(mah)	(mah)	(m)	(mbgs)	(mbgs)	(m)
Zone 6	276	287.4	11.4	257.7	268.3	10.6
Zone 5	298.9	310.3	11.4	279.0	289.7	10.6
Zone 4	349.3	359.1	9.8	326.1	335.2	9.1
Zone 3	381.3	392.7	11.4	356.0	366.6	10.6
Zone 2	440.8	452.2	11.4	411.5	422.2	10.6
Zone 1	488.1	499.0	10.9	455.7	465.9	10.2

Notes: Depth values were provided by Westbay Instruments Completion Report.
m = metres; mah = metres along the hole, relative to ground surface; mbgs = metres below ground surface.

Upon completion of the installation in 2016, the well was used to collect groundwater samples from select intervals that were within and below the proposed development; Ports 3, 4, and 6 ranging in depths from 276 m to 392 m. Sampling methods, data interpretation and water quality results were presented in Golder 2016a. The total dissolved solids (TDS) content in the Formation groundwater was determined to range between 3,198 mg/L and 4,042 mg/L (Golder 2016a).

The groundwater quality were used to predict groundwater inflow quantity into future mine developments (Golder 2016d), which were used as input to operational and post-closure hydrogeological and permafrost models (Golder 2018a) and into the Whale Tail pit lake hydrodynamic model (Golder 2018b). These models were ultimately used to assess effects of hydrogeological processes on site contact water quality during development, operations and closure and on pit lake water quality during closure and post-closure.

The results of the compendium of these studies for the Whale Tail Pit Project indicated that mass transfer from the pit to the pit lake is very low, that groundwater seepage into and out of the pit lake are negligible in volume, particularly compared to surface water exchanged annually post-closure when flows are re-established based on average climate year watershed runoff. The combination of results corroborates to support that the hydrogeological regime around the pit lake is not critical to pit lake water quality post-closure.

The data collected as part of the 2018 monitoring program aim to add to the pre-operational database of results and to verify model inputs and model outcomes obtained to date.

2.2 The Groundwater Monitoring Program

The 2018 groundwater monitoring program was completed to support the requirements of the Groundwater Monitoring Program stated in TC15 (NIRB 2018). TC15 requirements were as follows:

> *Subject to the additional direction and requirements of the Nunavut Water Board, the Proponent shall prepare and implement a Groundwater Monitoring Plan that, at a minimum includes:*
>
> - *The collection of additional site-specific hydraulic data (e.g., from new monitoring wells) in key areas during the pre-development, construction and operation phases;*

- *Definition of vertical and horizontal groundwater flows in the project development areas;*
- *Delineates monitoring plans for both vertical and horizontal ground water; and*
- *Thresholds that will trigger the implementation of adaptive management strategies that reflect site-specific conditions encountered at the project site.*

The groundwater monitoring program documented in this technical memorandum consisted of measurements of hydraulic head (vertical gradients) and sampling of the formation groundwater to evaluate groundwater quality with depth.

2.3 Thresholds for Additional Assessment or Adaptive Management

Groundwater monitoring data being collected in the pre-development phase is being compiled into a Project-specific data and will be used in combination with future data collected during operational and closure phases of the Project to evaluate trends in groundwater data with respect to pit inflow quantity and quality.

Measured groundwater inflow rates and groundwater quality will be compared to model predictions on an annual basis. If significant variations from model predictions are observed, the assumptions behind the data will be reviewed and the analysis updated if required. In addition, updates to the groundwater model will be made if operational changes occur as the open pit advances which could significantly alter groundwater inflow or quality.

Variations that would be considered significant include:

- Groundwater inflows to the mine, based on rolling monthly average of inflow over six consecutive months, is 20% higher than predicted groundwater inflow.
- Collected water samples that indicate that the concentration of total dissolved solids (TDS) is more than 25% higher than the estimated water quality.

If the above variations are observed, the groundwater data (quantity and quality) would be assessed to evaluate trends, the potential causes of the greater than expected groundwater inflow quantity or quality, and the potential for long-term effect associated with the groundwater flow or quality. If the greater than predicted flows were correlated to a short-term effect such as freezing in the pit walls, changes in mining rate, freshet or transient drainage of a high storage feature, then further reassessment of groundwater inflows may not be required, and the adaptive management of these short-term effects would be evaluated under the Water Management Plan.

If the greater than predicted flows or quality would be considered as potentially long term, consideration will be given to reviewing the model calibration. The six-month averaging period of observation is based on observed seasonal variations in inflow quantities in mines situated in permafrost regions.

If model re-calibration is deemed necessary, future groundwater inflow quantity and quality would be predicted using this re-calibrated model and new results will be considered as part of the adaptive management of the groundwater quantity contribution to the Water Management Plan.

Modification of groundwater management strategies: the ponds, sumps and water conveyance strategies around the pit can be modified to mitigate the effect of additional groundwater volume or salinity prior to treatment and discharge. The water conveyance strategy will be evaluated and optimized during operations and closure to maintain post-closure commitment.

Groundwater monitoring data collected at this stage is representative of the pre-development condition of the project, and therefore an evaluation of trends in flow quantity and quality is not possible for the operational and closure phases. Results of the monitoring has been compared to assumptions adopted in the initial conditions for groundwater conceptual and numerical models and has been used to assess if the post-closure predictions are likely reasonable in consideration of the observed vertical hydraulic gradients and flow directions in the November 2018 monitoring program.

3.0 2018 GROUNDWATER MONITORING PROGRAM

3.1 Objectives

The objectives of the program are as follows:

- To collect site specific hydraulic head data during Project pre-development through the measurement of the hydrostatic pressure profile from the existing Westbay well.
- Assess the vertical hydraulic gradient and groundwater flow direction in that location of the Whale Tail Lake talik.
- Collect groundwater samples from the Westbay Well for chemical analysis, adding to the database of groundwater quality results.
- Compared water quality results to the threshold adopted for additional assessment and adaptive management.

3.2 Monitoring Methods

3.2.1 Hydraulic Head Measurements and Assessment of Vertical Hydraulic Gradients

Hydraulic heads were derived from the formation pressures measured at each monitoring port installed along the Westbay system. The formation pressure for each monitoring port was measured on November 9, 2018 using the Mosdax sampler manufactured and supplied by Westbay Instruments (refer to Appendix B for instrument calibration record).

3.2.2 Groundwater Sampling

Groundwater samples were collected from fixed ports in the Westbay well system that are positioned at different intervals along the hole to assess baseline groundwater chemistry with depth. Ports 6, 4 and 3, which are located within the anticipated ramp development zone (0 to 385 m), were targeted for sampling because these intervals had been previously developed (drill water had been largely removed from the interval) in 2016. Port 2 was also sampled although it was less developed than the other sample intervals in 2016 in order to verify if the aquifer was naturally flushed of the drilling water. Information on each of the Ports that were purged is presented in Table 2.

Fluorescein tracer was added to the 2016 drilling water to differentiate between the drilling fluid and the formation water. It is assumed that the only source of fluorescein was introduced during the 2016 drilling activities of borehole AMQ16-626 such that it is a reliable tracer of introduced water into the Formation.

Table 2: 2018 AMQ16-626 Westbay Well Development and Groundwater Sampling Information

Sample Port	Sampling Interval (mah)		Volume of Water Removed in 2018 (L)	Sample Date	Groundwater Parameters at Sampling Period (field measured)			
	From	To			Residual Fluorescein (ppb)	Conductivity (mS/cm)	TDS (ppm)	pH
6	276.0	287.4	8.25	13-Nov-18	83.54	9.02	4543	6.37
4	349.3	359.1	13.25	11-Nov-18	66.21	14.56	7275	7.50
3	381.3	392.7	12.5	12-Nov-18	100.05	7.50	3765	8.33
2	440.8	452.2	6.25	10-Nov-18	73.30	17.52	8825	8.90
1	488.1	499.0	0.25	not sampled	-	-	-	-

m = metres, mah = metres along hole, relative to ground surface; L = litres, TDS = total dissolved solids

Throughout the development and upon water sample collection, field chemical parameters (pH, conductivity, TDS, fluorescein content and temperature) were measured in order to track the fluid introduced into the Formation by drilling and to follow the removal of this fluid from the Formation during development and sampling of groundwater. Fluorescein content was measured using the AquaFluor handheld Fluorometer manufactured by Turner Designs. Temperature, pH, TDS and electrical conductivity values were measured with a Hanna Combo tester (HI 98130). A drilling water content of less than 5% (estimated using fluorescein content) is targeted in order to provide a reliable estimate of formation groundwater quality. Higher residual drilling fluid content can be used for this purpose but decreases the precision of the calculation of groundwater quality.

Groundwater sampling was preformed using the Westbay Mosdax sampler in a similar fashion as the initial development and sampling program completed in 2016. The Mosdax sampler collects 1 Litre of groundwater at a time (per sampling instrument descent into the well); multiple sampler runs were carried out to collect one complete groundwater sample set from each interval. Calibration reports of the Mosdax sampler probe are included in Appendix B.

Groundwater samples were collected from Intervals 6, 4, 3, and 2 in triplicate. Groundwater samples were filtered and preserved in the field, as required, and collected in laboratory-supplied bottles which were packed and shipped to the analytical laboratory following the collection of each sample. Duplicate samples collected from Ports 6, 4, 3, and 2 were submitted for analysis, while the third sample set was kept on site as backup and disposed of upon receipt of the samples by the analytical laboratory. An equipment and field blank were also collected for quality assurance/quality control (QA/QC) purposes. Analysis of general chemistry was completed at ALS Environmental (ALS) in Vancouver for the following parameters:

- Physical tests, including hardness, pH, conductivity, total suspended solids and total dissolved solids
- Anions and nutrients, including alkalinity, ammonia, bicarbonate, bromide, carbonate, chloride, fluoride, nitrate, nitrite, phosphorus (total and dissolved) and sulphate
- Metals (dissolved and total), including aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, selenium, silicon, silver, sodium, strontium, sulfur, tellurium, thallium, tin, titanium, uranium, vanadium and zinc. Additional metals were also analyzed by the analytical laboratory as part of the metals package, however they are not of interest to the project and will not be discussed herein out: cesium, rhenium, rubidium, sulfur, thorium, tungsten, yttrium and zirconium

Certificates of analysis from ALS are included in Appendix C.

3.3 Evaluation of Formation Water Quality

To properly assess the quality and salinity of true rock formation groundwater, the drilling fluid present in the sampling interval must be removed as much as possible by purging. The amount of drilling fluid present in the Formation is estimated from the concentration of fluorescein in the raw groundwater sample at each interval, compared to the fluorescein content of the drilling fluid used during drilling of the borehole. In 2016 upon well installation, the sampling intervals were purged to remove as much of the drilling fluid as possible within the task schedule, prior to collecting a sample for chemical analysis.

In 2018, the fluorescein, electrical conductivity and TDS of groundwater was monitored during sampling and compared to data from the end of development in 2016 to assess whether the interval remained purged and still reflected true Formation groundwater quality. Fluorescein and conductivity were within the range of values recorded in 2016 and groundwater samples were collected and submitted for chemical analysis.

The following summarizes the calculations made to estimate true Formation water quality and TDS from field measurements of electrical conductivity and laboratory analytical results of raw groundwater samples in 2018 and drilling water fluid in 2016.

1) **Estimation of the chemistry of the drilling fluid introduced in the Formation during the 2016 well borehole drilling and installation activities.** The drilling fluid consisted of very low TDS lake water to which was added a concentrated brine. The range of composition of the drill fluid (the dilute brine) was estimated by comparing both the initial and maximum conductivity values measured in samples from the Formation (for each port 6, 4, 3, and 2; conductivity varied between sampling ports) against the conductivity of the concentrated brine[1]. This Dilute Brine Factor was used to calculate composition of the drilling fluid introduced into the sampling interval during the 2016 drilling and well installation activities as per equation (1) below.

$$(1) \qquad Dilute\ Brine\ Factor_{Port\ i} = \frac{Field\ Conductivity_{Port\ i}}{Brine\ Conductivity_{calculated}}$$

This calculation assumes an insignificant proportion of formation water is present immediately after drilling, which is a fair assumption given that a high volume of drilling water was lost to the Formation (Golder, 2016a).

The drilling brine composition for each parameter was calculated from the product of the dilution brine factors and the chemistry of the drilling brine fluid for each port per equation (2).

$$(2) \qquad Dilute\ Brine_{Port\ i} = Laboratory\ Result_{Brine} \times Dilution\ Brine\ Factor_{Port\ i}$$

2) **Calculation of the proportion of drill brine remaining in the Formation upon sampling.** This was calculated based on the amount of residual fluorescein measured upon sample collection at each port in 2018 compared to the initial fluorescein content of the drilling fluid measured in 2016 (i.e. 512.7 ppb).

3) **Removal of the drilling fluid chemistry from the raw groundwater sample analysis.** The concentration of constituents from the drilling fluid are removed from the reported analytical results for each chemical constituent per the below equation (3). The November 2018 laboratory results are provided in Appendix C.

$$(3) \qquad Groundwater\ Quality_{calculated} = Laboratory\ Result - \frac{Proportion\ of\ Drill\ Brine \times Dilute\ Brine\ Chemistry}{Proportion\ of\ Formation\ Water}$$

[1] Brine conductivity was estimated from the calculated TDS of the drilling brine fluid using a conversion factor of 0.75 which is appropriate for brine solutions (Rusydi, 2017). Brine TDS was calculated based on constituent concentrations (refer to Table 3 and Appendix C). Laboratory-reported TDS and conductivity were not reliable as they exceeded instrument calibration.

The estimated drilling brine chemistry, proportion of residual drilling brine and Formation water for each sampling port are summarized in Table 4. The calculated groundwater quality for Ports 6, 4, 3 and 2 are summarized in Table 5.

4.0 RESULTS AND DISCUSSION

4.1 Hydraulic Head Profile and Groundwater Flow Direction Below Whale Tail Lake

The planned Whale Tail Pit sits within the closed talik below the North Basin of Whale Tail Lake. The closed talik is inferred to transition to open talik below the South Basin due to the increased width and depth of the lake towards the south. The water table below both basins will be equivalent to the lake surface elevation.

Permafrost underlies the land surrounding the lake, which restricts the lateral flow of groundwater to the talik and restricts the recharge of the sub-permafrost groundwater flow system by precipitation. Groundwater flow is controlled by surface water elevations in lakes with open talik; water moves vertically through the open talik to the underlying sub-permafrost groundwater flow system. In effect, lakes with open taliks in continuous permafrost regions are equivalent to large monitoring wells.

AMQ16-626 was installed to evaluate groundwater quality in the unfrozen bedrock and to verify the hydraulic gradient that exists below Whale Tail Lake. The hydraulic gradient, in combination with the bedrock hydraulic conductivity, will control the potential flux to or from Whale Tail Lake, and the flooded Whale Tail Pit post-closure.

Table 3 summarizes the calculated hydraulic heads based on the measured pressure in each of the ports. Although Zone 6 (shallowest port) is included in Table 3, it is suspected that this port may be in permafrost or near the permafrost contact, which could affect the measured hydraulic head. This inference is supported by the measured formation temperature, which is less than zero. Although the measured hydraulic head in the shallowest port is consistent with the overall trend, data from the deeper ports, which are confirmed to be in unfrozen rock by the formation temperature, were used to assess the vertical gradient.

Table 3: AMQ16-626 Westbay Well Hydraulic Heads and Formation Temperatures (November 9, 2018)

Port/ Zone	Measurement Interval (mah)		Measurement Interval (mbgs)		Port Depth (mah)	Port Depth (mbgs)	Calculated Depth to Water (mbgs)	Calculated Hydraulic Head (masl)	Formation Temperature (°C)
	From	To	From	To					
6	276.0	287.4	257.7	268.3	276.2	257.9	1.9	154.0	-0.17
4	349.3	359.1	326.1	335.2	349.5	326.3	1.6	153.6	0.24
3	381.3	392.7	356.0	366.6	381.5	356.2	1.1	153.4	0.36
2	440.8	452.2	411.5	422.2	441.0	411.7	0.9	152.9	0.87
1	488.1	499.0	455.7	465.9	488.3	455.9	0.5	152.6	1.29

Source: Golder (2016a).
m = metres; mah = metres along hole relative to ground surface (borehole angled to surface); mbgs = metres below ground surface (vertical down from surface); masl = metres above sea level (elevation)

The data collected at AMQ16-626, indicates the presence of a downward hydraulic gradient. Assuming the measured hydraulic head is representative of the midpoint of the measurement interval, the downward gradient between Port 1 and Port 4 is 0.008 m/m. This gradient is consistent with the estimated gradient derived from looking at the relative elevation of Whale Tail Lake and DS1 (0.008 m/m), as reported in Agnico Eagles response to TC15 (Agnico Eagle 2018). DS1 is the predicted receptor from water in the area of Whale Tail Pit and Underground (Golder 2016c).

For the depth interval over which the hydraulic head was measured (326 to 456 mbgs), the estimated hydraulic conductivity of the bedrock for the FEIS for the Whale Tail Pit Project was 1 x10^{-8} to 3 x 10^{-8} m/s (Golder 2016c). In support of TC15 and the development of the Project, additional packer testing was conducted subsequent to the FEIS and the data indicate the hydraulic conductivity of bedrock over this depth interval is likely lower (1 x 10^{-9} m/s based on the geometric average of the test data) (Golder 2018a). Considering the measured gradient (0.008), the historical range of bedrock hydraulic conductivity adopted in the FEIS (1 x10^{-8} to 3 x 10^{-8}) and the now refined hydraulic conductivity (1 x 10^{-9} m/s) and an assumed effective porosity of 0.001 (Maidment 1992; Stober and Bucher 2007), the estimated downward groundwater flow velocity is between approximately 0.25 m/yr and 8 m/yr. The lower bound of this range is considered more reasonable, as it uses the refined hydraulic conductivity data discussed above, which is based on the geometric mean of all the packer test measurements (pre- and post-FEIS).

Gradients measured during this monitoring program are considered a reasonable interpretation of what long-term gradients could be post-closure following the formation of the pit lake. Recharge and discharge from the base of Whale Tail Lake or a flooded pit lake will be controlled by the vertical hydraulic gradients and the bedrock hydraulic conductivity near the base of the permafrost. Considering the approximate area of the Whale Tail Pit (0.5 km^2), the range in bedrock hydraulic conductivity (1 x 10^{-9} to 3 x 10^{-8} m/s), and the measured downward gradient (0.008), the data would indicate long-term groundwater flux would be approximately 0.3 m^3/day to 11 m^3/day. Similar to the estimated groundwater velocity, the lower bound of this range is considered more reasonable, as it uses the refined estimate of hydraulic conductivity. Overall, the estimated flux is similar to the long-term predicted discharge from the pit lake at post-closure (1.7 m^3/day; Golder 2016c) and supports the conclusion in the FEIS that long-term predicted flows from the pit lake to the groundwater flow system will be negligible relative to the surface water exchange into the pit lake (Golder 2018c).

4.2 Groundwater Quality

Field measurements of electrical conductivity and fluorescein concentration serve, in part, to evaluate whether the groundwater accessed via the Westbay well sampling ports continues to be representative of Formation groundwater quality.

The 2016 and 2018 electrical conductivity and fluorescein trends measured throughout the sampling program in Ports 6, 4, 3, 2, and 1 are summarized in Figures 1 and 2, respectively. Groundwater samples were collected from Ports 6, 4, 3, and 2. Port 1 groundwater quality was deemed not representative of Formation groundwater and was not sampled. The field measurements of electrical conductivity, TDS and fluorescein recorded at the time of sampling are summarized in Table 3. The values are averages from the subsamples collected to obtain the required volume of water for analysis.

Port 6

The temperature measured by the Mosdax sampler during the pressure profile and sampling at Port 6 was below zero (-0.17 °C, refer to Table 3) and slush was present in the sampling canister from this Port. The cryopeg zone (temperature below 0 degrees, but not frozen) is interpreted to extend to at least 258 m depth (top interval of Port 6) within the vicinity of the Westbay well. Groundwater from the crypogeg (Port 6) could have a heterogenous composition (non-saline ice and slightly saline groundwater) where free water is primarily transmitted through the more permeable unfrozen zones. Groundwater collected from Port 6 is interpreted to be located within the cryopeg have the potential to yield variable water quality even following periods of sufficient development.

Notwithstanding this, the estimation of true Formation groundwater quality was still completed per the method described in Section 2.3. Table 5 presents the minimum and maximum range of calculated concentrations of formation water at each port sampled in 2018 and 2016 for comparison.

The 2018 field-measured groundwater fluorescein content and electrical conductivity at the port remained within the same range albeit slightly higher than values recorded at the end of the well development period in 2016. This suggests that groundwater quality at that location remained representative of true Formation water since it was last sampled in 2016. The results of the 2018 groundwater quality estimation (Table 5) are also within the same order of magnitude but slightly higher than those reported in 2016 suggesting that residual drilling brine fluid is still present in Formation water at a proportion slightly higher than at the end of development in 2016. This can occur where drilling fluid that is still present in undeveloped zones in the aquifer (for example, in zones between sampling Ports) migrates back into the developed zones tapped by the sampling Ports following the normal movement of groundwater along the downward vertical gradient.

The estimated Formation groundwater minimum and maximum TDS concentrations in 2018 are 25% and 38% higher than the minimum and maximum TDS values estimated in 2016. The difference is higher than the TDS variability threshold of 25%. This is attributed to the higher proportion of drilling brine fluid in the Formation at Port 6 collected in 2018.

Arsenic concentration in groundwater at Port 6 is estimated to be low based on 2018 calculations, within the range of 2016 estimation.

The 2016 data is considered potentially more accurate, but 2018 data is still valid. The initial model input is still considered accurate and the new data does not warrant revising the conceptual model of groundwater TDS.

Ports 3 and 4

The 2018 field-measured groundwater fluorescein content and electrical conductivity at these sampling ports were similar (slightly higher) to measured values recorded at the end of the well development period in 2016, suggesting that groundwater quality remained representative of true Formation water at these zones. These slightly higher 2018 readings suggest that a small influx of drilling fluid that was still present in undeveloped zones migrated back into the developed zones as for Port 6. The higher proportion of drilling brine fluid in the Formation and in the samples collected may result in a lower accuracy of calculated groundwater quality from samples collected in 2018 compared to those collected in 2016 after a more complete purge; nonetheless, the data is still considered valid.

Figure 2 illustrates how electrical conductivity and fluorescein concentrations evolved in parallel during the short development period at Ports 3 and 4, inferring that groundwater in the vicinity of the Westbay well has not been affected by an outside brine source that could have originated from salt water used in exploration drilling nearby, approximately 26 metres from the Westbay well.

Estimated true Formation groundwater quality is shown in Table 5 presenting the minimum and maximum range of calculated concentrations of Formation water at each port sampled in 2018 and 2016. The results of the 2018 groundwater quality data are within the same order of magnitude to those reported in 2016 albeit slightly higher than in 2016. Port 3 minimum and maximum estimated TDS values are 35% and 28% higher than the calculated minimum and maximum values from 2016 data. At Port 4, they are 76% and 86% higher than the calculated minimum and maximum values from 2016 data. Variability is higher than the threshold of 25%. This is attributed to the higher proportion of drilling brine fluid in the Formation collected in 2018 compared to 2016.

Arsenic concentrations at both Ports 4 and 3 are estimated to be in the same order of magnitude as concentration ranges calculated in 2016.

The 2016 data is considered potentially more accurate, but 2018 data is still valid. The initial model input is still considered accurate and the new data does not warrant revising the conceptual model of groundwater TDS.

Port 2

Due to time constraints in 2016, this Port had not been extensively developed, leaving a higher proportion of drilling brine in the groundwater prior to sampling. A groundwater sample was collected in 2018 to verify the progression of water quality at that location; to assess whether drilling brine might have flushed out of the horizon since 2016 through natural groundwater flow. The 2018 field-measured groundwater fluorescein content and electrical conductivity were within a similar range than after development in 2016. Values were slightly lower than in 2016 but the trend was rising throughout the brief purging period in 2018. Electrical conductivity and fluorescein progressed at different rates during purging (conductivity rose faster than fluorescein; Figure 2) suggesting interference by a source of saline water that is not tagged with fluorescein, such as possibly, adjacent exploration borehole drilling water. Given the continued high proportion of drilling brine potentially mixed with another source of saline water that cannot be quantified at this time, a proper estimation of true Formation groundwater quality is not deemed possible for from this Port.

Summary

The higher TDS values calculated at Ports 6, 4, and 3 in 2018 are above the threshold value of 25%. These higher values are attributed to the presence of a higher content of non-Formation drilling brine in groundwater in 2018 compared to 2016. Consequently, the initial model input is still considered accurate and the new data does not warrant revising the conceptual model of groundwater TDS.

Arsenic concentration at all sampling ports is still low, the maximum calculated to be at Port 6 measured in 2016. Based on the results of the groundwater sampling completed to date, arsenic presence is low in the formation water.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

Groundwater samples were collected from each interval in triplicate and submitted in duplicate for analysis to the analytical laboratory as part of the quality assurance/quality control ('QA/QC') protocol. In addition, field and equipment blanks were also submitted for analysis of select parameters. The analytical laboratory performs equipment blanks as a method of internal QA/QC verification.

Analytical repeatability was tested by assessing the similarity between duplicate pairs of results. For each duplicate pairs of analysis where both results were higher than 5 times the method detection limit (MDL), the relative percent difference (RPD) was calculated as follows:

$$RPD = \frac{\text{absolute [difference (concentration of a given parameter)]}}{\text{[average (concentration of a given parameter)]}} \times 100$$

Per USEPA recommended methods (USEPA, 1994), an RPD of 20% or less was considered acceptable. Where one or both results of the duplicate pair were less than 5 times the MDL, a margin of +/- MDL was considered acceptable.

Table 6 presents the RPD or =/- MDL value calculated from the duplicate pair of results. Approximately 50% of duplicate pairs of analyses had one or both results below the method detection limit and consequently could not be assessed for repeatability. QA/QC results for the duplicate samples were within acceptable tolerance limits (RPD or +/- MDL) with the exception of duplicate concentrations of total suspended solids in Port 4 as well as duplicate concentrations of total chromium and nickel in Port 3. Trace components and major elements for all samples are considered adequately repeatable.

Groundwater samples were analyzed for TDS in the field and in 2018 by the analytical laboratory (ALS). The original brine fluid was analyzed by Multilab analytical laboratory. TDS values were also calculated from the laboratory results in order to assess potential discrepancies between the ionic balance and uncertainty of the results (refer to Tables 4 and 6). The results of the field, calculated, and laboratory measured values were within reasonable range limits for all

samples, with the exception of the brine fluid. The TDS result reported for the brine fluid (36,946 mg/L) was significantly less than the calculated value (130,500 mg/L). The laboratory measured TDS and consequently electrical conductivity (55.42 mS/cm) of the brine fluid were deemed unreliable due to the ionic imbalance discrepancy. This assumption was confirmed during a telephone discussion between Nuqsana Golder and the analytical laboratory (H2Lab, formerly Multilab chemist Jean-Francois Bouffard) on January 15, 2019, where the chemist indicated the TDS and electrical conductivity values reported for the brine fluid were outside the suitable range for the analytical instrument and may not be accurate. The certificate of analysis for the brine fluid is included in Appendix D. The calculated TDS of the brine fluid was used to correct the groundwater quality data as discussed in Section 2.3 of the report.

Uncertainty in the calculated groundwater water quality results from the variability in drill water composition augmented by probable mixing between aquifer zones having different levels of development (purging of drill water); this has a higher potential influence on the accuracy of 2018 calculated groundwater quality because of the higher proportion of drilling brine fluid remaining in the raw water samples compared to 2016 samples; thus while 2018 data remain valid to estimate water quality at Port 3, 4 and 6, 2016 results may be a more accurate representation of Formation groundwater quality than 2018 data.

6.0 CONCLUSION

The 2018 Westbay Well field program was carried out in support of the Whale Tail Pit Project Certificate No. 008, Term and Condition No. 15, to obtain additional pre-development groundwater quality data and to verify the hydraulic gradient. These data were used to verify modelling assumptions related to the groundwater quality and the hydraulic gradient near the mine development areas.

Hydraulic head measurements indicate that a downward vertical hydraulic gradient is present in the North Basin of Whale Tail Lake, which is consistent with the conceptual understanding of groundwater flow directions and the predicted conditions post-closure following the formation of the Whale Tail Pit Lake. Revisions to the numerical or conceptual models is not considered necessary based on the vertical gradients as the data is consistent the model assumptions.

Groundwater quality was estimated from the samples collected, removing the anticipated proportion of residual drilling water in the Formation (in the raw water sample). The 2018 program estimated groundwater quality at Ports 6, 4, and 3 are in the same range as previously estimated. The calculated groundwater TDS are slightly higher in 2018; the calculated increase in TDS ranges from 25% to 86% which is above the threshold value of 25% variability for TDS. The variation is attributed to the higher proportion of residual drilling water in the sample. In consideration that higher TDS is not considered to represent an increase in Formation water TDS, the assumptions for the conceptual model, which are based on the more reliable and applicable 2016 data, are still considered to be appropriate. Therefore, adaptive management is not considered necessary at this time.

The concentrations of metals and arsenic are low. The maximum calculated arsenic concentration remains similar to what was calculated for Port 6 in 2016. Given that the arsenic concentrations are similar to the assumptions adopted in the geochemical models (low arsenic in Formation groundwater), groundwater arsenic content is still not likely to have a significant effect on mine surface water quality.

7.0 STUDY LIMITATIONS

This technical memorandum was prepared for the exclusive use of Agnico Eagle Mines Limited. The technical memorandum, which specifically includes all tables and attachments, is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the property at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this technical memorandum.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the technical memorandum as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this technical memorandum, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this technical memorandum, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this technical memorandum.

The findings and conclusions of this technical memorandum are valid only as of the date of this technical memorandum and for the locations investigated. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this technical memorandum and provide amendments as required.

8.0 CLOSURE

We trust this report meets your needs at this time. Should you have any questions, please do not hesitate to contact the undersigned.

Golder Associates Ltd.

REGISTERED PROFESSIONAL GEOLOGIST
08-02-2019
V.J. BERTRAND
LICENSEE
NWT/NU

Dale Holtze, M.Sc.
Hydrogeologist

Valerie Bertrand, M.A.Sc., P.Geo. (NT, NU)
Associate, Senior Geochemist

Jennifer Levenick, M.Sc.
Senior Hydrogeologist

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature
Date 2019-02-08
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

DH/VJB/JL/jr
https://goldersociates.sharepoint.com/sites/19830g/9100_westbay/deliverables/rev0/1789310-244-tm-westbay gw monitoring_rev0.docx

Attachments: Tables 4, 5, 6
Figure 1 – 2016 and 2018 Development Record
Figure 2 – 2018 Development Record
Appendix A – AMQ160626 Westbay System Installation Details
Appendix B – Westbay Instruments Mosdax Sampler Calibration Reports
Appendix C – 2018 Laboratory Certificates of Analysis
Appendix D – 2016 Laboratory Certificate of Analysis – Brine Fluid

9.0 REFERENCES

Agnico Eagle (Agnico Eagle Mines Limited). 2018. Whale Tail Pit Management Plans - AEM RESPONSES TO ECCC & CIRNAC Reply - Waste Rock Management Plan, Water Management Plan, Water Quality and Flow Monitoring Plan. November 23 2018.

Golder (Golder Associates Ltd.). 2016a. Groundwater Quality Investigation, Amaruq, Nunavut. Technical Memorandum 1649355-080 prepared for Agnico Eagle Mines Ltd. November 15, 2016.

Golder. 2016b. Westbay System Installation Summary – Whale Tail Pit Project, Nunavut. Technical Memorandum 1649355-033-TM-Rev0-4000 prepared for Agnico Eagle Mines Ltd. July 7, 2016.

Golder. 2016c. Hydrogeological Model Pre-Mining, During Mining, and Closure. Submitted as Volume 6, Appendix 6-B in the Whale Tail Pit and Haul Road Final Environmental Impact Statement. June 2016.

Golder. 2016d. Hydrogeology Baseline Report – Whale Tail Project. Submitted as Volume 6, Appendix 6-A in the Whale Tail Pit and Haul Road Final Environmental Impact Statement. June 2016.

Golder. 2018a. Hydrogeological Assessment and Modelling, Whale Tail Pit – Expansion Project. Submitted to Agnico Eagle Mines Limited. Ref. 1789310-213-RPT-Rev0. November 2018.

Golder. 2018b. Whale Tail Pit Project, Hydrodynamic Modelling of Whale Tail Pit Lake. Submitted to Agnico Eagle Mines Limited. Ref. 1789310-181-TM-Rev0. June 26, 2018.

Golder. 2018c. Whale Tail Pit Post-Closure Hydrogeological Assessment for the Whale Tail Open Pit. Dated 27 June 2018.

Maidment, D.R. 1992. Handbook of Hydrology. McGraw-Hill, New York, USA

NIRB (Nunavut Impact Review Board). 2018. Whale Tail Pit Project, NIRB Project Certificate No.: 008. Issued March 15, 2018.

Rusydi, A. 2017. Correlation between conductivity and total dissolved solids in various types of water: A review. Global Colloquium on GeoSciences and Engineering 2017. IOP Conf. Series: Earth and Environmental Science 118 (2018) 012019. IOP Publishing. Pp. 1-6.

Table 4
Drilling Brine Composition
Westbay Well in Whale Tail Lake Talik
Whale Tail Project, Nunavut

Sample		Brine Fluid	Calculated Drilling Brine Port 6		Calculated Drilling Brine Port 4		Calculated Drilling Brine Port 3	
			Initial Brine	Maximum Brine	Initial Brine	Maximum Brine	Initial Brine	Maximum Brine
Date		17-Apr-16	21-Jul-16	21-Jul-16	24-Apr-16	27-Apr-16	02-Sep-16	02-Sep-16
Field measured parameters	Units							
Fluorescein Concentration	mg/L	512.70	138.00	158.10	512.70	341.90	445.90	437.20
Drilling Fluid Proportion		1.00	0.27	0.31	1.00	0.67	0.87	0.85
Formation Water Proportion		0.00	0.73	0.69	0.00	0.33	0.13	0.15
Initial Conductivity Reading	uS/cm	0	10240	12210	3810	19400	52280	53800
Dilution of Brine Factor in Port		0.00	0.06	0.07	0.02	0.11	0.30	0.31
Conventional Parameters								
Total dissolved solids (calculated)	mg/L	130500	7680	3122	2858	14550	39210	40350
Total dissolved solids (lab)	mg/L	36946	-	-	-	-	-	-
pH	S.U.	10	11.25	7.40	12	11	11	11
Conductivity (lab)	uS/cm	55420	-	-	-	-	-	-
Conductivity (calculated)	uS/cm	174000	10240	4684	3810	19400	52280	53800
Reported Hardness	mg $CaCO_3$/L	105554	6212	2230	2311	11769	31715	32637
Alkalinity	mg $CaCO_3$/L	145.0	8.5	38.0	3.2	16.2	43.6	44.8
Bicarbonate (HCO3)	mg $CaCO_3$/L	27.0	1.6	38.0	0.6	3.0	8.1	8.3
Major ions								
Calcium (Ca)	mg/L	42266	2487	2966	925	4712	12699	13068
Magnesium (Mg)	mg/L	3.92	0.23	0.28	0.09	0.44	1.18	1.21
Potassium (K)	mg/L	1717	101	120	38	191	516	531
Sodium (Na)	mg/L	838	49	59	18	93	252	259
Bromide (Br)	mg/L	1066	63	75	23	119	320	330
Chloride (Cl)	mg/L	83700	4926	5873	1833	9332	25149	25880
Fluoride (F)	mg/L	0.060	0.004	0.004	0.001	0.007	0.018	0.019
Sulphate (SO4)	mg SO_4/L	<0.6	0	0	0	0	0	0
Nutrients								
Nitrates (NO3)	mg N/L	0.540	0.032	0.038	0.012	0.060	0.162	0.167
Nitrites (NO2)	mg N/L	0.060	0.004	0.004	0.001	0.007	0.018	0.019

Table 4
Drilling Brine Composition
Westbay Well in Whale Tail Lake Talik
Whale Tail Project, Nunavut

Sample		Brine Fluid	Calculated Drilling Brine Port 6		Calculated Drilling Brine Port 4		Calculated Drilling Brine Port 3	
			Initial Brine	Maximum Brine	Initial Brine	Maximum Brine	Initial Brine	Maximum Brine
Date		17-Apr-16	21-Jul-16	21-Jul-16	24-Apr-16	27-Apr-16	02-Sep-16	02-Sep-16
Field measured parameters	Units							
Fluorescein Concentration	mg/L	512.70	138.00	158.10	512.70	341.90	445.90	437.20
Drilling Fluid Proportion		1.00	0.27	0.31	1.00	0.67	0.87	0.85
Formation Water Proportion		0.00	0.73	0.69	0.00	0.33	0.13	0.15
Initial Conductivity Reading	uS/cm	0	10240	12210	3810	19400	52280	53800
Dilution of Brine Factor in Port		0.00	0.06	0.07	0.02	0.11	0.30	0.31
Metals (dissolved)								
Aluminium (Al)	mg/L	0.498	0.0293	0.0349	0.0109	0.0555	0.1496	0.154
Antimony (Sb)	mg/L	0.0354	0.0021	0.0025	0.0008	0.0039	0.0106	0.0109
Silver (Ag)	mg/L	<0.0001	0.0	0.0	0.0	0.0	0.0	0.0
Arsenic (As)	mg/L	0.766	0.045	0.054	0.017	0.085	0.23	0.237
Barium (Ba)	mg/L	0.113	0.007	0.008	0.002	0.013	0.034	0.035
Berillium (Be)	mg/L	<0.0005	0.0	0.0	0.0	0.0	0.0	0.0
Bismuth (Bi)	mg/L	<0.0005	0.0	0.0	0.0	0.0	0.0	0.0
Boron (B)	mg/L	13.2	0.8	0.9	0.3	1.5	4.0	4.1
Cadmium (Cd)	mg/L	<0.00002	0.0	0.0	0.0	0.0	0.0	0.0
Chromium (Cr)	mg/L	<0.0006	0.0	0.0	0.0	0.0	0.0	0.0
Cobalt (Co)	mg/L	0.0406	0.0024	0.0028	0.0009	0.0045	0.0122	0.0126
Copper (Cu)	mg/L	0.0039	0.0002	0.0003	0.0001	0.0004	0.0012	0.0012
Tin (Sn)	mg/L	<0.001	0	0	0	0	0	0
Iron (Fe)	mg/L	2.6	0.15	0.18	0.06	0.29	0.78	0.8
Lithium (Li)	mg/L	34.52	2.03	2.42	0.76	3.85	10.37	10.67
Manganese (Mn)	mg/L	<0.0005	0	0	0	0	0	0
Mercury (Hg)	mg/L	0.0	0.00002	0.00003	0.00001	0.00004	0.00012	0.00012
Dissolved Mercury (Hg)	mg/L	-	0.00002	0.00003	0.00001	0.00004	0.00012	0.00012
Molybdenum (Mo)	mg/L	<0.0005	0	0	0	0	0	0
Nickel (Ni)	mg/L	1.35	0.08	0.09	0.03	0.15	0.41	0.42
Lead (Pb)	mg/L	<0.0003	0	0	0	0	0	0
Selenium (Se)	mg/L	3.83	0.23	0.27	0.08	0.43	1.15	1.18
Silica (Si)	mg/L	2.93	0.17	0.21	0.06	0.33	0.88	0.91
Strontium (Sr)	mg/L	656.0	38.61	46.03	14.36	73.14	197.1	202.83
Telluride (Te)	mg/L	<0.0005	0	0	0	0	0	0
Thallium (Tl)	mg/L	<0.002	0	0	0	0	0	0
Titanium (Ti)	mg/L	45.2	2.66	3.17	0.99	5.04	13.58	13.98
Uranium (U)	mg/L	-	0	0	0	0	0	0
Vanadium (V)	mg/L	<0.001	0	0	0	0	0	0
Zinc (Zn)	mg/L	<0.0005	0	0	0	0	0	0
QA/QC								
Calculated TDS (lab)	-	130500	-	-	-	-	-	-
Lab measured vs Calculated TDS	-	28%	-	-	-	-	-	-
Lab measured TDS vs Conductivity	-	0.67	-	-	-	-	-	-
Calculated TDS vs Calculated Conductivity	-	0.75	-	-	-	-	-	-

Table 5
Rock Formation Groundwater Quality Corrected to Remove Residual Drilling Water
Whale Tail Lake Talik
Whale Tail Project, Nunavut

Sample		Port 6				Port 4				Port 3			
Date		2-Aug-2016		13-Nov-2018		20-Jul-2016		11-Nov-2018		14-Sep-2016		12-Nov-2018	
Drilling Fluid Proportion		0.04	0.24	0.16		0.09	0.18	0.13		0.08	0.18	0.20	
Formation Water Proportion		0.96	0.76	0.84		0.91	0.82	0.87		0.92	0.82	0.80	
Sampling interval depth (metres along borehole)		274.0 m - 287.4 m				349.3 m - 359.1 m				381.3 m - 392.7 m			
Sampling interval vertical depth (metres)		257.7 m - 268.3 m				326.1 m - 335.2 m				356.0 m - 366.6 m			
Estimated concentration range (calculated)		minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
Average Field measured parameters													
Fluoroscein	ppb	41.77		83.54		93.00		66.21		81.90		100.05	
Total dissolved solids	mg/L	-	-	4543		-	-	7275		-	-	3765	
pH	S.U.	-	-	6.36		-	-	7.50		-	-	8.35	
Conductivity	uS/cm	4610		9083		6650		14555		4450		7500	
Estimated Water Quality													
Conventional parameters													
Total dissolved solids	mg/L	3198	4042	4681	5171	3581	3966	7970	9945	3483	3918	<4980	<5100
pH	S.U.	7.41	7.27	6.50	6.57	7.87	7.82	6.88	6.91	7.96	7.91	7.31	7.41
Conductivity	uS/cm	4797	6042	8041	8496	5366	5938	13084	15511	5220	5866	<7350	<7530
Reported Hardness	mg $CaCO_3$/L	2397	3030	2883	3127	2627	2910	4169	5582	1680	1891	<2600	<2740
Alkalinity	mg $CaCO_3$/L	40	51	30	31	18	20	9	11	52	58	51	52
Bicarbonate (HCO3)	mg $CaCO_3$/L	40	51	31	32	18	20	11	12	52	58	60	61
Major Ions													
Calcium (Ca)	mg/L	960	1213	1071	1164	1032	1143	1563	2125	671	756	<1040	<1090
Magnesium (Mg)	mg/L	22	27	51	51	12	14	62	66	1	1	1	1
Potassium (K)	mg/L	8	10	<20	<20	38	42	67	67	16	18	<38	<40
Sodium (Na)	mg/L	232	293	287	293	267	296	341	365	306	344	285	313
Bromide (Br)	mg/L	25	32	34	37	32	35	51	77	22	25	<32.5	<32.7
Chloride (Cl)	mg/L	2089	2641	2453	2697	2582	2860	3818	5722	1714	1929	<2700	<2700
Fluoride (F)	mg/L	0.21	0.27	<1.0	<1.0	0.5	0.5	<1.0	<1.0	1.1	1.2	<1.0	<1.0
Sulphate (SO4)	mg SO_4/L	-	-	<15	<15	-	-	<15	<15	-	-	<15	<15
Nutrients													
Ammonia N (NH3+NH4)	mg N/L	-	-	<0.437	<0.443	-	-	0.180	0.181	-	-	0.169	0.173
Nitrates (NO3)	mg N/L	0.063	0.079	<0.25	<0.25	0.06	0.06	<0.25	<0.25	0.016	0.018	<0.25	<0.25
Nitrites (NO2)	mg N/L	0.010	0.013	<0.050	<0.050	0.011	0.012	<0.050	<0.050	0.038	0.043	<0.050	<0.050
Total Phosphorous (P)	mg P/L	0.021	0.026	<0.0043	<0.0043	0.011	0.012	0.01	0.01	0.049	0.055	0.01	0.01

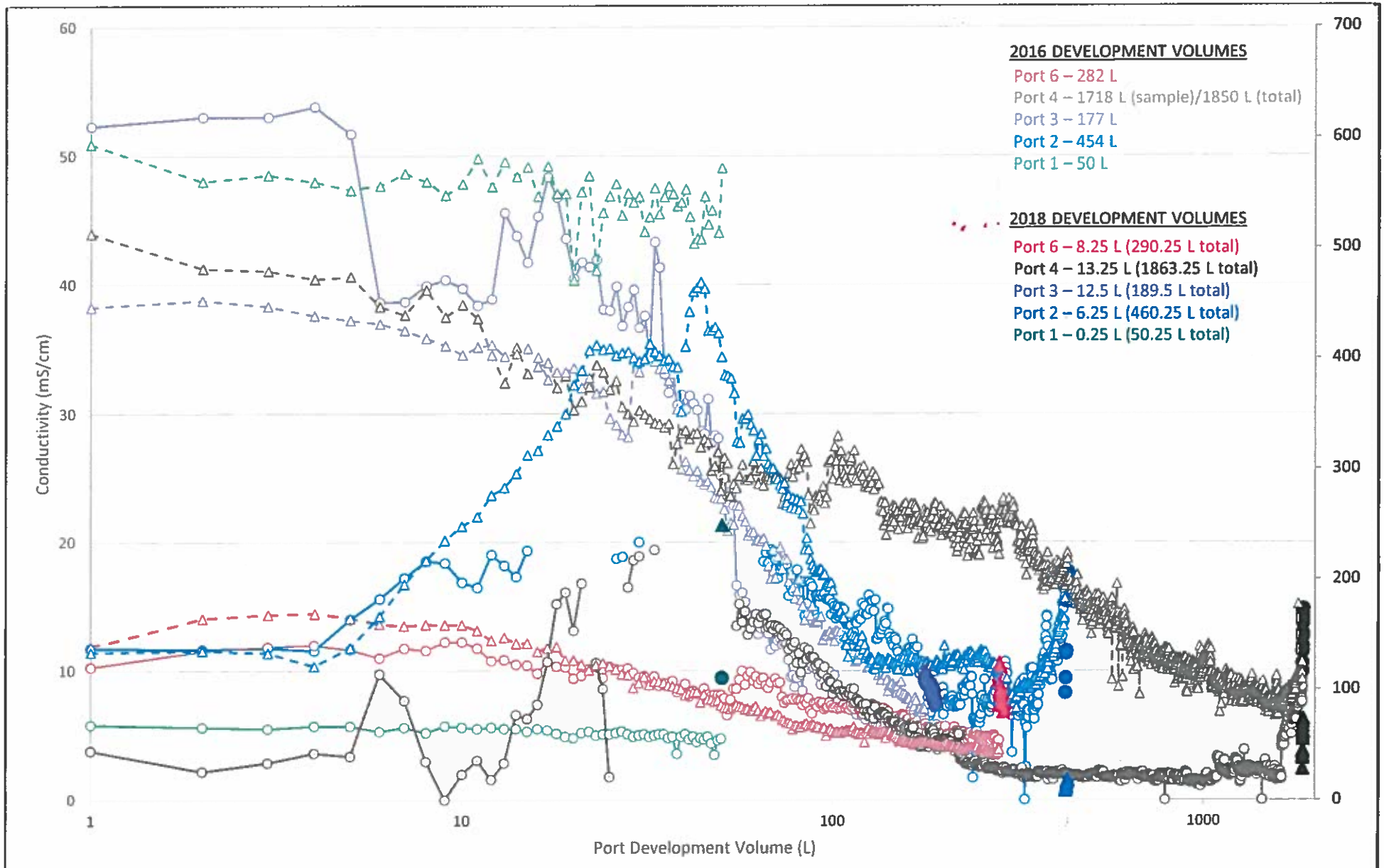
Table 5
Rock Formation Groundwater Quality Corrected to Remove Residual Drilling Water
Whale Tail Lake Talik
Whale Tail Project, Nunavut

Sample		Port 6				Port 4				Port 3			
Date		2, Aug-2016		13-Nov-2018		20-Jul-2016		11-Nov-2018		14-Sep-2016		12-Nov-2018	
Drilling Fluid Proportion		0.04	0.24	0.16		0.09	0.18	0.13		0.08	0.18	0.20	
Formation Water Proportion		0.96	0.76	0.84		0.91	0.82	0.87		0.92	0.82	0.80	
Sampling interval depth (metres along borehole)		274.0 m - 287.4 m				349.3 m - 359.1 m				381.3 m - 392.7 m			
Sampling interval vertical depth (metres)		257.7 m - 268.3 m				326.1 m - 335.2 m				356.0 m - 366.6 m			
Estimated concentration range (calculated)		minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum
Dissolved Metals													
Aluminium (Al)	mg/L	<0.006	<0.006	<0.0050	<0.0050	-	-	0.000	0.008	-	-	<0.0115	<0.0126
Antimony (Sb)	mg/L	0.0002	0.0003	0.001	0.001	0.003	0.004	0.001	0.002	0.0026	0.0029	0.001	0.001
Silver (Ag)	mg/L	<0.0001	<0.0001	<0.00010	<0.00010	<0.0001	<0.0001	<0.00010	<0.00010	<0.0001	<0.0001	<0.00010	<0.00010
Arsenic (As)	mg/L	0.0050	0.0063	<0.0021	<0.0024	0.0031	0.0035	<0.0020	<0.0020	<0.0005	<0.0005	<0.0034	<0.0034
Barium (Ba)	mg/L	0.528	0.667	0.947	0.976	0.134	0.148	0.533	0.561	0.057	0.065	0.098	0.104
Beriilium (Be)	mg/L	<0.0005	<0.0005	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050
Bismuth (Bi)	mg/L	<0.0005	<0.0005	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050
Boron (B)	mg/L	0.30	0.38	0.24	0.28	0.58	0.64	0.82	1.05	0.53	0.60	0.28	0.33
Cadmium (Cd)	mg/L	-	0.000033	<0.000050	<0.000050	<0.00002	<0.00002	<0.000050	<0.000050	<0.00002	<0.00002	<0.000050	<0.000050
Chromium (Cr)	mg/L	0.0070	0.0089	<0.00050	<0.00050	0.0054	0.0060	<0.00050	<0.00050	0.0048	0.0055	<0.00050	<0.00050
Cobalt (Co)	mg/L	0.0015	0.0019	<0.000050	<0.000050	0.0017	0.0018	<0.000050	<0.000050	0.0011	0.0012	<0.000050	<0.000050
Copper (Cu)	mg/L	0.0055	0.0069	<0.00050	<0.00050	0.0020	0.0023	<0.00050	<0.00050	0.0046	0.0052	<0.00050	<0.00050
Tin (Sn)	mg/L	0.0010	<0.001	<0.0010	<0.0010	0.0011	0.0012	<0.0010	<0.0010	<0.001	<0.001	<0.0010	<0.0010
Iron (Fe)	mg/L	0.17	0.21	0.264	0.276	0.15	0.16	0.078	0.120	0.08	0.09	<0.018	<0.019
Lithium (Li)	mg/L	0.33	0.41	0.15	0.24	0.64	0.71	1.06	1.63	0.31	0.34	<0.749	<0.779
Manganese (Mn)	mg/L	0.04	0.05	0.115	0.116	0.022	0.024	0.093	0.096	0.008	0.009	0.022	0.023
Mercury (Hg)	mg/L	0.0008	0.0010	<0.000010	<0.000010	0.0028	0.0031	<0.000010	<0.000010	0.00215	0.00242	<0.000010	<0.000010
Dissolved Mercury (Hg)	mg/L	0.0005	0.0006	<0.000010	<0.000010	0.0031	0.0034	<0.000010	<0.000010	0.00217	0.00244	<0.000010	<0.000010
Molybdenum (Mo)	mg/L	0.02	0.02	0.029	0.031	0.0062	0.0068	0.013	0.013	0.019	0.021	0.018	0.019
Nickel (Ni)	mg/L	0.05	0.06	<0.00050	<0.00050	0.05	0.05	<0.00050	<0.00050	0.04	0.05	<0.00050	<0.00050
Lead (Pb)	mg/L	<0.0003	<0.0003	<0.00030	<0.00030	0.0027	0.0030	<0.00030	<0.00030	<0.0003	<0.0003	<0.00030	<0.00030
Selenium (Se)	mg/L	0.11	0.14	<0.0020	<0.0020	0.12	0.13	<0.0020	<0.0020	0.08	0.09	<0.0020	<0.0020
Silica (Si)	mg/L	4.00	5.06	3.19	3.31	4.18	4.63	2.48	2.63	4.29	4.82	3.51	3.51
Strontium (Sr)	mg/L	13.2	16.7	14.3	16.0	18.9	20.9	27.7	36.5	12.7	14.2	<16.9	<17.2
Telluride (Te)	mg/L	<0.0005	<0.0005	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050
Thallium (Tl)	mg/L	<0.0008	<0.0008	<0.000050	<0.000050	<0.0008	<0.0008	<0.000050	<0.000050	<0.0008	<0.0008	<0.000050	<0.000050
Titanium (Ti)	mg/L	0.350	0.442	<0.0050	<0.0050	0.336	0.373	<0.0050	<0.0050	0.229	0.257	<0.0050	<0.0050
Uranium (U)	mg/L	<0.001	<0.001	0.025	0.026	<0.001	<0.001	0.051	0.052	0.064	0.072	0.085	0.090
Vanadium (V)	mg/L	0.002	0.002	<0.000050	<0.000050	<0.0005	<0.0005	<0.000050	<0.000050	<0.001	<0.001	0.00020	0.00020
Zinc (Zn)	mg/L	1.3	1.7	<0.00050	<0.00050	0.63	0.70	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050

Table 6
QA/QC of Rock Formation Groundwater Quality
Whale Tail Lake Talik
Whale Tail Project, Nunavut

Sample			Part B					Part A			Part B		
Date			13-Nov-2018					11-Nov-2018			12-Nov-2018		
Certificate No			L2198327-1	L2198327-2	RPD			L2197641-3	L2197641-4	RPD	L2197641-5	L2197641-6	RPD
Sample ID	Method Detection Limit	Units	Zone 6	Zone 66		Method Detection Limit	Units	Zone 4	Zone 44		Zone 3	Zone 33	
Parameters													
Physical Tests (Water)													
Conductivity	2	uS/cm	8720	8780	1%	2	uS/cm	13900	14000	1%	7530	7550	2%
pH	0.1	pH	6.58	6.65	1%	0.1	pH	6.97	6.94	0%	7.40	7.50	1%
Total Suspended Solids	3	mg/L	8	10	13%	3	mg/L	24	20	18%	8	8	5%
Total Dissolved Solids	30	mg/L	5580	5410	3%	3	mg/L	9030	8820	2%	5100	4980	2%
Anions and Nutrients													
Alkalinity, Bicarbonate (as CaCO3)	1	mg/L	27	26	3%	1	mg/L	10	10	2%	51	50	1%
Alkalinity, Carbonate (as CaCO3)	1	mg/L	<1.0	<1.0	--	1	mg/L	<1.0	<1.0	--	<1.0	<1.0	--
Alkalinity, Hydroxide (as CaCO3)	1	mg/L	<1.0	<1.0	--	1	mg/L	<1.0	<1.0	--	<1.0	<1.0	--
Alkalinity, Total (as CaCO3)	1	mg/L	27	26	3%	1	mg/L	10	10	2%	51	50	1%
Ammonia, Total (as N)	0.005	mg/L	0.443	0.437	1%	0.005	mg/L	0.157	0.158	1%	0.139	0.136	2%
Bromide (Br)	2.5	mg/L	41	41	1%	0.05	mg/L	70	60	15%	33	33	1%
Chloride (Cl)	5	mg/L	3010	3060	2%	0.5	mg/L	5220	4530	14%	2700	2700	0%
Fluoride (F)	1	mg/L	<1.0	<1.0	--	0.02	mg/L	<1.0	<1.0	--	<1.0	<1.0	--
Nitrate (as N)	0.25	mg/L	<0.25	<0.25	--	0.005	mg/L	<0.25	<0.25	--	<0.25	<0.25	--
Nitrite (as N)	0.05	mg/L	<0.050	<0.050	--	0.001	mg/L	<0.050	<0.050	--	<0.050	<0.050	--
Phosphorus (P)-Total	0.002	mg/L	0.004	0.005	19%	0.002	mg/L	0.01	0.01	13%	0.006	0.008	+/- MDL
Sulfate (SO4)	15	mg/L	<15	<15	--	0.3	mg/L	<15	<15	--	<15	<15	--
Physical Tests													
Hardness (as CaCO3)	4.8	mg/L	3630	3670	0.3%	4.8	mg/L	5160	5150	0%	2600	2740	5%
Dissolved Metals													
Aluminum (Al)-Dissolved	0.005	mg/L	<0.0050	<0.0050	1%	0.005	mg/L	0.0085	0.0076	11%	0.0126	0.0115	9%
Antimony (Sb)-Dissolved	0.0005	mg/L	<0.00050	0.0005	+/- MDL	0.0005	mg/L	0.00163	0.00172	5%	0.00308	0.003	3%
Arsenic (As)-Dissolved	0.002	mg/L	0.0021	0.0024	13%	0.002	mg/L	<0.0020	<0.0020	--	0.0034	0.0034	0%
Barium (Ba)-Dissolved	0.001	mg/L	0.818	0.794	3%	0.001	mg/L	0.466	0.489	5%	0.0902	0.0854	5%
Beryllium (Be)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Bismuth (Bi)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Boron (B)-Dissolved	0.1	mg/L	0.36	0.35	3%	0.1	mg/L	0.9	0.95	5%	1.04	1.02	2%
Cadmium (Cd)-Dissolved	0.000005	mg/L	<0.000050	<0.000050	--	0.000005	mg/L	<0.000050	<0.000050	--	<0.000050	<0.000050	--
Calcium (Ca)-Dissolved	1	mg/L	1380	1380	0%	1	mg/L	1970	1970	0%	1040	1090	5%
Cesium (Cs)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	0.00075	0.00074	1%	<0.00050	<0.00050	--
Chromium (Cr)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Cobalt (Co)-Dissolved	0.00005	mg/L	<0.000050	<0.000050	--	0.00005	mg/L	<0.000050	<0.000050	--	<0.000050	<0.000050	--
Copper (Cu)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Gallium (Ga)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Iron (Fe)-Dissolved	0.01	mg/L	0.251	0.256	2%	0.01	mg/L	0.112	0.105	6%	0.018	0.019	5%
Lead (Pb)-Dissolved	0.0003	mg/L	<0.00030	<0.00030	--	0.0003	mg/L	<0.00030	<0.00030	--	<0.00030	<0.00030	--
Lithium (Li)-Dissolved	0.02	mg/L	0.533	0.52	2%	0.02	mg/L	1.42	1.52	7%	0.779	0.749	4%
Magnesium (Mg)-Dissolved	1	mg/L	42.8	42.8	0%	1	mg/L	57.8	53.9	7%	1.2	1.2	0%
Manganese (Mn)-Dissolved	0.0002	mg/L	0.0961	0.097	1%	0.0002	mg/L	0.0836	0.0812	3%	0.0184	0.0181	2%
Mercury (Hg)-Dissolved	0.00001	mg/L	<0.000010	<0.000010	--	0.00001	mg/L	<0.000010	<0.000010	--	<0.000010	<0.000010	--
Molybdenum (Mo)-Dissolved	0.002	mg/L	0.0257	0.0245	5%	0.002	mg/L	0.0112	0.0116	4%	0.0154	0.0144	7%
Nickel (Ni)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Phosphorus (P)-Dissolved	0.05	mg/L	<0.050	<0.050	--	0.05	mg/L	<0.050	<0.050	--	<0.050	<0.050	--
Potassium (K)-Dissolved	20	mg/L	<20	<20	--	20	mg/L	67	66	2%	38	40	5%
Rhenium (Re)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Rubidium (Rb)-Dissolved	0.005	mg/L	0.0151	0.0146	3%	0.005	mg/L	0.0891	0.0814	9%	0.0549	0.0528	4%
Selenium (Se)-Dissolved	0.002	mg/L	<0.0020	<0.0020	--	0.002	mg/L	<0.0020	<0.0020	--	<0.0020	<0.0020	--
Silicon (Si)-Dissolved	1	mg/L	2.8	2.7	4%	1	mg/L	2.3	2.2	4%	3	3	0%
Silver (Ag)-Dissolved	0.0001	mg/L	<0.00010	<0.00010	--	0.0001	mg/L	<0.00010	<0.00010	--	<0.00010	<0.00010	--
Sodium (Na)-Dissolved	20	mg/L	253	250	1%	20	mg/L	309	320	3%	280	301	7%
Strontium (Sr)-Dissolved	0.05	mg/L	19.5	19.7	1%	0.05	mg/L	33.6	33.6	0%	16.9	17.2	2%
Sulfur (S)-Dissolved	5	mg/L	<5.0	<5.0	--	5	mg/L	<5.0	<5.0	--	<5.0	<5.0	--
Tellurium (Te)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Thallium (Tl)-Dissolved	0.00005	mg/L	<0.000050	<0.000050	--	0.00005	mg/L	<0.000050	<0.000050	--	<0.000050	<0.000050	--
Thorium (Th)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Tin (Sn)-Dissolved	0.001	mg/L	<0.0010	<0.0010	--	0.001	mg/L	<0.0010	<0.0010	--	<0.0010	<0.0010	--
Titanium (Ti)-Dissolved	0.005	mg/L	<0.0050	<0.0050	--	0.005	mg/L	<0.0050	<0.0050	--	<0.0050	<0.0050	--
Tungsten (W)-Dissolved	0.001	mg/L	0.0214	0.0208	3%	0.001	mg/L	0.0455	0.0443	3%	0.0722	0.0687	5%
Uranium (U)-Dissolved	0.00005	mg/L	<0.000050	<0.000050	--	0.00005	mg/L	<0.000050	<0.000050	--	0.00016	0.000144	11%
Vanadium (V)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Yttrium (Y)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
Zinc (Zn)-Dissolved	0.003	mg/L	0.0244	0.023	6%	0.003	mg/L	0.0096	0.01	4%	<0.0030	<0.0030	--
Zirconium (Zr)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	--	0.0005	mg/L	<0.00050	<0.00050	--	<0.00050	<0.00050	--
QA/QC													
Calculated TDS (lab)	-	mg/L	4779	4826	-	-	-	7743	7950	-	4165	4237	-
Lab measured vs Calculated TDS	-		156%	162%	-	-	-	154%	159%	-	148%	148%	-
Lab measured TDS vs conductivity	-	uS/cm	0.6	0.6	-	-	-	0.6	0.6	-	0.7	0.7	-

Notes
Concentrations are mg/L unless otherwise noted.
[1] Part F Item 2 of Meadowbank Water License. All regulated parameters for total concentration
RPD value exceeds 20%
FD = Field duplicate
RPD = relative percent difference
-- not calculated (one or both results below MDL)



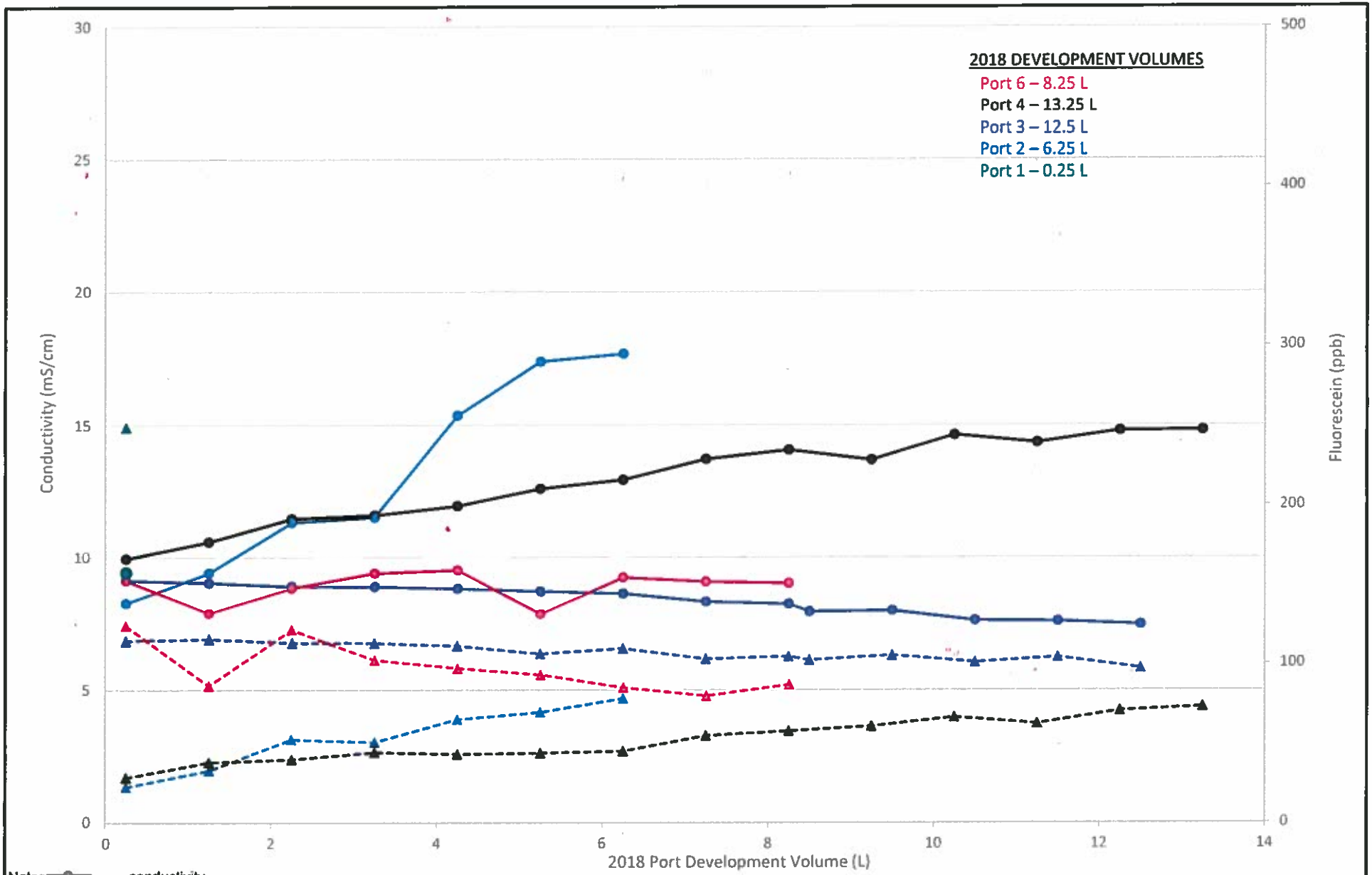
Notes:
2016 conductivity
2016 fluorescein
2018 conductivity
2018 fluorescein
Volumes reported at time of sample collection and/or end of development (Port 1, Port 4 - 1855 L only)

2016 Data: Port 6, Port 4, Port 3, Port 2 and Port 1
2018 Data: Port 6, Port 4, Port 3, Port 2 and Port 1

GOLDER

CLIENT	AGNICO EAGLE MINES LIMITED
CONSULTANT	
YYYY-MM-DD	2019-02-08
PREPARED	OH
DESIGN	--
REVIEW	VJB
APPROVED	VJB
PROJECT	2018 WESTBAY SYSTEM GROUNDWATER MONITORING INVESTIGATION
TITLE	2016 AND 2018 DEVELOPMENT RECORD
PROJECT No.	1789310-244
Rev	

FIGURE 1



Notes: conductivity
fluorescein
Volumes reported at time of sample collection and/or end of development (for Port 1)

Colours Port 6, Port 4, Port 3, Port 2 and Port 1

CLIENT
AGNICO EAGLE MINES LIMITED

CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-08
PREPARED	DH
DESIGN	–
REVIEW	VJB
APPROVED	VJB

PROJECT
2018 WESTBAY SYSTEM GROUNDWATER MONITORING INVESTIGATION

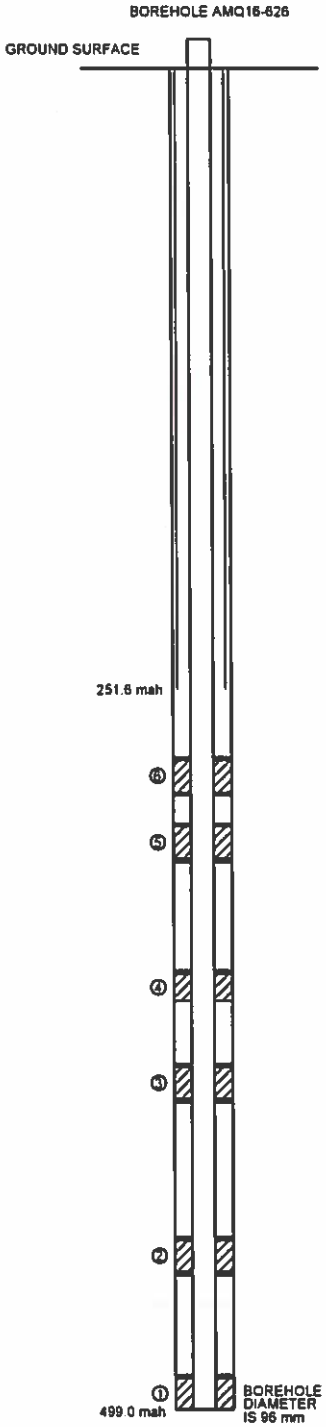
TITLE
2018 DEVELOPMENT RECORD

PROJECT No. Rev.
1789310-244

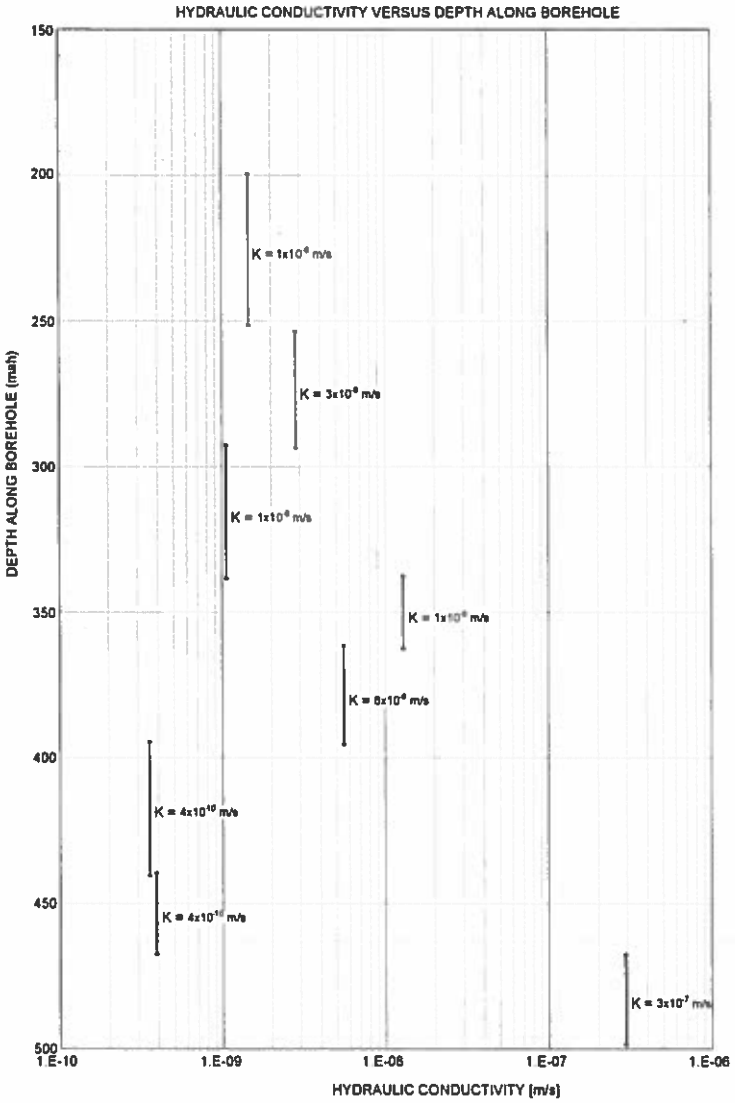
FIGURE 2

APPENDIX A

AMQ160626 Westbay System Installation Details



WESTBAY SYSTEM ZONE DEPTH SUMMARY						
ZONE	DEPTH ALONG HOLE			VERTICAL DEPTH		
	FROM (mah)	TO (mah)	LENGTH (m)	FROM (mbgs)	TO (mbgs)	THICKNESS (m)
6	276.0	287.4	11.4	257.7	268.3	10.6
5	298.9	310.3	11.4	279	289.7	10.6
4	349.3	359.1	9.8	326.1	335.2	9.1
3	381.3	392.7	11.4	356.0	366.6	10.6
2	440.8	452.2	11.4	411.5	422.2	10.6
1	488.1	499.0	10.9	455.7	465.9	10.2



LEGEND

	PACKER	K	HYDRAULIC CONDUCTIVITY
①	WESTBAY MONITORING ZONE	mah	METRES ALONG BOREHOLE, RELATIVE TO GROUND SURFACE
	STEEL CASING	mbgs	METRES BELOW GROUND SURFACE
		m/s	METRES PER SECOND

NOTES

1. ALL UNITS ARE IN METERS UNLESS OTHERWISE NOTED
2. PERMAFROST ASSUMED 200 m ALONG HOLE ALIGNMENT.
3. DRILL RODS TO 251.6 m ALONG HOLE.
4. BOREHOLE LOCATED IN UTM NAD 83 ZONE 14, N =7255363.5 E = 607161.68 ELEVATION = 154.46 m.
5. AVERAGE BOREHOLE INCLINATION IS 69°.

NOT TO SCALE
SCHEMATIC ONLY

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	
D	2016-07-06	ISSUED FOR FINAL	JJ	PP	DV	DC
A	2016-05-27	ISSUED FOR REVIEW	JJ	PP		

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
WHALE TAIL PIT PROJECT
NUNAVUT, CANADA

TITLE

AMQ16-626 WESTBAY SYSTEM INSTALLATION DETAILS

Golder Associates

PROJECT No.	1649355 4000.3000		FILE No.	1649355-4000-3000-03	
DESIGN	JJ	2016-07-06	SCALE	NOT TO SCALE	
CADD	PP	2016-07-06	FIGURE	3	
CHECK	DV	2016-07-06			
REVIEW	DC	2016-07-06			

\\golder.gds\ga\Nunavik\CAD-GIS\Client\Agnico_Eagle_Mines_LtdWhale_Tail\99_PROJECTS\1649355\02_PRODUCTION\4000\3000\DWG\1649355-4000-3000-03.dwg | Layout: AMQ16-626 WESTBAY SYSTEM INSTALLATION DETAILS | Modified: gmacuhesh 05/26/2016 1:35 PM | Plotted: gmacuhesh 07/06/2016

APPENDIX B

Westbay Instruments Mosdax Sampler Calibration Reports

MOSDAX Calibration Report 1: EMS - 1764 Module 323

Full Scale: 2000 (psia)

File: E:\DATA\CAL\0-2018\2000\26JAN2~1\01764

Pressure Reference: Paroscientific Model 42K-101 S/N 59937

Range: 2K PSI

Date of last reference to traceable standard: Oct 5 2017

EMS - 1764 Jan 26 17:09:52 2018
Range 1 Temp 3.1° C

Ref Pres (psia)	Error (psia)	(% FS)
14.817	0.208	0.010
193.345	-0.073	-0.004
393.618	-0.272	-0.014
589.887	-0.183	-0.009
787.108	-0.110	-0.006
992.089	-0.024	-0.001
1191.192	0.036	0.002
1390.713	0.133	0.007
1589.940	0.097	0.005
1781.966	0.014	0.001
1987.965	-0.329	-0.016
1817.144	-0.012	-0.001
1618.742	0.102	0.005
1413.125	0.180	0.009
1213.194	0.106	0.005
1009.488	0.089	0.004
807.541	-0.027	-0.001
606.650	-0.114	-0.006
406.828	-0.184	-0.009
205.695	-0.015	-0.001
14.824	0.214	0.011

EMS - 1764 Jan 26 07:09:09 2018
Range 2 Temp 10.1° C

Ref Pres (psia)	Error (psia)	(% FS)
14.763	0.210	0.011
193.566	-0.123	-0.006
392.913	-0.184	-0.009
591.481	-0.211	-0.011
790.656	-0.114	-0.006
990.073	0.058	0.003
1184.170	0.092	0.005
1382.638	0.117	0.006
1583.021	0.197	0.010
1783.679	0.027	0.001
1991.373	-0.178	-0.009
1816.737	0.061	0.003
1611.101	0.226	0.011
1410.177	0.278	0.014
1209.052	0.204	0.010
1008.134	0.118	0.006
809.316	-0.034	-0.002
608.601	-0.077	-0.004
406.467	-0.147	-0.007
205.759	-0.012	-0.001
14.783	0.231	0.012

EMS - 1764 Jan 26 02:21:39 2018
Range 3 Temp 19.9° C

Ref Pres (psia)	Error (psia)	(% FS)
14.745	0.228	0.011
193.251	-0.079	-0.004
392.313	-0.228	-0.011
591.070	-0.177	-0.009
790.016	-0.162	-0.008
988.877	-0.001	0.000
1189.677	-0.007	0.000
1383.376	0.058	0.003
1582.918	0.132	0.007
1783.642	-0.023	-0.001
1990.362	-0.278	-0.014
1807.379	-0.041	-0.002
1611.387	0.144	0.007
1410.184	0.103	0.005
1209.054	0.151	0.008
1007.771	0.068	0.003
807.386	-0.029	-0.001
608.200	-0.110	-0.005
407.925	-0.205	-0.010
206.304	-0.075	-0.004
14.730	0.212	0.011

EMS - 1764 Jan 25 20:49:38 2018
Range 4 Temp 29.9° C

Ref Pres (psia)	Error (psia)	(% FS)
14.664	0.129	0.006
193.289	-0.074	-0.004
392.551	-0.259	-0.013
590.683	-0.199	-0.010
790.879	-0.111	-0.006
989.404	-0.070	-0.003
1188.900	-0.088	-0.004
1383.144	0.006	0.000
1582.510	-0.017	-0.001
1783.117	-0.170	-0.008
1990.420	-0.360	-0.018
1817.923	-0.145	-0.007
1612.561	0.048	0.002
1409.796	0.050	0.003
1208.930	0.011	0.001
1007.679	0.001	0.000
807.799	-0.074	-0.004
607.517	-0.125	-0.006
406.301	-0.139	-0.007
205.701	-0.048	-0.002
14.686	0.149	0.007

EMS - 1764 Jan 25 15:45:50 2018
Range 5 Temp 39.9° C

Ref Pres (psia)	Error (psia)	(% FS)
14.630	0.147	0.007
193.274	-0.098	-0.005
393.384	-0.239	-0.012
590.646	-0.204	-0.010
792.587	-0.140	-0.007
989.121	-0.059	-0.003
1188.417	-0.084	-0.004
1390.226	0.040	0.002
1582.457	0.023	0.001
1783.077	-0.054	-0.003
1990.337	-0.125	-0.006
1809.812	-0.012	-0.001
1612.027	0.084	0.004
1410.656	0.064	0.003
1207.895	0.018	0.001
1007.484	0.004	0.000
807.295	-0.056	-0.003
608.401	-0.142	-0.007
406.285	-0.237	-0.012
205.685	-0.138	-0.007
14.645	0.098	0.005

Issued by

Westbay Instruments

MOSDAX Calibration Report 2: EMS - 1764 Module 323

Full Scale: 2000 (psia)

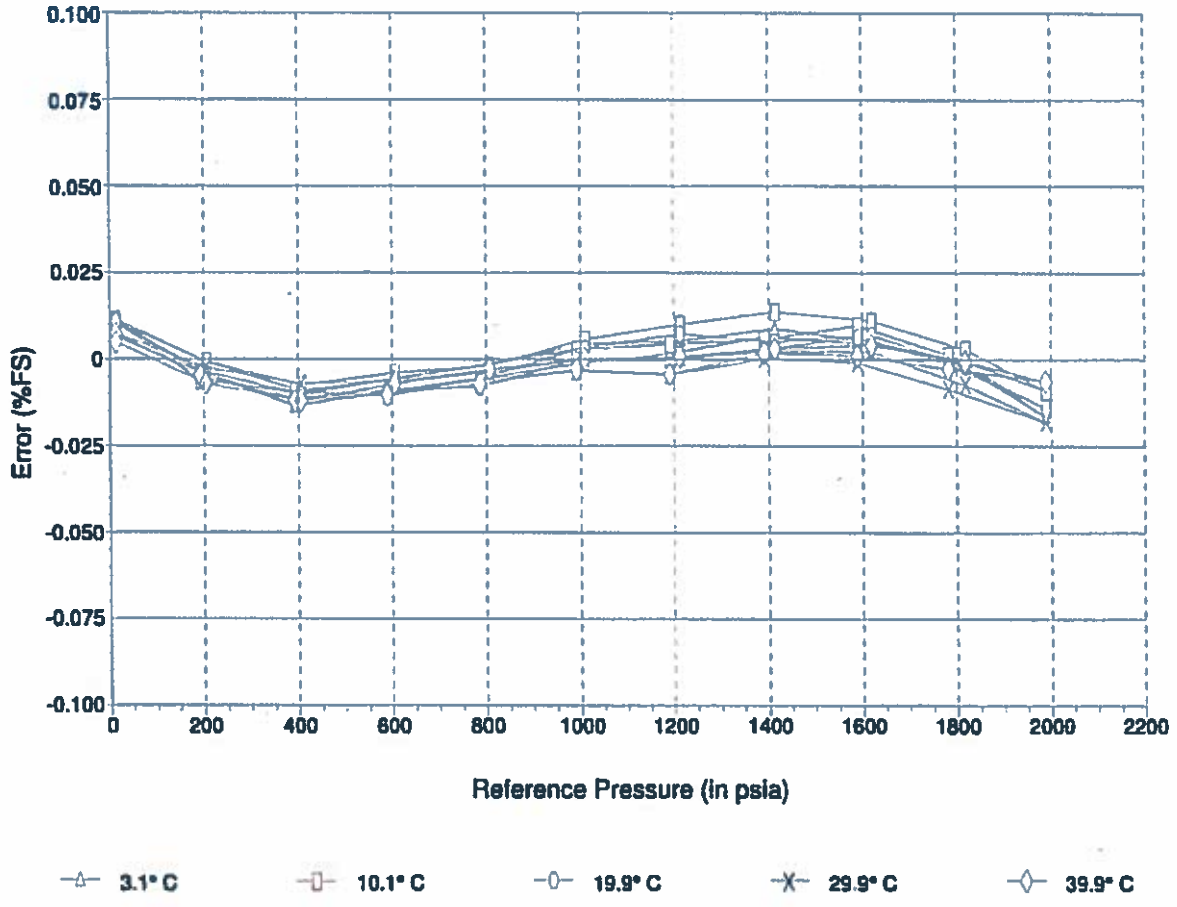
File: E:\DATA\CAL\0-2018\2000\26JAN2-1\01764

Pressure Reference: Paroscientific Model 42K-101 S/N 59937

Range: 2K PSI

Date of last reference to traceable standard: Oct 5 2017

Plot of Error vs. Reference Pressure



Comments

Issued by

Westbay Instruments

As Received MOSDAX Cal. Report 2: EMS - 1764 Module 323

Full Scale: 2000 (psia)

File: E:\DATA\CAL\0-2018\2000\26JAN2-1\01764

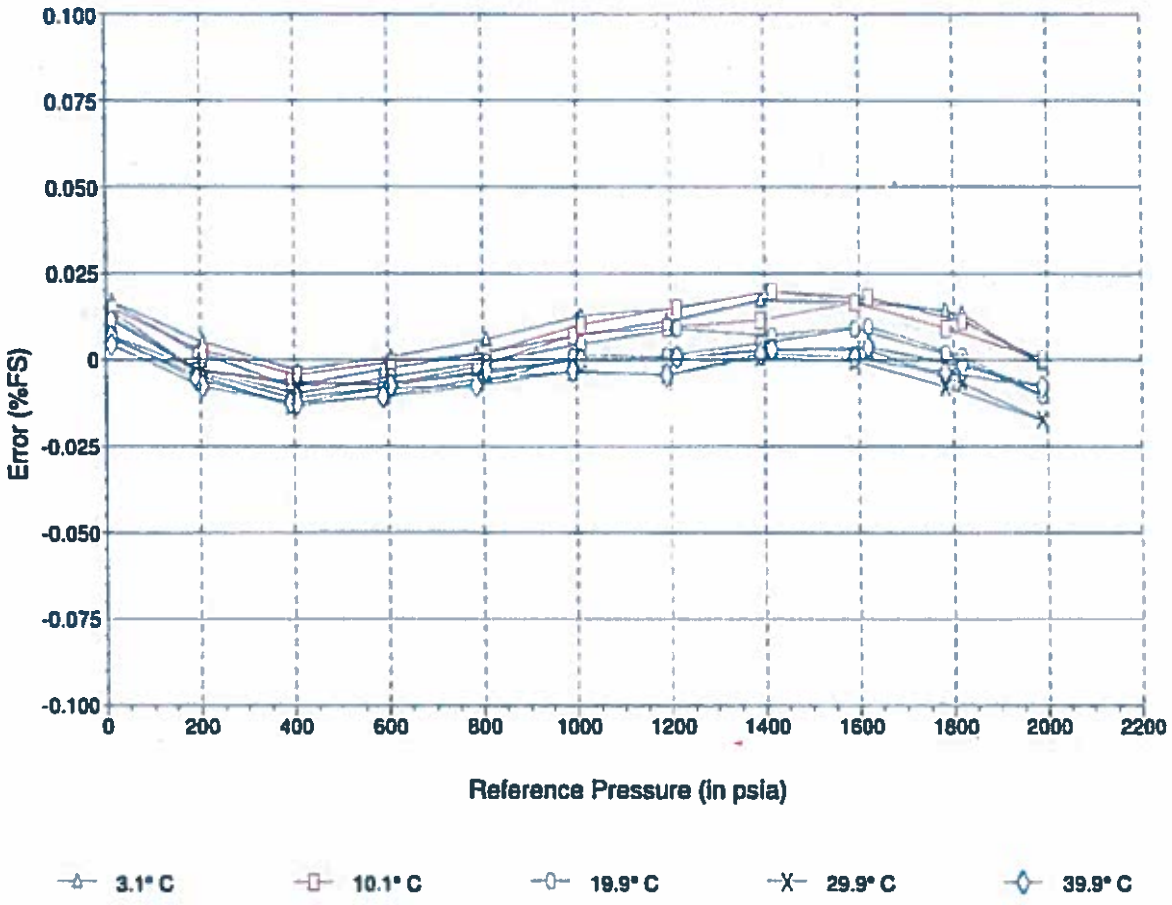
Pressure Reference: Paroscientific Model 42K-101 S/N 59937

Range: 2K PSI

Date of last reference to traceable standard: Oct 5 2017

Plot of Error vs. Reference Pressure

EMS - 1764 Module 323



Comments

Issued by

Westbay Instruments

As Received MOSDAX Cal. Report 1: EMS - 1764 Module 323

Full Scale: 2000 (psia)

File: E:\DATA\CAL\0-2018\2000\25JAN2-1\01764

Pressure Reference: Paroscientific Model 42K-101 S/N 59937

Range: 2K PSI

Date of last reference to traceable standard: Oct 5 2017

EMS - 1764 Jan 26 17:09:52 2018 Range 1 Temp 3.1° C			EMS - 1764 Jan 26 07:09:09 2018 Range 2 Temp 10.1° C			EMS - 1764 Jan 26 02:21:39 2018 Range 3 Temp 19.9° C		
Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)
14.817	0.330	0.016	14.763	0.276	0.014	14.745	0.240	0.012
193.345	0.046	0.002	193.566	-0.061	-0.003	193.251	-0.068	-0.003
393.618	-0.152	-0.008	392.913	-0.123	-0.006	392.313	-0.217	-0.011
589.887	-0.055	-0.003	591.481	-0.147	-0.007	591.070	-0.165	-0.008
787.108	0.031	0.002	790.656	-0.043	-0.002	790.016	-0.146	-0.007
992.089	0.136	0.007	990.073	0.140	0.007	988.677	0.020	0.001
1191.192	0.219	0.011	1184.170	0.188	0.009	1189.677	0.022	0.001
1390.713	0.343	0.017	1382.638	0.231	0.012	1383.376	0.095	0.005
1589.940	0.337	0.017	1583.021	0.331	0.017	1582.918	0.179	0.009
1781.966	0.285	0.014	1783.679	0.185	0.009	1783.642	0.037	0.002
1987.965	-0.022	-0.001	1991.373	0.007	0.000	1990.362	-0.203	-0.010
1817.144	0.265	0.013	1816.737	0.223	0.011	1807.379	0.021	0.001
1618.742	0.348	0.017	1611.101	0.363	0.018	1611.387	0.194	0.010
1413.125	0.394	0.020	1410.177	0.394	0.020	1410.184	0.141	0.007
1213.194	0.296	0.015	1209.052	0.302	0.015	1209.054	0.180	0.009
1009.488	0.252	0.013	1008.134	0.201	0.010	1007.771	0.089	0.004
807.541	0.117	0.006	809.316	0.037	0.002	807.386	-0.013	-0.001
606.650	0.016	0.001	608.601	-0.013	-0.001	608.200	-0.098	-0.005
406.828	-0.062	-0.003	406.467	-0.087	-0.004	407.925	-0.194	-0.010
205.695	0.104	0.005	205.759	0.050	0.002	206.304	-0.064	-0.003
14.824	0.336	0.017	14.783	0.297	0.015	14.730	0.225	0.011

EMS - 1764 Jan 25 20:49:38 2018 Range 4 Temp 29.9° C			EMS - 1764 Jan 25 15:45:50 2018 Range 5 Temp 39.9° C		
Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)
14.664	0.116	0.006	14.630	0.132	0.007
193.289	-0.086	-0.004	193.274	-0.112	-0.006
392.551	-0.268	-0.013	393.384	-0.250	-0.013
590.683	-0.206	-0.010	590.646	-0.212	-0.011
790.879	-0.114	-0.006	792.587	-0.146	-0.007
989.404	-0.069	-0.003	989.121	-0.063	-0.003
1188.900	-0.084	-0.004	1188.417	-0.088	-0.004
1383.144	0.013	0.001	1390.226	0.034	0.002
1582.510	-0.007	0.000	1582.457	0.014	0.001
1783.117	-0.157	-0.008	1783.077	-0.071	-0.004
1990.420	-0.345	-0.017	1990.337	-0.153	-0.008
1817.923	-0.132	-0.007	1809.812	-0.030	-0.002
1612.561	0.056	0.003	1612.027	0.074	0.004
1409.796	0.058	0.003	1410.656	0.058	0.003
1208.930	0.015	0.001	1207.895	0.014	0.001
1007.679	0.001	0.000	1007.484	0.000	0.000
807.799	-0.077	-0.004	807.295	-0.062	-0.003
607.517	-0.131	-0.007	608.401	-0.150	-0.007
406.301	-0.148	-0.007	406.285	-0.249	-0.012
205.701	-0.059	-0.003	205.685	-0.152	-0.008
14.686	0.136	0.007	14.645	0.083	0.004

Issued by

Westbay Instruments

MOSDAX Calibration Report 1: EMS - 2652 Module 3008

Full Scale: 2000 (psia)

File: E:\DATA\CAL\0-2018\2000\2JUNE2-1\02652

Pressure Reference: Paroscientific Model 42K-101 S/N 59937

Range: 2K PSI

Date of last reference to traceable standard: Oct 5 2017

EMS - 2652 Jun 02 12:30:14 2018 Range 1 Temp 3.3° C			EMS - 2652 Jun 02 07:51:36 2018 Range 2 Temp 10.3° C			EMS - 2652 Jun 02 03:10:20 2018 Range 3 Temp 20.1° C		
Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)
14.846	-0.142	-0.007	14.855	-0.105	-0.005	14.842	-0.118	-0.006
192.843	-0.001	0.000	192.231	-0.010	-0.001	194.509	-0.104	-0.005
393.849	0.122	0.006	393.607	0.068	0.003	390.935	0.064	0.003
587.948	-0.023	-0.001	593.420	0.070	0.003	592.897	0.002	0.000
791.882	-0.022	-0.001	792.296	0.087	0.004	791.655	0.062	0.003
990.911	-0.057	-0.003	991.833	0.075	0.004	991.348	0.019	0.001
1190.327	-0.189	-0.009	1191.049	-0.061	-0.003	1190.921	-0.121	-0.006
1390.264	-0.181	-0.009	1390.953	-0.006	0.000	1390.842	-0.037	-0.002
1589.406	-0.082	-0.004	1589.174	0.014	0.001	1589.397	-0.028	-0.001
1781.525	0.044	0.002	1781.549	0.156	0.008	1781.207	0.088	0.004
1989.515	0.123	0.006	1989.230	0.324	0.016	1989.355	0.295	0.015
1818.398	0.071	0.004	1818.861	0.206	0.010	1816.258	0.129	0.006
1619.022	-0.012	-0.001	1618.518	0.147	0.007	1618.089	0.091	0.005
1412.880	-0.003	0.000	1415.894	0.075	0.004	1413.069	0.081	0.004
1211.907	-0.038	-0.002	1212.127	0.094	0.005	1212.924	0.023	0.001
1009.806	0.075	0.004	1010.514	0.213	0.011	1009.965	0.189	0.009
808.334	0.096	0.005	808.014	0.218	0.011	807.813	0.215	0.011
606.956	0.169	0.008	606.949	0.179	0.009	606.634	0.213	0.011
406.373	0.123	0.006	406.191	0.137	0.007	407.189	0.192	0.010
205.741	0.110	0.006	206.072	0.110	0.005	205.699	0.162	0.008
14.848	-0.083	-0.004	14.863	-0.040	-0.002	14.852	-0.051	-0.003

EMS - 2652 Jun 01 22:31:07 2018 Range 4 Temp 30.0° C			EMS - 2652 Jun 01 17:53:01 2018 Range 5 Temp 39.8° C		
Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)
14.847	-0.019	-0.001	14.838	-0.006	0.000
194.042	-0.002	0.000	194.229	0.072	0.004
393.209	0.097	0.005	393.823	0.095	0.005
593.265	0.087	0.004	592.922	0.099	0.005
792.056	0.052	0.003	792.743	0.066	0.003
991.614	0.043	0.002	991.261	0.057	0.003
1189.236	-0.151	-0.008	1190.280	-0.056	-0.003
1389.839	-0.128	-0.006	1389.590	-0.057	-0.003
1588.713	-0.048	-0.002	1588.437	0.020	0.001
1788.124	0.061	0.003	1789.309	0.187	0.009
1989.624	0.201	0.010	1989.755	0.368	0.018
1817.189	0.140	0.007	1818.126	0.224	0.011
1616.308	0.001	0.000	1615.388	0.129	0.006
1412.900	0.022	0.001	1413.930	0.177	0.009
1212.611	0.060	0.003	1208.395	0.080	0.004
1009.750	0.246	0.012	1009.785	0.309	0.015
808.478	0.183	0.009	808.128	0.308	0.015
606.817	0.225	0.011	606.791	0.317	0.016
406.966	0.233	0.012	407.604	0.144	0.007
205.745	0.163	0.008	206.494	0.092	0.005
14.853	-0.013	-0.001	14.839	-0.005	0.000

Issued by

Westbay Instruments

MOSDAX Calibration Report 2: EMS - 2652 Module 3008

Full Scale: 2000 (psia)

File E:\DATA\CAL\0-2018\2000\2JUNE2-1\02652

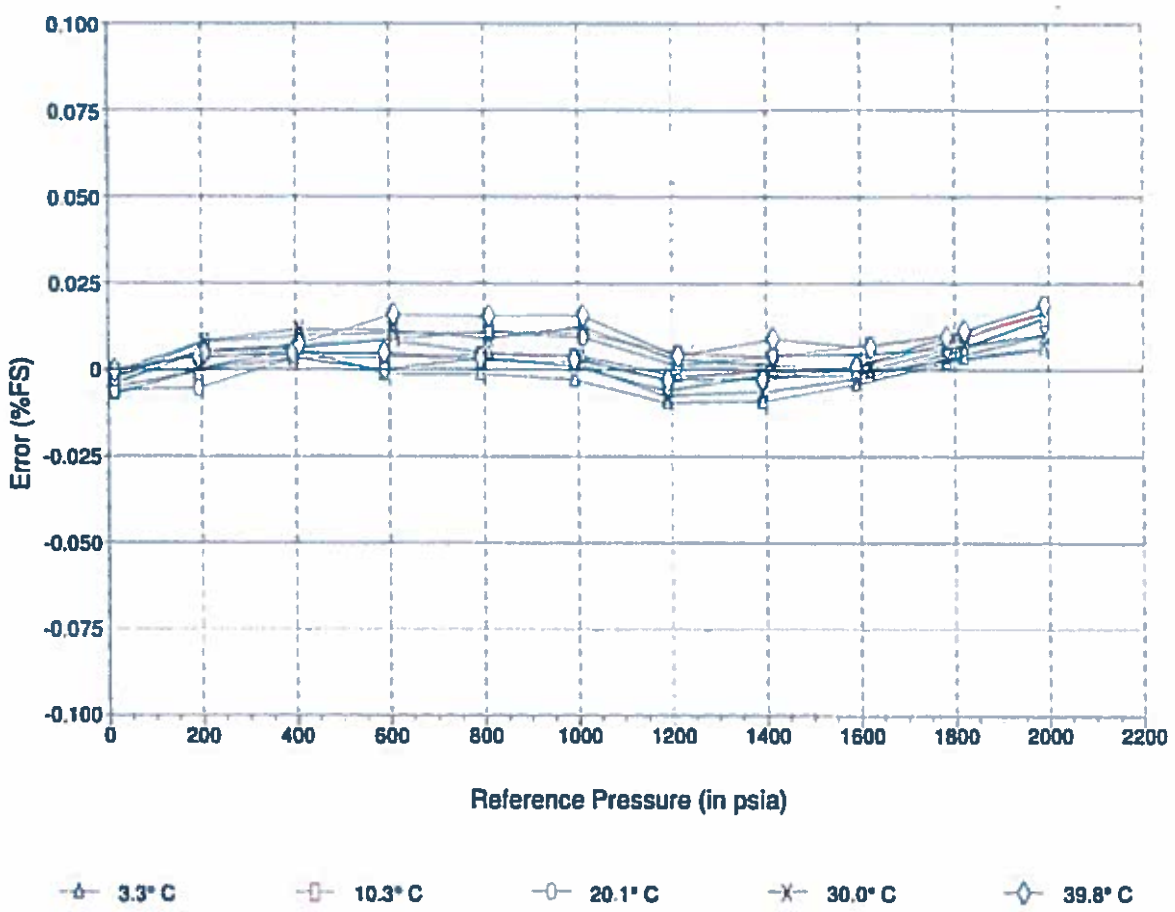
Pressure Reference: Paroscientific Model 42K-101 S/N 59937

Range: 2K PSI

Date of last reference to traceable standard: Oct 5 2017

Plot of Error vs. Reference Pressure

EMS - 2652 Module 3008



Comments

Issued by

Westbay Instruments

As Received MOSDAX Cal. Report 1: EMS - 2652 Module 3008

Full Scale: 2000 (psia)

File: E:\DATA\CAL\0-2018\200002\JUNE2-1\02652

Pressure Reference: Paroscientific Model 42K-101 S/N 59937

Range: 2K PSI

Date of last reference to traceable standard: Oct 5 2017

EMS - 2652 Jun 02 12:30:14 2018 Range 1 Temp 3.3° C			EMS - 2652 Jun 02 07:51:36 2018 Range 2 Temp 10.3° C			EMS - 2652 Jun 02 03:10:20 2018 Range 3 Temp 20.1° C		
Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)
14.846	0.013	0.001	14.855	0.042	0.002	14.842	0.032	0.002
192.843	0.170	0.008	192.231	0.155	0.008	194.509	0.061	0.003
393.849	0.313	0.016	393.607	0.255	0.013	390.935	0.244	0.012
587.948	0.190	0.009	593.420	0.277	0.014	592.897	0.196	0.010
791.882	0.218	0.011	792.296	0.315	0.016	791.655	0.268	0.013
990.911	0.211	0.011	991.833	0.321	0.016	991.348	0.236	0.012
1190.327	0.110	0.005	1191.049	0.204	0.010	1190.921	0.105	0.005
1390.264	0.152	0.008	1390.953	0.279	0.014	1390.842	0.196	0.010
1589.406	0.286	0.014	1589.174	0.318	0.016	1589.397	0.211	0.011
1781.525	0.449	0.022	1781.549	0.476	0.024	1781.207	0.331	0.017
1989.515	0.569	0.028	1989.230	0.682	0.033	1989.355	0.540	0.027
1818.398	0.484	0.024	1818.861	0.530	0.027	1816.258	0.372	0.019
1619.022	0.362	0.018	1618.518	0.453	0.023	1618.089	0.330	0.017
1412.880	0.333	0.017	1415.894	0.362	0.018	1413.069	0.314	0.016
1211.907	0.264	0.013	1212.127	0.362	0.018	1212.924	0.250	0.013
1009.806	0.346	0.017	1010.514	0.462	0.023	1009.965	0.407	0.020
808.334	0.338	0.017	808.014	0.447	0.022	807.813	0.422	0.021
606.956	0.385	0.019	606.949	0.388	0.019	606.634	0.408	0.020
406.373	0.315	0.016	406.191	0.325	0.016	407.189	0.373	0.019
205.741	0.282	0.014	206.072	0.277	0.014	205.699	0.328	0.016
14.848	0.072	0.004	14.863	0.107	0.005	14.852	0.098	0.005

EMS - 2652 Jun 01 22:31:07 2018 Range 4 Temp 30.0° C			EMS - 2652 Jun 01 17:53:01 2018 Range 5 Temp 39.8° C		
Ref Pres (psia)	Error (psia)	(% FS)	Ref Pres (psia)	Error (psia)	(% FS)
14.847	0.148	0.007	14.838	0.193	0.010
194.042	0.167	0.008	194.229	0.252	0.013
393.209	0.270	0.013	393.823	0.259	0.013
593.265	0.263	0.013	592.922	0.253	0.013
792.056	0.233	0.012	792.743	0.216	0.011
991.614	0.229	0.011	991.261	0.209	0.010
1189.236	0.040	0.002	1190.280	0.104	0.005
1389.839	0.070	0.003	1389.590	0.117	0.006
1588.713	0.156	0.008	1588.437	0.215	0.011
1788.124	0.271	0.014	1789.309	0.410	0.020
1989.624	0.418	0.021	1989.755	0.624	0.031
1817.189	0.351	0.018	1818.126	0.450	0.023
1616.308	0.205	0.010	1615.388	0.327	0.016
1412.900	0.220	0.011	1413.930	0.354	0.018
1212.611	0.252	0.013	1208.395	0.241	0.012
1009.750	0.432	0.022	1009.785	0.462	0.023
808.478	0.364	0.018	808.128	0.458	0.023
606.817	0.403	0.020	606.791	0.471	0.024
406.966	0.406	0.020	407.604	0.307	0.015
205.745	0.332	0.017	206.494	0.271	0.014
14.853	0.154	0.008	14.839	0.194	0.010

Issued by

Westbay Instruments

As Received MOSDAX Cal. Report 2: EMS - 2652 Module 3008

Full Scale: 2000 (psia)

File: E:\DATA\CAL\0 2018\20002\JUNE2 - 1\02652

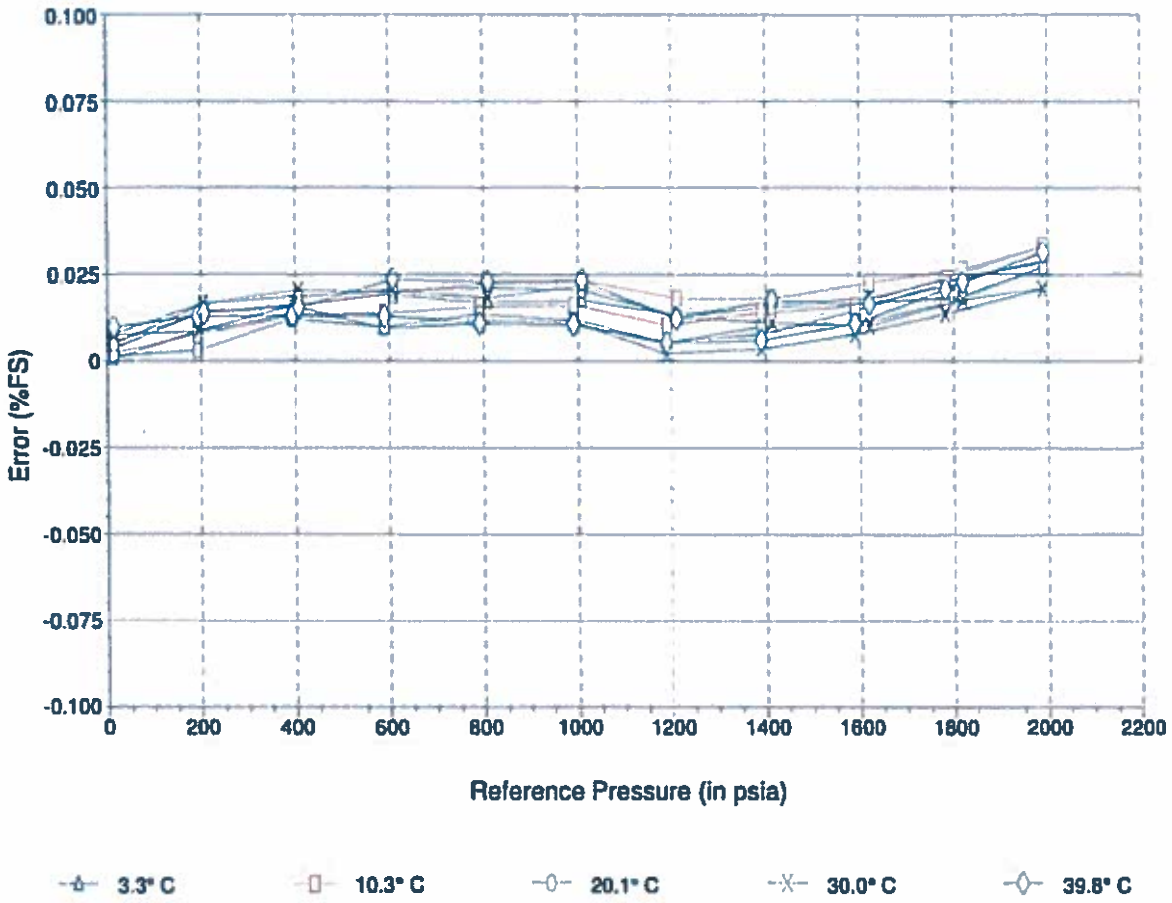
Pressure Reference: Paroscientific Model 42K-101 S/N 59937

Range: 2K PSI

Date of last reference to traceable standard: Oct 5 2017

Plot of Error vs. Reference Pressure

EMS - 2652 Module 3008



Comments

Issued by

Westbay Instruments

APPENDIX C

2018 Laboratory Certificates of Analysis

Golder Associates Ltd. (Ottawa)
ATTN: Dale Holtze
1931 Robertson Road
Ottawa ON K2H 5B7

Date Received: 16-NOV-18
Report Date: 22-NOV-18 16:58 (MT)
Version: FINAL REV. 2

Client Phone: 613-592-9600

Certificate of Analysis

Lab Work Order #: L2197641

Project P.O. #: NOT SUBMITTED
Job Reference: 1789310
C of C Numbers: 17-720417
Legal Site Desc:

Comments: ADDITIONAL 21-NOV-18 16:20
ADDITIONAL 19-NOV-18 17:56

Joanne Lee
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2197641-1	L2197641-2	L2197641-3	L2197641-4	L2197641-5
Description	GW	GW	GW	GW	GW
Sampled Date	10-NOV-18	10-NOV-18	11-NOV-18	11-NOV-18	12-NOV-18
Sampled Time	17:30	17:30	17:30	17:30	17:30
Client ID	ZONE 2	ZONE 22	ZONE 4	ZONE 44	ZONE 3
Grouping / **Analyte**					
SEAWATER					
Physical Tests Hardness (as CaCO3) (mg/L)	6260	6260	5160	5150	2600
Total Metals Aluminum (Al)-Total (mg/L)	0.118	0.126	0.0140	0.0139	0.0128
Antimony (Sb)-Total (mg/L)	0.00126	0.00129	0.00180	0.00186	0.00322
Arsenic (As)-Total (mg/L)	<0.0020	<0.0020	0.0021	0.0022	0.0032
Barium (Ba)-Total (mg/L)	0.102	0.0985	0.493	0.510	0.0918
Beryllium (Be)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Total (mg/L)	1.86	1.72	0.97	1.00	1.10
Cadmium (Cd)-Total (mg/L)	<0.000050	<0.000050	<0.000050	0.000055	<0.000050
Calcium (Ca)-Total (mg/L)	2710	2580	2040	1920	991
Cesium (Cs)-Total (mg/L)	0.00190	0.00184	0.00075	0.00077	<0.00050
Chromium (Cr)-Total (mg/L)	0.00246	0.00119	0.0130	0.0127	0.00999
Cobalt (Co)-Total (mg/L)	0.000120	0.000101	0.000237	0.000231	0.000166
Copper (Cu)-Total (mg/L)	0.00272	0.00303	0.00113	0.00102	<0.00050
Gallium (Ga)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)-Total (mg/L)	0.555	0.584	0.366	0.354	0.076
Lead (Pb)-Total (mg/L)	0.00460	0.00472	<0.00030	<0.00030	<0.00030
Lithium (Li)-Total (mg/L)	2.33	2.14	1.48	1.65	0.802
Magnesium (Mg)-Total (mg/L)	<1.0	<1.0	55.3	53.3	1.2
Manganese (Mn)-Total (mg/L)	0.0215	0.0228	0.0816	0.0752	0.0181
Mercury (Hg)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Total (mg/L)	0.0096	0.0092	0.0130	0.0141	0.0172
Nickel (Ni)-Total (mg/L)	0.00276	0.00190	0.00818	0.00817	0.00703
Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
Potassium (K)-Total (mg/L)	106	100	67.1	70.8	35.9
Rhenium (Re)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)-Total (mg/L)	0.171	0.171	0.0933	0.101	0.0559
Selenium (Se)-Total (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon (Si)-Total (mg/L)	3.2	3.6	2.2	1.9	2.7
Silver (Ag)-Total (mg/L)	0.00034	0.00038	<0.00010	<0.00010	<0.00010
Sodium (Na)-Total (mg/L)	379	372	326	318	275
Strontium (Sr)-Total (mg/L)	47.3	47.5	34.8	34.4	16.9
Sulfur (S)-Total (mg/L)	<5.0	<5.0	<5.0	<5.0	<5.0
Tellurium (Te)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (Tl)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thorium (Th)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Tin (Sn)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2197641-6
	Description	GW
	Sampled Date	12-NOV-18
	Sampled Time	17:30
	Client ID	ZONE 33
Grouping	**Analyte**	
SEAWATER		
Physical Tests	Hardness (as CaCO3) (mg/L)	2740
Total Metals	Aluminum (Al)-Total (mg/L)	0.0126
	Antimony (Sb)-Total (mg/L)	0.00339
	Arsenic (As)-Total (mg/L)	0.0038
	Barium (Ba)-Total (mg/L)	0.0956
	Beryllium (Be)-Total (mg/L)	<0.00050
	Bismuth (Bi)-Total (mg/L)	<0.00050
	Boron (B)-Total (mg/L)	1.19
	Cadmium (Cd)-Total (mg/L)	<0.000050
	Calcium (Ca)-Total (mg/L)	1080
	Cesium (Cs)-Total (mg/L)	<0.00050
	Chromium (Cr)-Total (mg/L)	0.00674
	Cobalt (Co)-Total (mg/L)	0.000111
	Copper (Cu)-Total (mg/L)	<0.00050
	Gallium (Ga)-Total (mg/L)	<0.00050
	Iron (Fe)-Total (mg/L)	0.064
	Lead (Pb)-Total (mg/L)	<0.00030
	Lithium (Li)-Total (mg/L)	0.850
	Magnesium (Mg)-Total (mg/L)	1.2
	Manganese (Mn)-Total (mg/L)	0.0171
	Mercury (Hg)-Total (mg/L)	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.0184
	Nickel (Ni)-Total (mg/L)	0.00436
	Phosphorus (P)-Total (mg/L)	<0.050
	Potassium (K)-Total (mg/L)	39.7
	Rhenium (Re)-Total (mg/L)	<0.00050
	Rubidium (Rb)-Total (mg/L)	0.0564
	Selenium (Se)-Total (mg/L)	<0.0020
	Silicon (Si)-Total (mg/L)	2.8
	Silver (Ag)-Total (mg/L)	<0.00010
	Sodium (Na)-Total (mg/L)	300
	Strontium (Sr)-Total (mg/L)	17.2
	Sulfur (S)-Total (mg/L)	<5.0
	Tellurium (Te)-Total (mg/L)	<0.00050
	Thallium (Tl)-Total (mg/L)	<0.000050
	Thorium (Th)-Total (mg/L)	<0.00050
	Tin (Sn)-Total (mg/L)	<0.0010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2197641-1	L2197641-2	L2197641-3	L2197641-4	L2197641-5
Description	GW	GW	GW	GW	GW
Sampled Date	10-NOV-18	10-NOV-18	11-NOV-18	11-NOV-18	12-NOV-18
Sampled Time	17:30	17:30	17:30	17:30	17:30
Client ID	ZONE 2	ZONE 22	ZONE 4	ZONE 44	ZONE 3
Grouping / **Analyte**					
SEAWATER					
Total Metals Titanium (Ti)-Total (mg/L)	0.0070	0.0075	<0.0050	<0.0050	<0.0050
Tungsten (W)-Total (mg/L)	0.0815	0.0854	0.0470	0.0462	0.0736
Uranium (U)-Total (mg/L)	0.000283	0.000304	<0.000050	<0.000050	0.000160
Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Yttrium (Y)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Total (mg/L)	0.0374	0.0410	0.0625	0.0605	0.0395
Zirconium (Zr)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Dissolved Metals Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
Aluminum (Al)-Dissolved (mg/L)	0.0219	0.0176	0.0085	0.0076	0.0126
Antimony (Sb)-Dissolved (mg/L)	0.00125	0.00128	0.00163	0.00172	0.00308
Arsenic (As)-Dissolved (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	0.0034
Barium (Ba)-Dissolved (mg/L)	0.0986	0.0996	0.466	0.489	0.0902
Beryllium (Be)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Dissolved (mg/L)	1.76	1.88	0.90	0.95	1.04
Cadmium (Cd)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Calcium (Ca)-Dissolved (mg/L)	2510	2510	1970	1970	1040
Cesium (Cs)-Dissolved (mg/L)	0.00189	0.00195	0.00075	0.00074	<0.00050
Chromium (Cr)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Gallium (Ga)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)-Dissolved (mg/L)	0.013	0.013	0.112	0.105	0.018
Lead (Pb)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Lithium (Li)-Dissolved (mg/L)	2.25	2.16	1.42	1.52	0.779
Magnesium (Mg)-Dissolved (mg/L)	<1.0	<1.0	57.8	53.9	1.2
Manganese (Mn)-Dissolved (mg/L)	0.0171	0.0164	0.0836	0.0812	0.0184
Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved (mg/L)	0.0090	0.0093	0.0112	0.0116	0.0154
Nickel (Ni)-Dissolved (mg/L)	0.00118	0.00122	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
Potassium (K)-Dissolved (mg/L)	99	98	67	66	38
Rhenium (Re)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)-Dissolved (mg/L)	0.173	0.174	0.0891	0.0914	0.0549
Selenium (Se)-Dissolved (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon (Si)-Dissolved (mg/L)	2.8	2.7	2.3	2.2	3.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2197641-6
	Description	GW
	Sampled Date	12-NOV-18
	Sampled Time	17:30
	Client ID	ZONE 33
Grouping	**Analyte**	
SEAWATER		
Total Metals	Titanium (Ti)-Total (mg/L)	<0.0050
	Tungsten (W)-Total (mg/L)	0.0756
	Uranium (U)-Total (mg/L)	0.000164
	Vanadium (V)-Total (mg/L)	<0.00050
	Yttrium (Y)-Total (mg/L)	<0.00050
	Zinc (Zn)-Total (mg/L)	0.0477
	Zirconium (Zr)-Total (mg/L)	<0.00050
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD
	Dissolved Metals Filtration Location	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0115
	Antimony (Sb)-Dissolved (mg/L)	0.00300
	Arsenic (As)-Dissolved (mg/L)	0.0034
	Barium (Ba)-Dissolved (mg/L)	0.0854
	Beryllium (Be)-Dissolved (mg/L)	<0.00050
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050
	Boron (B)-Dissolved (mg/L)	1.02
	Cadmium (Cd)-Dissolved (mg/L)	<0.000050
	Calcium (Ca)-Dissolved (mg/L)	1090
	Cesium (Cs)-Dissolved (mg/L)	<0.00050
	Chromium (Cr)-Dissolved (mg/L)	<0.00050
	Cobalt (Co)-Dissolved (mg/L)	<0.000050
	Copper (Cu)-Dissolved (mg/L)	<0.00050
	Gallium (Ga)-Dissolved (mg/L)	<0.00050
	Iron (Fe)-Dissolved (mg/L)	0.019
	Lead (Pb)-Dissolved (mg/L)	<0.00030
	Lithium (Li)-Dissolved (mg/L)	0.749
	Magnesium (Mg)-Dissolved (mg/L)	1.2
	Manganese (Mn)-Dissolved (mg/L)	0.0181
	Mercury (Hg)-Dissolved (mg/L)	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.0144
	Nickel (Ni)-Dissolved (mg/L)	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050
	Potassium (K)-Dissolved (mg/L)	40
	Rhenium (Re)-Dissolved (mg/L)	<0.00050
	Rubidium (Rb)-Dissolved (mg/L)	0.0528
	Selenium (Se)-Dissolved (mg/L)	<0.0020
	Silicon (Si)-Dissolved (mg/L)	3.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	Sample ID: L2197641-1 Description: GW Sampled Date: 10-NOV-18 Sampled Time: 17:30 Client ID: ZONE 2	L2197641-2 GW 10-NOV-18 17:30 ZONE 22	L2197641-3 GW 11-NOV-18 17:30 ZONE 4	L2197641-4 GW 11-NOV-18 17:30 ZONE 44	L2197641-5 GW 12-NOV-18 17:30 ZONE 3
SEAWATER						
Dissolved Metals	Silver (Ag)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Sodium (Na)-Dissolved (mg/L)	353	368	309	320	280
	Strontium (Sr)-Dissolved (mg/L)	44.9	45.3	33.6	33.6	16.9
	Sulfur (S)-Dissolved (mg/L)	<5.0	<5.0	<5.0	<5.0	<5.0
	Tellurium (Te)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Thallium (Tl)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Thorium (Th)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Tin (Sn)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Titanium (Ti)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Tungsten (W)-Dissolved (mg/L)	0.0806	0.0789	0.0455	0.0443	0.0722
	Uranium (U)-Dissolved (mg/L)	0.000235	0.000238	<0.000050	<0.000050	0.000160
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Yttrium (Y)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	<0.0030	<0.0030	0.0096	0.0100	<0.0030
	Zirconium (Zr)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2197641-6
	Description	GW
	Sampled Date	12-NOV-18
	Sampled Time	17:30
	Client ID	ZONE 33
Grouping	**Analyte**	
SEAWATER		
Dissolved Metals	Silver (Ag)-Dissolved (mg/L)	<0.00010
	Sodium (Na)-Dissolved (mg/L)	301
	Strontium (Sr)-Dissolved (mg/L)	17.2
	Sulfur (S)-Dissolved (mg/L)	<5.0
	Tellurium (Te)-Dissolved (mg/L)	<0.00050
	Thallium (Tl)-Dissolved (mg/L)	<0.000050
	Thorium (Th)-Dissolved (mg/L)	<0.00050
	Tin (Sn)-Dissolved (mg/L)	<0.0010
	Titanium (Ti)-Dissolved (mg/L)	<0.0050
	Tungsten (W)-Dissolved (mg/L)	0.0687
	Uranium (U)-Dissolved (mg/L)	0.000144
	Vanadium (V)-Dissolved (mg/L)	<0.00050
	Yttrium (Y)-Dissolved (mg/L)	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	<0.0030
	Zirconium (Zr)-Dissolved (mg/L)	<0.00050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2197641-1	L2197641-2	L2197641-3	L2197641-4	L2197641-5
Description	GW	GW	GW	GW	GW
Sampled Date	10-NOV-18	10-NOV-18	11-NOV-18	11-NOV-18	12-NOV-18
Sampled Time	17:30	17:30	17:30	17:30	17:30
Client ID	ZONE 2	ZONE 22	ZONE 4	ZONE 44	ZONE 3
Grouping / **Analyte**					
WATER					
Physical Tests					
Conductivity (uS/cm)	16700	16800	13900	14000	7530
pH (pH)	8.13	8.22	6.97	6.94	7.40
Total Suspended Solids (mg/L)	17.3	32.5	24.3	20.3	7.9
Total Dissolved Solids (mg/L)	10900	10800	9030	8820	5100
Anions and Nutrients					
Alkalinity, Bicarbonate (as CaCO3) (mg/L)	61.8	61.2	10.2	10.4	50.5
Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
Alkalinity, Total (as CaCO3) (mg/L)	61.8	61.2	10.2	10.4	50.5
Ammonia, Total (as N) (mg/L)	0.142	0.141	0.157	0.158	0.139
Bromide (Br) (mg/L)	76.1	76.8	69.7	60.1	32.7
Chloride (Cl) (mg/L)	5900 DLDS	5910 DLDS	5220 DLDS	4530 DLDS	2700 DLDS
Fluoride (F) (mg/L)	<1.0 DLDS	<1.0 DLDS	<1.0 DLDS	<1.0 DLDS	<1.0 DLDS
Nitrate (as N) (mg/L)	<0.25 DLDS	<0.25 DLDS	<0.25 DLDS	<0.25 DLDS	<0.25 DLDS
Nitrite (as N) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus (P)-Total (mg/L)	0.0120 DLDS	0.0132 DLDS	0.0067 DLDS	0.0059 DLDS	0.0061 DLDS
Sulfate (SO4) (mg/L)	<15	<15	<15	<15	<15

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L2197641-6
		Description	GW
		Sampled Date	12-NOV-18
		Sampled Time	17:30
		Client ID	ZONE 33
Grouping	Analyte		
WATER			
Physical Tests	Conductivity (uS/cm)	7350	
	pH (pH)	7.50	
	Total Suspended Solids (mg/L)	7.5	
	Total Dissolved Solids (mg/L)	4980	
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	50.1	
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	
	Alkalinity, Total (as CaCO3) (mg/L)	50.1	
	Ammonia, Total (as N) (mg/L)	0.136	
	Bromide (Br) (mg/L)	32.5	
	Chloride (Cl) (mg/L)	2700	
	Fluoride (F) (mg/L)	<1.0 DLDS	
	Nitrate (as N) (mg/L)	<0.25 DLDS	
	Nitrite (as N) (mg/L)	<0.050 DLDS	
	Phosphorus (P)-Total (mg/L)	0.0082	
	Sulfate (SO4) (mg/L)	<15 DLDS	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
WSMT	Water sample(s) for total mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2197641-1, -2, -3, -4, -5, -6
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2197641-1, -2, -3, -4, -5, -6
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L2197641-1, -2, -3, -4, -5, -6
Matrix Spike	Calcium (Ca)-Total	MS-B	L2197641-1, -2, -3, -4, -5, -6
Matrix Spike	Lithium (Li)-Total	MS-B	L2197641-1, -2, -3, -4, -5, -6
Matrix Spike	Potassium (K)-Total	MS-B	L2197641-1, -2, -3, -4, -5, -6
Matrix Spike	Rubidium (Rb)-Total	MS-B	L2197641-1, -2, -3, -4, -5, -6
Matrix Spike	Sodium (Na)-Total	MS-B	L2197641-1, -2, -3, -4, -5, -6
Matrix Spike	Strontium (Sr)-Total	MS-B	L2197641-1, -2, -3, -4, -5, -6

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-L-IC-N-VA	Water	Chloride in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Seawater	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-C-CVAFS-VA	Seawater	Diss. Mercury in Seawater by CVAFS	PUGET SOUND PROTOCOLS, EPA 245.7

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified seawater sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-TOT-C-CVAFS-VA	Seawater	Total Mercury in Seawater by CVAFS	PUGET SOUND PROTOCOLS, EPA 245.7

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. The procedure involves a cold-oxidation of the acidified seawater sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

Reference Information

MET-D-L-HRMS-VA	Seawater	Diss. Metals in Seawater by HR-ICPMS	EPA 200.8

Trace metals in seawater are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) based on US EPA Method 200.8, (Revision 5.5). The procedures may involve laboratory sample filtration based on APHA Method 3030B.

MET-T-L-HRMS-VA	Seawater	Tot. Metals in Seawater by HR-ICPMS	EPA 200.8

Trace metals in seawater are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) based on US EPA Method 200.8, (Revision 5.5). The procedures may involve preliminary sample treatment by acid digestion based on APHA Method 3030E.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-LOW-VA	Water	Low Level TDS (3.0mg/L) by Gravimetric	APHA 2540C

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total dissolved solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

17-720417

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2197641-COFC

COC Number: 17 - 720417

Page of

Report To	Contact and company name below will appear on the final report
Company:	Golder Associates Ltd.
Contact:	Dale Holtze
Phone:	613-592-9600
	Company address below will appear on the final report
Street:	1931 Robertson Road
City/Province:	Ottawa, ON
Postal Code:	K2H 5B7
Invoice To	Same as Report To [X] YES [ ] NO
	Copy of Invoice with Report [ ] YES [ ] NO
Company:	
Contact:	

Report Format / Distribution	
Select Report Format:	[X] PDF [X] EXCEL | | EDD (DIGITAL)
Quality Control (QC) Report with Report	[ ] YES [ ] NO
[ ] Compare Results to Criteria on Report - provide details below if box checked	
Select Distribution:	[ ] EMAIL | | [ ] MAIL [ ] FAX
Email 1 or Fax	dholtze@golder.com
Email 2	valerie_bartrand@golder.com
Email 3	

Invoice Distribution	
Select Invoice Distribution:	[X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax	dholtze@golder.com
Email 2	

Project Information	
ALS Account # / Quote #:	Q70283
Job #:	1789310
PO / AFE:	
LSD:	

Oil and Gas Required Fields (client use)	
AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Lab Work Order # (lab use only):

ALS Contact: Joanne Lee Sampler: D. Holtze

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] [X] Standard TAT if received by 3 pm - business days - no surcharges apply

Priority (Business Days): 4 day [P4-20%] [ ] | 3 day [P3-25%] [ ] | 2 day [P2-50%] [ ]

Emergency: 1 Business day [E-100%] [ ] | Same Day, Weekend or Statutory holiday [E2-200% (Laboratory opening fees may apply)] [ ]

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	total metals	dissolved metals	total O	anions and major	TDS, TSS	SAMPLES ON HOLD	Sample is hazardous (please provide further details)	NUMBER OF CONTAINERS
	Zone 2	10-Nov-18	17:30	GW	X	X	X	X	X			6
	Zone 22	10-Nov-18	17:30									
	Zone 4	11-Nov-18	17:30									
	Zone 44	11-Nov-18	17:30									
	Zone 3	12-Nov-18	17:30									
	Zone 33	12-Nov-18	17:30									

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? [ ] YES [X] NO

Are samples for human consumption/ use? [ ] YES [X] NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

Elevated Salt concentrations likely (Brine)
EC Zone 2+22 ~ 17.37 mS/cm
Zone 4+44 ~ 14.8 mS/cm Zone 3+33 ~ 7.5 mS/cm

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ] SIF Observations Yes [ ] No [ ]

Ice Packs [X] Ice Cubes [ ] Custody seal intact Yes [X] No [ ]

Cooling Initiated [ ]

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
			7		

SHIPMENT RELEASE (client use)

Released by:	Date:	Time:
Dale Holtze	2018-11-13	8:00

INITIAL SHIPMENT RECEPTION (lab use only)

Received by:	Date:	Time:

FINAL SHIPMENT RECEPTION (lab use only)

Received by:	Date:	Time:
AH JC	Nov 16/18	8:30AM

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1 If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form

JULY 2017 FRONT

Golder Associates Ltd. (Ottawa)
ATTN: Dale Holtze
1931 Robertson Road
Ottawa ON K2H 5B7

Date Received: 19-NOV-18
Report Date: 22-NOV-18 17:29 (MT)
Version: FINAL

Client Phone: 613-592-9600

Certificate of Analysis

Lab Work Order #: L2198327

Project P.O. #: NOT SUBMITTED
Job Reference: 1789310
C of C Numbers: 18-1789310
Legal Site Desc:

Joanne Lee
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2198327-1	L2198327-2	L2198327-3	L2198327-4	
Description	Groundwater	Groundwater	Groundwater	Groundwater	
Sampled Date	13-NOV-18	13-NOV-18	13-NOV-18	13-NOV-18	
Sampled Time	17:00	17:00	15:00	15:30	
Client ID	ZONE 6	ZONE 66	EB	TB	
Grouping / **Analyte**					
SEAWATER					
Physical Tests Hardness (as CaCO3) (mg/L)	3630	3620	<4.8	<4.8	
Total Metals Aluminum (Al)-Total (mg/L)	0.0118	0.0127	<0.0050		
Antimony (Sb)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Arsenic (As)-Total (mg/L)	0.0024	0.0024	<0.0020		
Barium (Ba)-Total (mg/L)	0.859	0.894	<0.0010		
Beryllium (Be)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Boron (B)-Total (mg/L)	0.41	0.40	<0.10		
Cadmium (Cd)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
Calcium (Ca)-Total (mg/L)	1330	1370	<1.0		
Cesium (Cs)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Chromium (Cr)-Total (mg/L)	0.00383	0.00381	<0.00050		
Cobalt (Co)-Total (mg/L)	0.000072	0.000093	<0.000050		
Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Gallium (Ga)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Iron (Fe)-Total (mg/L)	0.314	0.322	<0.010		
Lead (Pb)-Total (mg/L)	<0.00030	<0.00030	<0.00030		
Lithium (Li)-Total (mg/L)	0.558	0.563	<0.020		
Magnesium (Mg)-Total (mg/L)	40.6	39.8	<1.0		
Manganese (Mn)-Total (mg/L)	0.101	0.103	<0.00020		
Mercury (Hg)-Total (mg/L)	<0.000010	<0.000010	<0.000010		
Molybdenum (Mo)-Total (mg/L)	0.0279	0.0270	<0.0020		
Nickel (Ni)-Total (mg/L)	0.00288	0.00262	<0.00050		
Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050		
Potassium (K)-Total (mg/L)	9.7	10.1	<1.0		
Rhenium (Re)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Rubidium (Rb)-Total (mg/L)	0.0166	0.0164	<0.0050		
Selenium (Se)-Total (mg/L)	<0.0020	<0.0020	<0.0020		
Silicon (Si)-Total (mg/L)	2.6	2.5	<1.0		
Silver (Ag)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
Sodium (Na)-Total (mg/L)	232	238	<1.0		
Strontium (Sr)-Total (mg/L)	18.1	18.6	<0.010		
Sulfur (S)-Total (mg/L)	<5.0	<5.0	<5.0		
Tellurium (Te)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Thallium (Tl)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
Thorium (Th)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Tin (Sn)-Total (mg/L)	<0.0010	<0.0010	<0.0010		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2198327-1	L2198327-2	L2198327-3	L2198327-4	
Description	Groundwater	Groundwater	Groundwater	Groundwater	
Sampled Date	13-NOV-18	13-NOV-18	13-NOV-18	13-NOV-18	
Sampled Time	17:00	17:00	15:00	15:30	
Client ID	ZONE 6	ZONE 66	EB	TB	
Grouping / **Analyte**					
SEAWATER					
Total Metals					
Titanium (Ti)-Total (mg/L)	<0.0050	<0.0050	<0.0050		
Tungsten (W)-Total (mg/L)	0.0214	0.0223	<0.0010		
Uranium (U)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Yttrium (Y)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Zinc (Zn)-Total (mg/L)	0.109	0.113	<0.0030		
Zirconium (Zr)-Total (mg/L)	<0.00050	<0.00050	<0.00050		
Dissolved Metals					
Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	
Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
Aluminum (Al)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	
Antimony (Sb)-Dissolved (mg/L)	<0.00050	0.00050	<0.00050	<0.00050	
Arsenic (As)-Dissolved (mg/L)	0.0021	0.0024	<0.0020	<0.0020	
Barium (Ba)-Dissolved (mg/L)	0.818	0.794	<0.0010	<0.0010	
Beryllium (Be)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Boron (B)-Dissolved (mg/L)	0.36	0.35	<0.10	<0.10	
Cadmium (Cd)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
Calcium (Ca)-Dissolved (mg/L)	1380	1380	<1.0	<1.0	
Cesium (Cs)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Chromium (Cr)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Cobalt (Co)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
Copper (Cu)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Gallium (Ga)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Iron (Fe)-Dissolved (mg/L)	0.251	0.256	<0.010	<0.010	
Lead (Pb)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
Lithium (Li)-Dissolved (mg/L)	0.533	0.520	<0.020	<0.020	
Magnesium (Mg)-Dissolved (mg/L)	42.8	42.8	<1.0	<1.0	
Manganese (Mn)-Dissolved (mg/L)	0.0961	0.0970	<0.00020	<0.00020	
Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
Molybdenum (Mo)-Dissolved (mg/L)	0.0257	0.0245	<0.0020	<0.0020	
Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	
Potassium (K)-Dissolved (mg/L)	<20	<20	<20	<20	
Rhenium (Re)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Rubidium (Rb)-Dissolved (mg/L)	0.0151	0.0146	<0.0050	<0.0050	
Selenium (Se)-Dissolved (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	
Silicon (Si)-Dissolved (mg/L)	2.8	2.7	<1.0	<1.0	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2198327-1	L2198327-2	L2198327-3	L2198327-4	
Description	Groundwater	Groundwater	Groundwater	Groundwater	
Sampled Date	13-NOV-18	13-NOV-18	13-NOV-18	13-NOV-18	
Sampled Time	17:00	17:00	15:00	15:30	
Client ID	ZONE 6	ZONE 66	EB	TB	
Grouping **Analyte**					
SEAWATER					
Dissolved Metals Silver (Ag)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
Sodium (Na)-Dissolved (mg/L)	253	250	<20	<20	
Strontium (Sr)-Dissolved (mg/L)	19.5	19.7	<0.050	<0.050	
Sulfur (S)-Dissolved (mg/L)	<5.0	<5.0	<5.0	<5.0	
Tellurium (Te)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Thallium (Tl)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
Thorium (Th)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Tin (Sn)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
Titanium (Ti)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	
Tungsten (W)-Dissolved (mg/L)	0.0214	0.0208	<0.0010	<0.0010	
Uranium (U)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Yttrium (Y)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
Zinc (Zn)-Dissolved (mg/L)	0.0244	0.0230	<0.0030	<0.0030	
Zirconium (Zr)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	Sample ID: L2198327-1 Description: Groundwater Sampled Date: 13-NOV-18 Sampled Time: 17:00 Client ID: ZONE 6	Sample ID: L2198327-2 Description: Groundwater Sampled Date: 13-NOV-18 Sampled Time: 17:00 Client ID: ZONE 66	Sample ID: L2198327-3 Description: Groundwater Sampled Date: 13-NOV-18 Sampled Time: 15:00 Client ID: EB	Sample ID: L2198327-4 Description: Groundwater Sampled Date: 13-NOV-18 Sampled Time: 15:30 Client ID: TB
WATER					
Physical Tests	Conductivity (uS/cm)	8720	8780	<2.0	<2.0
	pH (pH)	6.58	6.65	5.76	5.98
	Total Suspended Solids (mg/L)	8.3	9.5	<3.0	<3.0
	Total Dissolved Solids (mg/L)	5580	5410	<3.0	<3.0
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	27.2	26.4	<1.0	<1.0
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	27.2	26.4	<1.0	<1.0
	Ammonia, Total (as N) (mg/L)	0.443	0.437	<0.0050	<0.0050
	Bromide (Br) (mg/L)	40.9	41.4	<0.050	<0.050
	Chloride (Cl) (mg/L)	3010 DLDS	3060 DLDS	<0.50	<0.50
	Fluoride (F) (mg/L)	<1.0 DLDS	<1.0 DLDS	<0.020	<0.020
	Nitrate (as N) (mg/L)	<0.25 DLDS	<0.25 DLDS	<0.0050	<0.0050
	Nitrite (as N) (mg/L)	<0.050 DLDS	<0.050 DLDS	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	0.0043 DLDS	0.0052 DLDS	<0.0020	<0.0020
	Sulfate (SO4) (mg/L)	<15	<15	<0.30	<0.30

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.

Qualifiers for Individual Samples Listed:

Sample Number	Client Sample ID	Qualifier	Description
L2198327-1	ZONE 6	WSMT	Water sample(s) for total mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
L2198327-2	ZONE 66	WSMT	Water sample(s) for total mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
L2198327-3	EB	WSMT	Water sample(s) for total mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L2198327-1, -2, -3, -4
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2198327-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2198327-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L2198327-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Seawater	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-C-CVAFS-VA	Seawater	Diss. Mercury in Seawater by CVAFS	PUGET SOUND PROTOCOLS, EPA 245.7

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified seawater sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-TOT-C-CVAFS-VA	Seawater	Total Mercury in Seawater by CVAFS	PUGET SOUND PROTOCOLS, EPA 245.7

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. The procedure involves a cold-oxidation of the acidified seawater sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method

Reference Information

245.7).

MET-D-L-HRMS-VA	Seawater	Diss. Metals in Seawater by HR-ICPMS	EPA 200.8

Trace metals in seawater are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) based on US EPA Method 200.8, (Revision 5.5). The procedures may involve laboratory sample filtration based on APHA Method 3030B.

MET-T-L-HRMS-VA	Seawater	Tot. Metals in Seawater by HR-ICPMS	EPA 200.8

Trace metals in seawater are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) based on US EPA Method 200.8, (Revision 5.5). The procedures may involve preliminary sample treatment by acid digestion based on APHA Method 3030E.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-LOW-VA	Water	Low Level TDS (3.0mg/L) by Gravimetric	APHA 2540C

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total dissolved solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

18-1789310

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2198327-COFC

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # 18-1789310

Page 1 of 1

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	GOLDER ASSOCIATES LTD	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Dale Holtze	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	1931 Robertson Road	Email 1: dholtze@golder.com		○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Ottawa, ON K2H 5B7	Email 2: valerie_bertrand@golder.com		○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	613-592-9600 Fax: 613-592-9601	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Analysis Request
Hardcopy of Invoice with Report?	☐ Yes ☐ No	Job #: 1789310		Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #: Q70883		
Lab Work Order # (lab use only)		ALS Contact: Joanne Lee	Sampler: Dale Holtze	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	DISSOLVED METALS	TOTAL METALS	TOTAL PHOSPHORUS	MAJOR IONS, TDS, TSS	24	EC	NH3	Anions	Number of Containers
	Zone 6 } 2 DAY RUSH	13-Nov-18	17:00	Groundwater									4
	Zone 66 } 2 DAY RUSH	13-Nov-18	17:00	Groundwater									4
	EB } Routine 5 days	13-Nov-18	15:00	Water									4
	TB } Routine 5 days	13-Nov-18	15:30	Water									3

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

SAMPLES 'ZONE 6' AND 'ZONE 66' HAVE ELEVATED TDS/CONDUCTIVTY. FIELD MEASURED CONDUCTIVITY RANGES BETWEEN 9 AND 9.1 mS/cm.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Dale Holtze	14-Nov-18	8:00	PAVL	NOV 19	08:30	9.8 °C				

APPENDIX D

2016 Laboratory Certificate of Analysis – Brine Fluid

Multilab Val-d'Or

Certificat d'analyse

Client : **Agnico-Eagle CSD - Amaruq Study**

Responsable : Mme Odrée-Maude Vachon
Adresse : CSD

tél.: (819) 759-3555 ()
fax.: (000) 000-0000

Numéro de projet : V-52584

Lieu de prélèvement : Brine Fluid
Échantillon : Brine Fluid
Nom du préleveur : N/D
Type d'échantillon : Eau surface
Réseau:

Date de prélèvement : 17 avril 2016
Heure de prélèvement : N/D
Date de réception : 19 avril 2016

Certificat corrigé, remplace le certificat V-52584 émis le 09 mai 2016

Les résultats ne se rapportent qu'aux échantillons soumis pour analyse.

Les échantillons seront conservés pendant 30 jours à partir de la date du rapport à moins d'avis écrit du client.

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc: (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième: 26/10/2005

Multilab Val-d'Or

Certificat d'analyse

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètres	Résultats	Méthode d'analyse	Date d'analyse
Aluminium (Al)	0.498 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Antimoine (Sb)	0.0354 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Argent (Ag)	<0.0001 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Arsenic (As)	0.7662 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Baryum (Ba)	0.1126 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Béryllium (Be)	<0.0005 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Bicarbonate (HCO3)	27 mg CaCO3/L	M-TIT-1.0	19 avril 2016
Bismuth (Bi)	<0.0005 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Bore (B)	13.2 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Bromures	1066 mg/L	Sous-traitance\Multilab Direct	22 avril 2016
Cadmium (Cd)	<0.00002 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Calcium (Ca)	42266 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Carbone inorganique total (C.I.T.	2.1 mg/L	M-COT-1.0	19 avril 2016
Carbone organique total (C.O.T.)	28.5 mg/L	M-COT-1.0	19 avril 2016
Chlorure (Cl)	83700 mg/L	Sous-traitance\Multilab Direct	29 avril 2016
Chrome (Cr)	<0.0006 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Cobalt (Co)	0.0406 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Conductivité	55420 µmhos/cm	M-TIT-1.0	19 avril 2016
Cuivre (Cu)	0.0039 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Dureté	105554 mg CaCO3/L	Sous-traitance\Multilab Direct	20 avril 2016
Étain (Sn)	<0.001 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Fer (Fe)	2.60 mg/L	Sous-traitance\Multilab Direct	22 avril 2016
Fluorures (F)	0.06 mg/L	Sous-traitance\Multilab Direct	27 avril 2016
Lithium (Li)	34.52 mg/L	Sous-traitance\Multilab Direct	22 avril 2016
Magnésium (Mg)	3.92 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Manganèse (Mn)	<0.0005 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Mercure (Hg)	0.00039 mg/L	Sous-traitance\Multilab Direct	21 avril 2016
Molybdene (Mo)	<0.0005 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
NH3 (NH3 non-ionisé)	1.52 mg N/L	Sous-traitance\Multilab Direct	20 avril 2016
NH4	0.67 mg N/L	Sous-traitance\Multilab Direct	20 avril 2016
Nickel (Ni)	1.350 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Nitrates (NO3)	0.54 mg N/L	Sous-traitance\Multilab Direct	19 avril 2016
Nitrites (NO2)	0.06 mg N/L	Sous-traitance\Multilab Direct	21 avril 2016
pH	10.02	M-TIT-1.0	19 avril 2016
Plomb (Pb)	<0.0003 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Potassium (K)	1717 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Radium (RA 226)	<0.066 Becquerels/L	M-RA-2.0	02 mai 2016
Sélénium (Se)	3.83 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Silice (Si)	2.93 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Sodium (Na)	838 mg/L	Sous-traitance\Multilab Direct	20 avril 2016

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc: (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième: 26/10/2005

Multilab Val-d'Or

Certificat d'analyse

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètres	Résultats	Méthode d'analyse	Date d'analyse
Solides dissous	36946 mg/L	M-TIT-1.0	19 avril 2016
Solides totaux	149736 mg/L	M-SOLI-1.0	27 avril 2016
Strontium (Sr)	656 mg/L	Sous-traitance\Multilab Direct	22 avril 2016
Tellure (Te)	<0.0005 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Thallium (Tl)	<0.002 mg/L	Sous-traitance\Multilab Direct	22 avril 2016
Titane (Ti)	45.2 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Uranium (U)	<0.001 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Vanadium (V)	<0.0005 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Zinc (Zn)	<0.001 mg/L	Sous-traitance\Multilab Direct	20 avril 2016
Alcalinité	145 mg CaCO3/L	M-TIT-1.0	20 avril 2016
Sulfate (SO4)	<0.6 mg SO4/L	Sous-traitance\Multilab Direct	12 mai 2016

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc : (819) 874-0360
E-mail : valdor@multilab-direct.com
Site web : www.multilab-direct.com

F-02-06
Version 3ième, 26/10/2005

Multilab Val-d'Or

Limite de détection rapportée

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètre	Valeur	Unité	Méthode	Accréditation
Aluminium (Al)	0.006	mg/L	Sous-traitance	
Antimoine (Sb)	0.0001	mg/L	Sous-traitance	Oui
Argent (Ag)	0.0001	mg/L	Sous-traitance	Oui
Arsenic (As)	0.0005	mg/L	Sous-traitance	Oui
Baryum (Ba)	0.0005	mg/L	Sous-traitance	Oui
Béryllium (Be)	0.0005	mg/L	Sous-traitance	
Bicarbonate (HCO3)	2	mg CaCO3/L	M-TIT-1.0	
Bismuth (Bi)	0.0005	mg/L	Sous-traitance	
Bore (B)	0.01	mg/L	Sous-traitance	Oui
Bromures	0.01	mg/L	Sous-traitance	
Cadmium (Cd)	0.00002	mg/L	Sous-traitance	Oui
Calcium (Ca)	0.03	mg/L	Sous-traitance	Oui
Carbone inorganique total (C.I.T.	0.2	mg/L	M-COT-1.0	--
Carbone organique total (C.O.T.)	0.2	mg/L	M-COT-1.0	Oui
Chlorure (Cl)	0.5	mg/L	Sous-traitance	Oui
Chrome (Cr)	0.0006	mg/L	Sous-traitance	Oui
Cobalt (Co)	0.0005	mg/L	Sous-traitance	
Conductivité	1	µmhos/cm	M-TIT-1.0	Oui
Cuivre (Cu)	0.0005	mg/L	Sous-traitance	Oui
Dureté	1	mg CaCO3/L	Sous-traitance	
Étain (Sn)	0.001	mg/L	Sous-traitance	Oui
Fer (Fe)	0.01	mg/L	Sous-traitance	Oui
Fluorures (F)	0.02	mg/L	Sous-traitance	Oui
Lithium (Li)	0.005	mg/L	Sous-traitance	
Magnésium (Mg)	0.02	mg/L	Sous-traitance	Oui
Manganèse (Mn)	0.0005	mg/L	Sous-traitance	Oui
Mercure (Hg)	0.00001	mg/L	Sous-traitance	Oui
Molybdene (Mo)	0.0005	mg/L	Sous-traitance	Oui
NH3 (NH3 non-ionisé)	0.01	mg N/L	Sous-traitance	-
NH4	0.01	mg N/L	Sous-traitance	-
Nickel (Ni)	0.0005	mg/L	Sous-traitance	Oui
Nitrates (NO3)	0.01	mg N/L	Sous-traitance	Oui
Nitrites (NO2)	0.01	mg N/L	Sous-traitance	Oui
pH			M-TIT-1.0	Oui
Plomb (Pb)	0.0003	mg/L	Sous-traitance	Oui
Potassium (K)	0.05	mg/L	Sous-traitance	
Radium (RA 226)	0.002	Becquerels/L	M-RA-2.0	Oui
Sélénium (Se)	0.001	mg/L	Sous-traitance	Oui
Silice (Si)	0.01	mg/L	Sous-traitance	
Sodium (Na)	0.05	mg/L	Sous-traitance	Oui

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc: (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième, 26/10/2005

Multilab Val-d'Or

Limite de détection rapportée

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètre	Valeur	Unité	Méthode	Accréditation
Solides dissous	1	mg/L	M-TIT-1.0	
Solides totaux	2	mg/L	M-SOLI-1.0	Oui
Strontium (Sr)	0.005	mg/L	Sous-traitance	
Tellure (Te)	0.0005	mg/L	Sous-traitance	
Thallium (Tl)	0.002	mg/L	Sous-traitance	
Titane (Ti)	0.01	mg/L	Sous-traitance	
Uranium (U)	0.001	mg/L	Sous-traitance	
Vanadium (V)	0.0005	mg/L	Sous-traitance	Oui
Zinc (Zn)	0.001	mg/L	Sous-traitance	Oui
Alcalinité	2	mg CaCO3/L	M-TIT-1.0	
Sulfate (SO4)	0.6	mg SO4/L	Sous-traitance	Oui

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc: (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième: 26/10/2005

Multilab Val-d'Or

Certificat contrôle qualité

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètres		
Alcalinité mg CaCO3/L	Nom Standard	STD alcalinité
	Valeur obtenue	144
	Justesse	99.3%
	Intervalle	123 - 167
Aluminium (Al) mg/L	Blanc	<0.006
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	6.82
	Justesse	92.9%
	Intervalle	5.10 - 7.64
Antimoine (Sb) mg/L	Blanc	<0.0001
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	0.2049
	Justesse	92.3%
	Intervalle	0.178 - 0.266
Argent (Ag) mg/L	Blanc	<0.0001
	Nom Standard	DMR-0009-2016-Ag
	Valeur obtenue	0.6004
	Justesse	82.9%
	Intervalle	0.579 - 0.869
Arsenic (As) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	0.2700
	Justesse	95.4%
	Intervalle	0.198 - 0.368
Baryum (Ba) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	2.572
	Justesse	94.2%
	Intervalle	1.94 - 2.92
Béryllium (Be) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	1.900
	Justesse	88.2%
	Intervalle	1.36 - 2.04
Bismuth (Bi) mg/L	Blanc	<0.0005
Bore (B) mg/L	Blanc	<0.01
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	3.43
	Justesse	83.7%
	Intervalle	2.36 - 3.54

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc : (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième: 26/10/2005

Multilab Val-d'Or

Certificat contrôle qualité

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètres		
Bromures mg/L	Blanc	<0.01
	Nom Standard	DMR-0123-2016-Br
	Valeur obtenue	5.39
	Justesse	95.7%
	Intervalle	4.50 - 6.76
Cadmium (Cd) mg/L	Blanc	<0.00002
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	0.89802
	Justesse	99.8%
	Intervalle	0.720 - 1.080
Calcium (Ca) mg/L	Blanc	<0.03
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	17.1
	Justesse	98.3%
	Intervalle	13.9 - 20.9
Chlorure (Cl) mg/L	Blanc	<0.5
	Nom Standard	DMR-0175-2016-Cl
	Valeur obtenue	53.7
	Justesse	96.7%
	Intervalle	46 - 58
Chrome (Cr) mg/L	Blanc	<0.0006
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	4.115
	Justesse	98.4%
	Intervalle	3.24 - 4.86
Cobalt (Co) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	1.549
	Justesse	99.9%
	Intervalle	1.24 - 1.86
Conductivité µmhos/cm	Nom Standard	STD cond maison
	Valeur obtenue	1407
	Justesse	99.4%
	Intervalle	1203 - 1627
Cuivre (Cu) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	1.379
	Justesse	94.7%
	Intervalle	1.05 - 1.57
Étain (Sn) mg/L	Blanc	<0.001

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc: (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième; 26/10/2005

Multilab Val-d'Or

Certificat contrôle qualité

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètres		
Fer (Fe) mg/L	Blanc	<0.01
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	16.0
	Justesse	88.1%
	Intervalle	11.4 - 17.2
Lithium (Li) mg/L	Blanc	<0.005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	0.827
	Justesse	97.8%
	Intervalle	0.677 - 1.015
Magnésium (Mg) mg/L	Blanc	<0.02
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	8.04
	Justesse	89.4%
	Intervalle	5.82 - 8.72
Manganèse (Mn) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	3.781
	Justesse	97.2%
	Intervalle	3.11 - 4.67
Mercure (Hg) mg/L	Blanc	<0.00001
	Nom Standard	DMR-0123-2016-HgEu
	Valeur obtenue	0.00062
	Justesse	93.9%
	Intervalle	0.00040 - 0.00092
Molybdene (Mo) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	0.6382
	Justesse	90.1%
	Intervalle	0.566 - 0.850
Nickel (Ni) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	1.110
	Justesse	98.2%
	Intervalle	0.90 - 1.36
Nitrates (NO3) mg N/L	Blanc	<0.01
Nitrites (NO2) mg N/L	Blanc	<0.01
	Nom Standard	DMR-0175-2016-NO2
	Valeur obtenue	1.97
	Justesse	97.5%

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième: 26/10/2005

Multilab Val-d'Or

Certificat contrôle qualité

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètres		
	Intervalle	1.72 - 2.32
pH	Nom Standard	STD pH 7.0
	Valeur obtenue	7.01
	Justesse	99.9%
	Intervalle	6.96 - 7.04
Plomb (Pb) mg/L	Blanc	<0.0003
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	0.9397
	Justesse	96.6%
	Intervalle	0.727 - 1.091
Potassium (K) mg/L	Blanc	<0.05
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	20.2
	Justesse	89%
	Intervalle	14.6 - 21.8
Radium (RA 226) Becquerels/L	Blanc	<0.002
	Nom Standard	STD 45462
	Valeur obtenue	0.0700
	Justesse	85%
	Intervalle	0.0700 - 0.0948
Sélénium (Se) mg/L	Blanc	<0.001
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	1.33
	Justesse	98.5%
	Intervalle	1.08 - 1.62
Sodium (Na) mg/L	Blanc	<0.05
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	29.0
	Justesse	91%
	Intervalle	21.3 - 31.9
Solides totaux mg/L	Blanc	<2
	Nom Standard	DMR-0124-2016-3
	Valeur obtenue	289
	Justesse	99%
	Intervalle	243 - 329
Strontium (Sr) mg/L	Blanc	<0.005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	1.25
	Justesse	97.7%
	Intervalle	1.02 - 1.54

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième: 26/10/2005

Multilab Val-d'Or

Certificat contrôle qualité

Numéro de projet : V-52584

Échantillon : Brine Fluid — Date de prélèvement : 17 avril 2016

Lieu de prélèvement : Brine Fluid — Heure de prélèvement : N/D

Paramètres		
Sulfate (SO4) mg SO4/L	Blanc	<0.6
	Nom Standard	DMR-0175-2016-SO4
	Valeur obtenue	71.2
	Justesse	93.7%
	Intervalle	60.3 - 73.7
Tellure (Te) mg/L	Blanc	<0.0005
Thallium (Tl) mg/L	Blanc	<0.002
	Nom Standard	Tl-S140909023-1000ppm
	Valeur obtenue	989
	Justesse	98.9%
	Intervalle	800 - 1200
Titane (Ti) mg/L	Blanc	<0.01
Uranium (U) mg/L	Blanc	<0.001
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	1.93
	Justesse	90.3%
	Intervalle	1.41 - 2.11
Vanadium (V) mg/L	Blanc	<0.0005
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	2.023
	Justesse	98.3%
	Intervalle	1.59 - 2.39
Zinc (Zn) mg/L	Blanc	<0.001
	Nom Standard	DMR-0009-2016-Eu
	Valeur obtenue	4.67
	Justesse	97.7%
	Intervalle	3.82 - 5.74

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc: (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième; 26/10/2005

Multilab Val-d'Or

Informations supplémentaires

Numéro de projet : V-52584

Échantillon : Brine Fluid
Lieu de prélèvement : Brine Fluid

Date de prélèvement : 17 avril 2016
Heure de prélèvement : N/D

Méthode laboratoire	Méthode de référence
M-MET-3.0	MA.200-Mét. 1.2
M-TIT-1.0	MA.303-Titr Auto 2.0
M-CL-2.0	MA.300-Ions 1.3
M-CI-1.0	MA.300-Anions 1.0
M-NITR-2.0	MA.300-NO3 2.0
M-RA-2.0	APHA 7500-Ra B et EPA P.13 (EMSL-CI)
M-SOLI-1.0	MA.104-S.S. 1.1
M-SULF-2.0	MA.300-Ions 1.3

Sauf indication contraire, tous les échantillons ont été reçus en bon état.
Toute reproduction, sinon en entier, est interdite sans l'autorisation écrite du laboratoire.

900, 5ième avenue
Val d'Or (Québec)
J9P 1B9
Téléphone : (819) 874-0350
Fax / Téléc: (819) 874-0360
E-mail: valdor@multilab-direct.com
Site web: www.multilab-direct.com

F-02-06
Version 3ième: 26/10/2005

Haul Road Management Plan, Version 2

AGNICO EAGLE

MEADOWBANK DIVISION

Whale Tail Pit – Haul Road Management Plan

MARCH 2019

VERSION 2

TABLE OF CONTENTS

Table of Contents ii

Figures iii

Document Control iv

Executive Summary v

Acronyms vii

Section 1 • Introduction 8

Section 2 • Related Documents 11

Section 3 • Consultation 12

Section 4 • Measures to Prevent Permafrost Degradation 14

Section 5 • Borrow Pit Management 17

Section 6 • Traffic Management on the Haul Road 22

Section 7 • Inspection and Maintenance of The Whale Tail Pit HauL Road 25

Section 8 • Road Safety 29

Section 9 • Accidents, Spills, Malfunctions and Emergency Response 32

Section 10 • Wildlife Management 35

Section 11 • Closure and Reclamation 36

Section 12 ● References 38

FIGURES

Figure 1.1. Cross section view of the expanded Whale Tail Pit Haul Road..... 9

Figure 1.2 Whale Tail Pit Haul Road and location of existing borrow pits and quarries..... 10

Figure 4.1 Typical cross-section of Haul road on ice wedge and very thaw susceptible soil 15

Figure 4.2 Typical Cross-section of Haul road built over thaw susceptible soil..... 16

Figure 4.3 Typical section of Haul road built over soil relatively unsusceptible to freeze and thaw settlement..... 16

Figure 6.1 Design of traditional land use crossing at km 12.....23

TABLES

Table 5.1 Haul Road Borrow Pits, Quarries and Waste Rock Sources for Road Construction and maintenance 17

Table 8-1. Road Signage..... 30

DOCUMENT CONTROL

Version	Date	Section	Page	Revision
WT	June 15, 2016	All	All	Whale Tail Pit Haul Road Management Plan
1	August, 2018	All	All	Comprehensive review of the Whale Tail Pit Haul Road Management Plan
2	March, 2019	All	All	Comprehensive review following road expansion completed

Plan prepared by:

Agnico Eagle Mines Limited

Plan approved by:



Robin Allard
Environment General Supervisor

EXECUTIVE SUMMARY

Agnico Eagle Mine Limited – Meadowbank Division (Agnico Eagle) is developing the Whale Tail Pit Project (Project), a satellite deposit located on the Amaruq property, to extend mine operations and milling at Meadowbank Mine. Whale Tail Pit will be mined by truck-and-shovel operation and will require the hauling of material from the pit operations to the Meadowbank Mill.

For the purposes of this document, the Road Management Plan (RMP) applies to the Whale Tail Pit Haul Road from construction through post-closure.

The RMP was prepared as per Part B, conditions 14 and 15 of the Whale Tail Type A Water License 2AM-WTP1826. Other plans prepared for the Whale Tail Pit Haul Road include an Emergency Response and Spill Contingency Plan and the Interim Closure and Reclamation Plan.

Land and environmental management in the area of the road are generally governed by the provisions of the Nunavut Land Claims Agreement. A list of the current licences, permits, agreements, authorizations, and approvals for the approved Whale Tail Pit Haul Road are presented. Agnico Eagle has expended the road to be 9.6 m in width, with a bypass bay every 400 m to accommodate a single oversized vehicle along the approved 64.1 km alignment. Additional widening could be considered in the future should it be required for safety purposes.

The Whale Tail Pit Haul road will not be publicly accessible rather only used by Agnico Eagle employees and contractors; furthermore, it will continue to be used by the exploration division. Agnico Eagle will educate all its employees and those of its contractors on road safety before they first drive the road. Daily traffic on the road will transport ore to the Meadowbank Mill, equipment, supplies, fuel and personnel.

The RMP presents mitigation measures and protocols to be implemented during the expansion (construction of the haul road) and operations to protect wildlife, prevent permafrost degradation, control surface runoff and sedimentation. Agnico Eagle will put in place operational procedures for daily operation and maintenance of the road including, if deemed necessary, dust suppression, snow removal and de-icing. Unmanned but properly identified entry points will be installed at both ends of the road. There will be occasions when access to the Haul road needs to be curtailed for short time periods for special reasons, such as bad weather, unsafe road conditions, maintenance activity on the road, heavy project related truck traffic, movement of oversized loads, and/or presence of large numbers of caribou or other wildlife incidences on or adjacent to the road. The road could also be temporarily closed in the event of an incident, accident or other event requiring mitigation or response. Typically, these short-term closures will be required to ensure safety.

Protocols for accidents and anticipated use of police services are presented. Agnico Eagle has an established Emergency Response Team based at the Meadowbank Mine with trained first responders based at the Whale Tail Pit site whose combined responsibilities in part will include responding to

emergencies on the road in a timely manner. Agnico Eagle will also report all reportable scale incidents to the appropriate Government authority.

The Whale Tail Pit road will be decommissioned and reclaimed by Agnico Eagle when operations at Whale Tail Pit cease and when exploration on the Amaruq property fails to find sufficient ore resources to support mining. Closure and reclamation of the road would be initiated within a year following the completion of closure and reclamation of the Whale Tail Pit operations infrastructure, Amaruq camp and exploration sites.

This Plan will be updated as required to reflect any changes in operation or economic feasibility, and to incorporate new information or the latest technology, as appropriate.

ACRONYMS

Agnico Eagle	Agnico-Eagle Mines Limited
ARD/ML	Acid Rock Drainage/Metal Leaching
ATV	All-Terrain Vehicle
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
CLARC	Community Lands and Resources Committee
DFO	Department of Fisheries and Oceans Canada
GN	Government of Nunavut
HTO	Hunters and Trappers' Organization
IOL	Inuit Owned Lands
KIA	Kivalliq Inuit Association
NIRB	Nunavut Impact Review Board
NLCA	Nunavut Land Claims Agreement
NTI	Nunavut Tunngavik Incorporated
NPC	Nunavut Planning Commission
NU	Nunavut
NWB	Nunavut Water Board
RCMP	Royal Canadian Mounted Police
RMP	Road Management Plan
TEMP	Terrestrial Ecosystem Management Plan
TSF	Tailings Storage Facilities
VEC	Valued Ecosystem Components
VESC	Valued Economic and Social Components

SECTION 1 • INTRODUCTION

1.1 Project Description

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is developing the Whale Tail Pit Project (Project), a satellite deposit on the Amaruq property, to continue mine operations and milling at Meadowbank Mine. The Whale Tail Project and the Whale Tail Pit Haul Road are subjected to the conditions presented in Nunavut Impact Review Board (NIRB) Whale Tail Project Certificate No.008, as well as in Nunavut Water Board (NWB) Type A Water License 2AM-WTP1826.

The Amaruq property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of Meadowbank Mine in the Kivalliq Region of Nunavut. The deposit will be mined as two open pits (i.e., Whale Tail Pit, and ore will be hauled to the approved infrastructure at Meadowbank Mine for milling.

For the purposes of this document, the Road Management Plan (RMP) applies to the Whale Tail Pit Haul Road from construction through post-closure. Agnico Eagle is expanding the road to be 9.6m in width, or more if required for safety reasons, with a bypass bay approximately every 400m depending on the topography and safety considerations to accommodate a single oversized vehicle along the approved 64.1 km alignment. All bridges from the Exploration Access Road will continue to be used and culverts will be extended to accommodate the hauling of ore from the Project to the Meadowbank Mill (refer to Figure 1.2).

The bridges and round culverts allow normal river and stream flow, and fish migration at road water crossings. The expansion to the Haul Road requires the use of approved quarries, approved borrow areas, associated short spur roads and Vault Pit as a Quarry. The haul road will be private and located on Crown Land and Inuit Owned Land. Figure 1.1 is a cross sectional view of the expanded road.

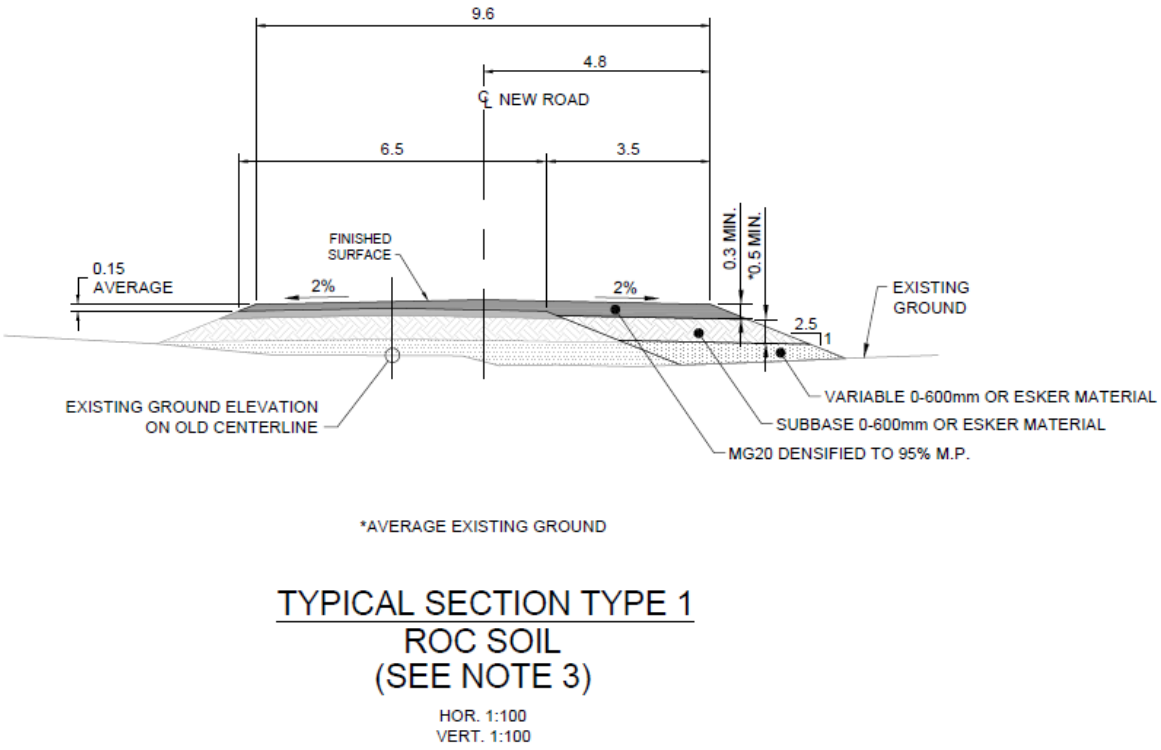


Figure 1.1. Cross section view of the expanded Whale Tail Pit Haul Road

The routing of the Whale Tail Pit road is shown on Figure 1.2.

The road is being constructed, inspected, and maintained by Agnico Eagle. Consequently, Agnico Eagle has sole responsibility for the construction, operation, and decommissioning of this road, including the road bed, bridges, culverts, borrow pits and quarries used in the construction of the road.

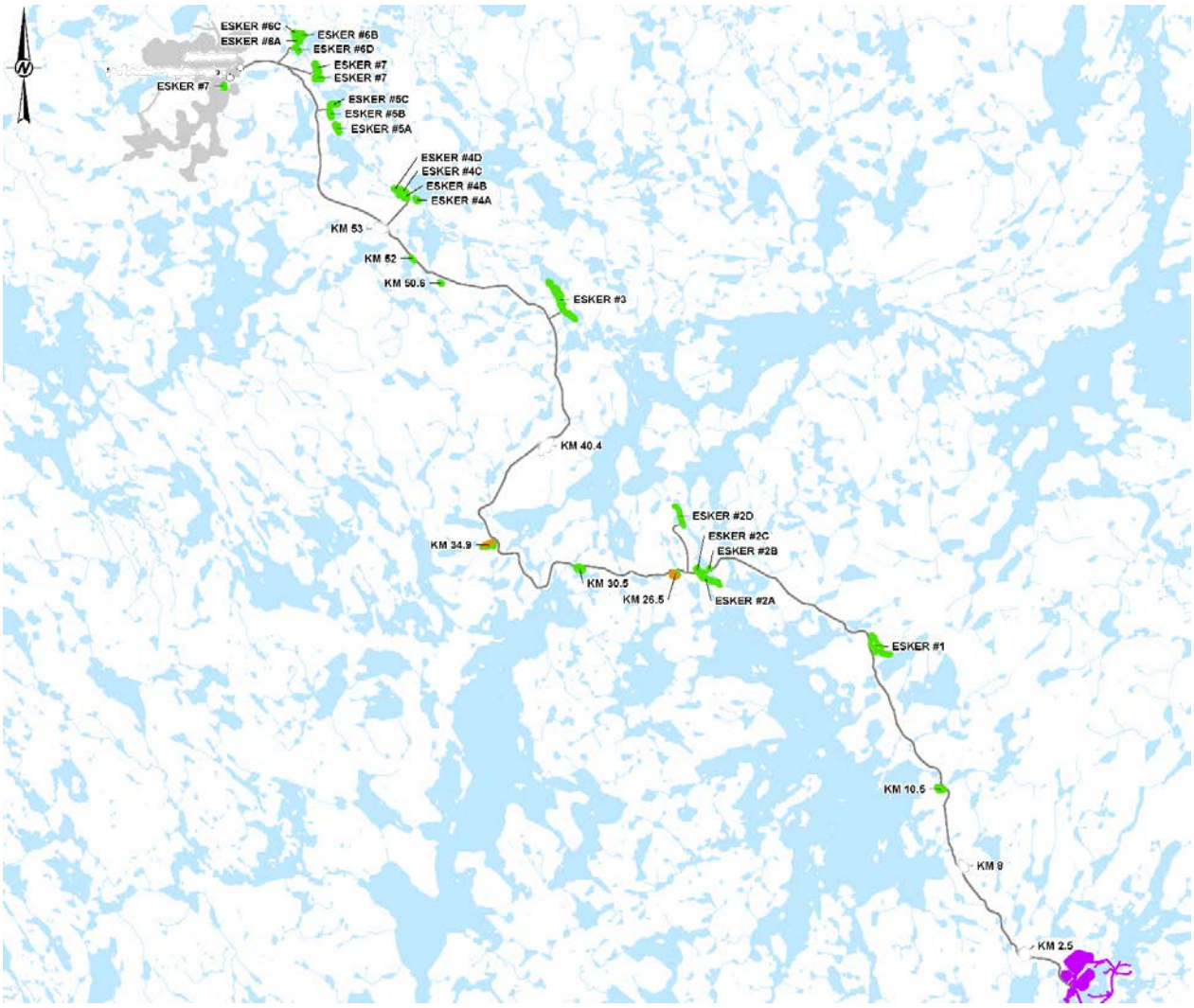


Figure 1.2 Whale Tail Pit Haul Road and location of existing borrow pits and quarries

SECTION 2 • RELATED DOCUMENTS

The specific plans that provided input to the Road Management Plan (RMP) and that are cited throughout this plan include the following:

- Emergency Response;
- Spill Contingency Plan;
- Terrestrial Ecosystem Management Plan; and
- Interim Whale Tail Pit Closure and Reclamation Plan.

The RMP is in effect for the expansion of the exploration access road to a haul road (construction), operation, and closure phases of the road. It will also be in effect during any periods of temporary closure of the Whale Tail Pit Haul Road.

SECTION 3 • CONSULTATION

Public consultation and engagement is a legal requirement in Nunavut, an industry best practice, and an important corporate commitment. Effective public consultation and engagement helps ensure that community members are informed and knowledgeable about proposed projects, that community support for those projects is more readily obtained, and sustainable development goals are achieved. A key goal of Agnico Eagle's public consultation and engagement program has been to ensure the Company obtains a "social licence to operate", by securing the support of a majority of residents from potentially impacted local communities.

To obtain this goal, a number of process goals have been followed:

- identification and prioritization of communities and community stakeholder groups;
- developing an understanding of key community and stakeholder views regarding the Project;
- addressing community and stakeholder issues and expectations;
- identifying current and historical patterns of land- and resource-use;
- identifying VECs and VSECs;
- determining criteria for evaluating the significance of potential impacts;
- deciding upon mitigating measures;
- formulating compensation packages where necessary;
- identifying and implementing monitoring measures, including post-project audits; and
- continuous improvement.

Since operation of the Meadowbank Mine began, Agnico Eagle has continued public consultation by meeting with employees, especially local employees that live throughout the Kivalliq, meeting in the communities with local stakeholders and regulatory agencies which has allowed a better general understanding of the rights, interests, values, aspirations, and concerns of the potentially affected stakeholders, with particular reference to the local population. Through this continued consultation Agnico Eagle has developed an operational culture that recognizes and respects these relevant interests in the planning and executing processes. A record of consultation that included the Whale Tail Pit Haul Road is provided in Volume 2 of the FEIS, Table 2-H (Agnico Eagle, 2016a). Agnico Eagle has and will continue to engage with regulatory agencies, the KIA and other stakeholders.

3.1 Road Use by Nunavummiut and Other Developers

The Whale Tail Pit Haul Road is a private road used solely by Agnico Eagle and its contractors. Agnico Eagle intends to keep the road closed for public use at this time. This is mainly due to the fact that the road is not entirely accessible from Baker Lake as there is restricted use near the Meadowbank mine site, which bisects the road. Agnico Eagle is unaware of any possible future developments in the vicinity of the Meadowbank Mine and Whale Tail Pit that could use the road.

However, it is Agnico Eagle's responsibility to decommission and reclaim the road once its activities in the area are completed. For a third party to take over the road(s), that third party would have to complete its own arrangements with the land owners (KIA and Crown) and then complete its own environmental screening/assessment and permitting process covering future use. Agnico Eagle does not own the land on which the access road is constructed on and, thus, cannot transfer future ownership or use privileges to any third party. Agnico Eagle must complete its obligation to decommission and reclaim the road unless directed otherwise by a combination of the landowners and other regulatory agencies who issued permits/authorizations for it.

SECTION 4 • MEASURES TO PREVENT PERMAFROST DEGRADATION

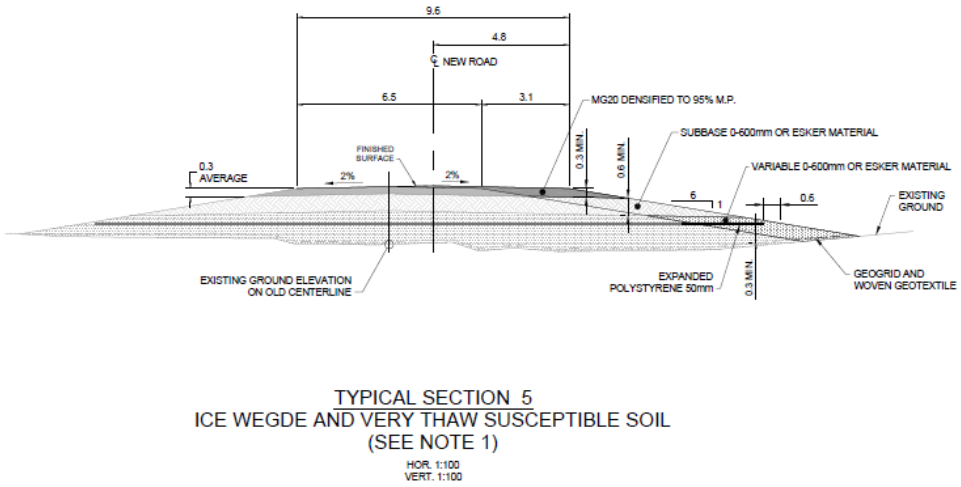
The Whale Tail Pit Haul Road has been designed with a minimum fill thickness to maintain permafrost conditions within the subgrade soils.

Mitigation and environmental design features to reduce the potential for permafrost degradation are as follows:

- The road alignment avoids, where possible, fine-grained, poorly drained, ice-rich, frost susceptible soil conditions due to susceptibility to thaw related settlement;
- Regions of high ground relief (higher elevations) were sought to provide better drainage conditions, to minimize the potential for snow drifting on the road and to avoid organic depressions and/or other poor ground conditions, which are more abundant in the low lying areas;
- Road fill material will be placed directly over the existing soil layer without cutting, stripping, or grubbing to avoid disturbing the subgrade soils;
- Only thick drifted snow will be removed before the road fills are placed;
- Road fill used will be dependent on the underlying ground conditions; these are:
  - Soils very susceptible to freeze and thaw induced settlement where thawing of the near-surface sub-grade is expected to result in significant strength loss and excessive settlements. The road fill thickness in this situation will be a minimum of 1 m plus sub-base[1], and will employ the use of geogrids, woven geotextiles and expanded polystyrene to protect the soil (see figure 4-1 for details);
  - Soils relatively susceptible to freeze and thaw induced settlement where thawing of the near-surface sub-grade is expected to result in significant strength loss and excessive settlements. Where appropriate, the road fill thickness in this situation will be a minimum of 1.5 metres plus sub-base and may also employ the use of geogrids and woven geotextiles over the soil (see figure 4-2 for details); and
  - Soils relatively unsusceptible to freeze and thaw settlement where thawing of the near-surface sub-grade is expected to result in minimal strength loss and tolerable settlements. In this situation the thickness of the roadbed will be a minimum of 0.9 metres plus subbase (see figure 4-3 for details).
- To prevent thawing of subgrade soils, to the greatest extent possible the road will be constructed in the winter when the subgrade soils are frozen.

[1] The thickness of the sub-base will be variable and will in part be dependent on the topography of the ground surface where the road is to be constructed.

The haul road, the road and its shoulders will be inspected weekly (at a minimum) during the summer period for evidence of seasonal freeze and thaw adjacent to the toe of the road embankment. Such movements are expected and may lead to longitudinal cracking and thaw settlement especially for portions of the road founded on thaw susceptible (ice rich) soils. When such areas are discovered, the affected area will be repaired using granular material obtained from a borrow pit. Agnico Eagle will maintain stockpiles of such material in select borrow pits that will remain open following completion of the road.



TYPICAL SECTION 5
ICE WEGDE AND VERY THAW SUSCEPTIBLE SOIL
(SEE NOTE 1)
HOR. 1:100
VERT. 1:100

Figure 4.1 Typical cross-section of Haul road on ice wedge and very thaw susceptible soil

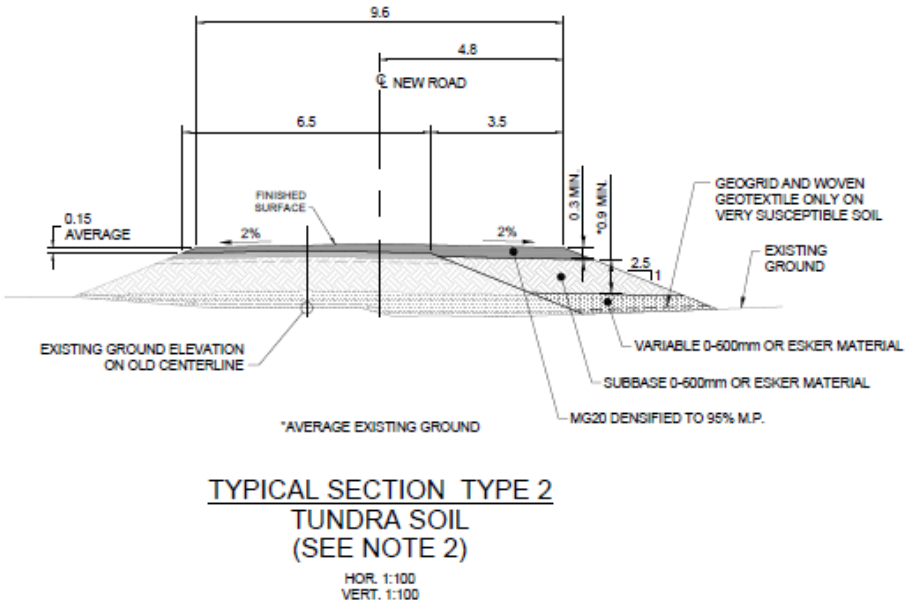


Figure 4.2 Typical Cross-section of Haul road built over thaw susceptible soil

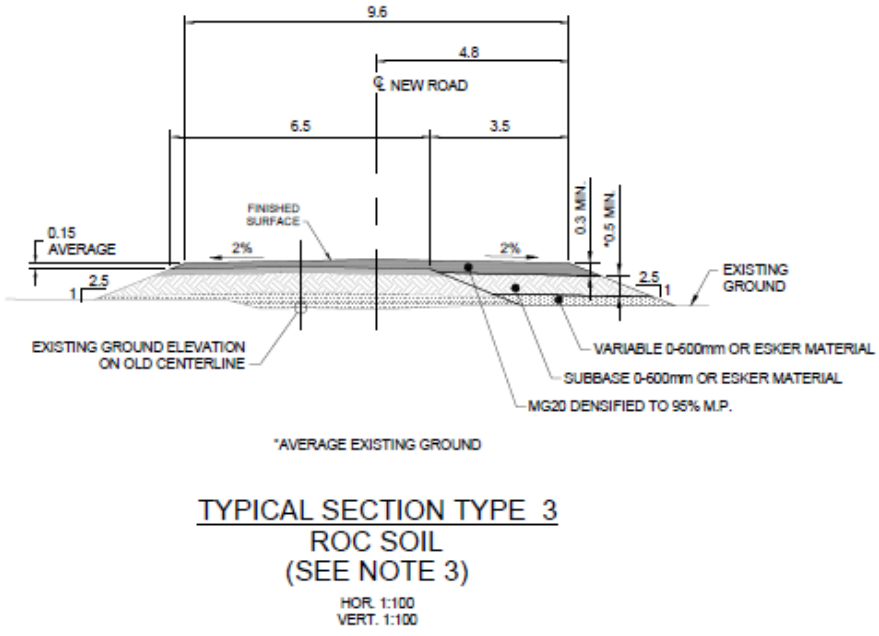


Figure 4.3 Typical section of Haul road built over soil relatively unsusceptible to freeze and thaw settlement

SECTION 5 • BORROW PIT MANAGEMENT

5.1 Open Pit and Borrow Pit Extraction Methods (including blasting if needed)

Table 6.1 presents the location and area of the approved borrow areas that was used to extract material for the expansion of 9 of the 6.5 m Amaruq exploration access road to the 9.5 m Whale Tail Pit Haul Road. Esker and quarry locations are presented in Table 5.1.

The excavation and material removal in the eskers were as follows: ripping frozen borrow area material will be attempted using a dozer. This loosens the material and allows it to be picked up using a loader or a hydraulic shovel. Should this fail, standard drill and blast procedures can be used. The sequence of steps under this circumstance follows that for waste rock from the Vault open pit. As for material in quarries, it will be extracted following standard drill and blast procedures.

Table 5.1 Haul Road Borrow Pits, Quarries and Waste Rock Sources for Road Construction and maintenance

ID Number	Land Ownership	Location UTM Zone 14 W	
		Easting (m)	Northing (m)
Vault Open Pit	Meadowbank Gold Mine (IOL)	640141	7221038
Esker 1	CL	633379	7232759
Esker 2	CL	626649	7235662
Esker 3	CL	621825	7247508
Esker 4	CL	614953	7250442
Esker 5	IOL	611936	7253888
Esker 6	IOL	610689	7256058
Esker 7	IOL	607799	7254627
Quarry km 10.50	IOL	635421	7227574
Quarry km 26.25	CL	625203	7235912
Quarry km 30.05	CL	621434	7236108
Quarry km 34.90	CL	618135	7237042
Quarry km 50.60	CL	616169	7247096
Quarry km 52.00	CL	615073	7248027

CL=Crown Land, IOL= Inuit Owned Land.

If deemed necessary, the design, size and shape of the blasts are planned with safety being the foremost consideration and best management practices for blast procedures will be followed. A

predetermined pattern of drill holes are drilled to a predetermined depth and filled with explosives. Prior to a blast, all personnel and equipment are moved to a safe distance from the blast area. The blast fragments the rock and/or frozen esker material which is then loaded into haul trucks using either a loader or by a hydraulic shovel. The truck drives to the end of the road where the rock/esker material is dumped. The final step is moving the rock/esker material into place using a dozer. This sequence is called a "drill, blast, load, haul, dump" sequence.

Approved ammonia management procedures at the Meadowbank Mine, will be adopted to ensure blasting practices monitor explosive quantities and blast performance to optimize the blasting practices while reducing impacts to nearby water quality from blast residue.

Some rock can be moved to a crusher to produce aggregate of various sizes[2]. Operations in the Vault open pit use explosives to break the rock. The crusher is to be located as far from water as possible and where it is best shielded from the prevailing wind, preferably behind a high wall so as to reduce the quantity of wind-blown dust and have as much dust as possible fall within the bounds of the borrow pit.

With the onset of winter, ramps will be built to the top of some eskers to obtain access to the borrow pit. The following summer the aggregate material will be allowed to thaw and subsequently be stripped using a dozer or loader. It should be possible to strip two layers over the summer period, each to a depth of approximately one metre. The material will be piled in mounds to allow drainage. Subsequently the mounded material will be easily handled at all times of the year[3]. If access to the esker borrow pits is delayed, other procedures will be used to access road building materials at all times of the year.

5.2 Borrow Pits Mitigation Measures

The ranking of mitigation options is as follows:

- **Avoidance** – using an alternate site to avoid the adverse effect all together. This is the most desirable;
- **Minimization** – taking actions to minimize and/or contain effects to the maximum extent possible during engineering design, construction, operation and closure;
- **Rectification** – taking actions to rehabilitate or restore the affected environment after the fact; and
- **Compensation** – this is used as a last resort to offset adverse environmental effects. This is the least desirable.

[2] Aggregate will only be produced if it is required in building or maintaining the road.

[3] This procedure will be used if time allows.

Best management practices will employ the following general mitigation measures for the borrow pits:

- Minimize the surface area of borrow pits;
- Locate borrow pits in well drained areas;
- Maintain a minimal distance of 31 meters between the borrow pits and waterbodies;
- Where possible, maintain the floor of the borrow pits slightly above the elevation of the surrounding area or blast with a sloped floor to drain water naturally to promote natural drainage patterns, to avoid creating ponds, and to prevent permafrost degradation in borrow pits;
- Prevent erosion and sedimentation through appropriate control measures such as silt fences;
- Carry out ARD/ML testing and water quality monitoring in support of mitigation measures;
- Protect archeological resources and mitigate as deemed appropriate by GN Cultural and Heritage department;
- Protect predatory mammal denning sites;
- If deemed necessary, maintain air quality through dust control/suppression;
- At the request of the NIRB and local stakeholders, as a safety measure, flag borrow areas and refuelling areas; and
- Use progressive reclamation in closing borrow pits that are no longer needed.

Where mitigation measures are not proving effective, adaptive management will be employed to address shortcomings.

5.3 Acid Rock Drainage and Metal Leaching

Geochemical testing was carried out to assess the chemical composition of the potential building material, its potential to generate acid rock drainage (ARD), and its potential to leach metals into the receiving environment upon exposure to ambient conditions. Sampling and testing prior to use of any borrow pit significantly reduced the risk of ARD/ML. Avoiding the use of undesirable or questionable road building materials ranks this mitigation measure as highly desirable.

To confirm that the best available road building materials are being used in constructing the road, additional samples will be collected during the construction of the road. Additionally, water quality monitoring will be carried out in confirming that the road building materials are not negatively affecting nearby water quality.

5.4 Management of Water Originating from Borrow Pits

While ARD/ML testing is a measure to avoid using questionable road building materials, water quality monitoring of seeps from borrow pits provides information on possible impacts on the environment should the water reach any nearby water bodies. A buffer of at least 31 m of undisturbed land is maintained between borrow pits and water bodies, and best management practices will prevent direct drainage. However, any significant seeps originating from the borrow pits that are likely to

reach receiving waters will be sampled and analyzed for a full suite of water quality parameters[4]. All surface runoff during the construction where flow may directly or indirectly enter a water body will be sampled for TSS as per the requirement of Part D, condition 13 of the Water License 2AM-WTP1826.

Any problematic water will be directed away from water bodies, or held if possible. If necessary, silt curtains will be used to control suspended sediments in water seeping from the borrow pits.

Although erosion is not expected to originate from water flow from borrow pits, any evidence of erosion will be repaired by placing rip-rap over the affected area, and measures will be taken to reduce the velocity of the water with, for example, silt curtains and/or small dikes, as per Part D, condition 11 of the Water License 2AM-WTP1826.

As per the quarry leases requirements (Item 17 of Quarry Permit KVCA15Q02, Item 17 of Quarry Permit KVCA15Q01, and Item 18 of Quarry Permit KVCA18Q01), a water monitoring plan will be prepared for quarries in which explosives are in use. Water will be sampled monthly and analyzed for a full suite of water quality parameters[4]. Prior to the tenth day of each month, a report will be submitted to the KIA indicating the water quality results. Water results shall be tabulated and compared to applicable CCME and MMER guidelines.

5.5 Management of Archaeological Resources at Borrow Pits

Borrow pits and quarries identified for material extraction were surveyed for archaeological resources. Areas selected avoid archaeological resources.

If any potential archaeological site is identified during the operation of any borrow pit, work will stop, a professional archaeologist will be consulted, and Culture and Heritage will be informed of the discovery. If an archaeological site or find is confirmed, the quarry/esker or borrow pit will not be developed or the site will be mitigated.

All road construction equipment will remain within the boundaries of the borrow pits to ensure any nearby archaeological site is not inadvertently damaged.

[4] Physical Parameters: pH (field and laboratory), temperature (field), alkalinity, bicarbonate, carbonate, electrical conductivity, hardness, hydroxide, ion balance, total dissolved solids, total suspended sediments
Nutrients: NH_4, NO_3, NO_2, PO_4
Major Ions: Ca, Cl, Mg, K, Na, SO_4
Trace Metals: Al, Sb, As, Ba, Be, B, Cd, Cr, Cu, Fe, Pb, Li, Mn, Hg, Mo, Ni, Se, Ag, Sr, Sn, Ti, U, V, Zn

5.6 Ground Ice and Permafrost Protection

The selected borrow pits sites are on well-drained esker deposits. All eskers have positive topography rising above the local setting. These types of granular deposits were selected because they are largely free of ground ice, thereby minimizing possible thaw settlement, which can result in erosion, slumping of side slopes, and an altered landscape that extends beyond the borrow pit.

Should permafrost degradation become evident, the area will be monitored and, if necessary, stabilized by covering the affected land with 1.0 to 1.5 m of granular material. This reclamation effort would allow the permafrost to move up into the material covering the area and stop any further permafrost degradation or prevent further melting of any ground ice. Inspections of borrow pits will continue after their closure at the end of construction.

Any significant seeps originating from the borrow pits as a result of ground ice, permafrost melting, or from precipitation events will be monitored if the water is likely to reach receiving waters[5].

[5] Shallow, standing water will not be collected as it poses little risk to the receiving environment.

SECTION 6 • TRAFFIC MANAGEMENT ON THE HAUL ROAD

All ore transportation to the Meadowbank Mill, backhauling of material, and resupply of required fuel, supplies, equipment and workers for the Whale Tail Pit will be transported via the Whale Tail Pit Haul Road. All drivers transporting these materials and personnel will either be Agnico Eagle employees or employees of contractors directly hired by Agnico Eagle. In order to operate vehicles on the haul road, they must possess the Meadowbank certification for the appropriate class of vehicle. Agnico Eagle will educate all its employees and all its contractor's employees on road safety rules during the safety induction training that occurs before they first drive the road. The safety rules[6] developed for the road will apply to Agnico Eagle employees and Agnico Eagle contractor employees. The Whale Tail Pit Haul Road will be closed for public use.

All Agnico Eagle and contractor's vehicles that travel routinely on the road will be equipped with a radio set to the requisite road frequency. Consequently, traffic on the road will always have radio contact with security, and other Agnico Eagle and contractor traffic. This system will be used to report any unusual conditions along the road such as location of other vehicles, presence of wildlife on the roadway, presence of non-Agnico Eagle traffic such as snowmobiles or ATVs crossing the road, any special road conditions, any special weather conditions, etc.

6.1 Intersection of Haul Road with Traditional Land Use Crossings

Two traditional land use crossing locations were identified during IQ/TK workshops and following meetings with the Hunters and Trappers Organization (HTO). A first location has been set at km 12. The crossing design is shown on Figure 6.1. More locations for Traditional Land Use Crossings will be identified in collaboration with the HTO. Haul traffic from the Whale Tail Pit to Meadowbank Mill will have the right-of-way. Traditional land users (i.e. hunters on ATVs or snowmobiles) crossing the Whale Tail Haul Road on identified ramps must yield to Haul Road Traffic; Haul Road Traffic approaching traditional land use crossings must be vigilant of the potential use by ATVs or snowmobiles. This intersection will have a stop sign on the traditional land use crossing locations to give way to the mine haul trucks. Hunters and traditional land users on snowmobiles or ATVs will have to stop, look both ways and yield to traffic before crossing the road. Traditional land use marked signs will be installed on the haul road to warn haul trucks and other vehicles on the road to ensure users protection and safety of traditional land users on ATVs or snowmobiles.

[6] See the Section 9 for complete details on safety measures proposed for the haul road.

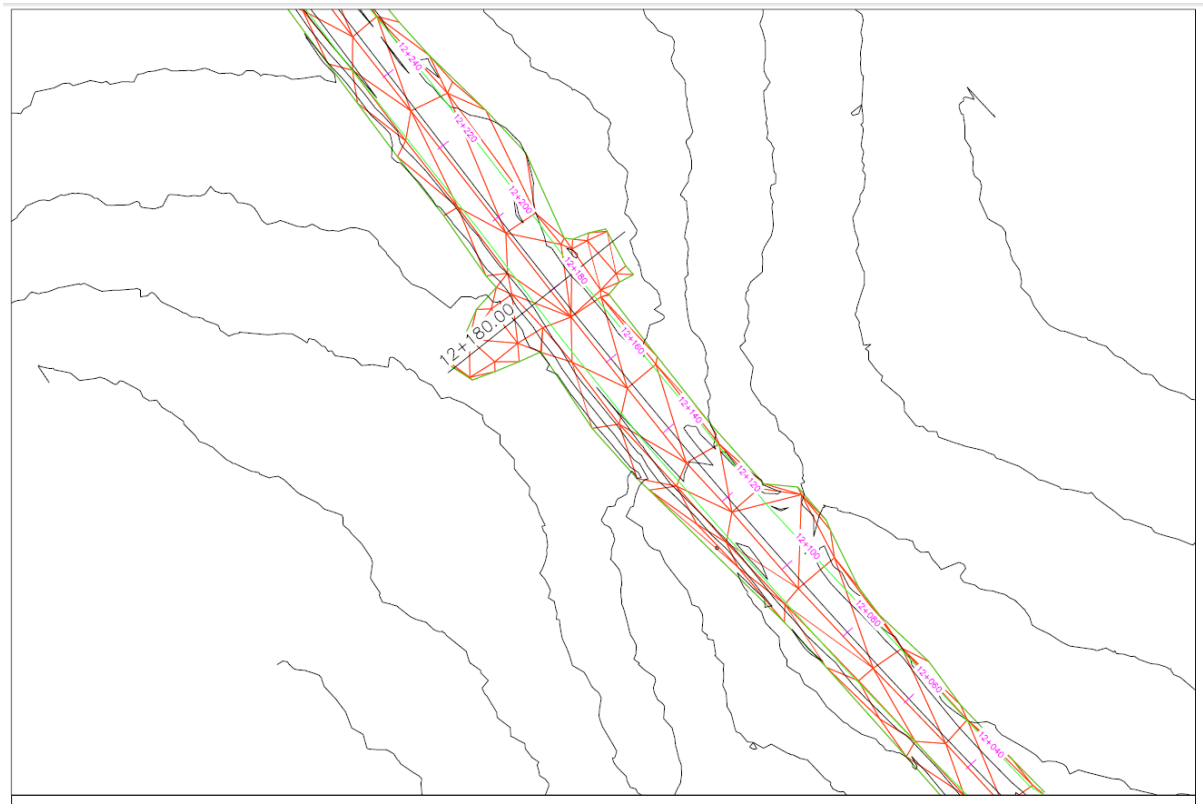


Figure 6.1. Design of traditional land use crossing at km 12

6.2 Other Access Control Procedures

There will be occasions when access to the Whale Tail Pit Haul Road will need to be curtailed for short time periods for special reasons, such as bad weather, unsafe road conditions, maintenance activity on the road, heavy operational related truck traffic, movement of oversized loads, and/or presence of large numbers of caribou on or adjacent to the road. The road could also be temporarily closed in the event of an incident, accident or other event requiring mitigation or response. Typically, these short-term closures will be required to ensure safety. During these times, the road access would be physically blocked at both ends of the road when appropriate.

6.3 Projected Whale Tail Traffic on the Whale Tail Pit Haul Road

The amount of traffic on the road will be continuous and may increase during different periods of the year. This will be highly dependent on the level of activity at the Whale Tail Pit or Exploration camp site and the time of year, such as summer when more traffic can be expected following the arrival of supplies and materials by sea). Weather will also directly influence use of the road (e.g. virtually no traffic is to be expected when the weather is bad).

Agnico Eagle and contractor vehicles expected to use the road will include, but not be limited to, long distance haul trucks, emulsion truck, pick-up trucks, cube vans, cargo trucks (to transport landfarm

material, sewage sludge, and exploration supplies), buses, fuel trucks, tractor-trailers, snowplows and graders.

Summer traffic is expected to be moderately higher than winter traffic as more contractual work can be expected over the summer, especially during the construction period at Whale Tail Pit. Hauling ore, backhauling material to Meadowbank, fuel deliveries and passenger van/bus traffic are not expected to vary a great deal between winter and summer.

SECTION 7 • INSPECTION AND MAINTENANCE OF THE WHALE TAIL PIT HAUL ROAD

Inspection precedes maintenance of the haul road. Agnico Eagle recognizes that a good inspection program will lead to the early identification of areas of the road where improvements are necessary. As per best practice management, the early resolution of any deficiencies will result in less ongoing maintenance and repair of the driving surface and to water crossings.

Agnico Eagle has sole responsibility for the ongoing inspection and maintenance of all of the components of the road, including the roadbed, bridges, circular corrugated culverts, and the borrow pits used in the construction, expansion and maintenance of the road. Agnico Eagle will apply the experience that it has gained from the ongoing operation of the Meadowbank All-weather Road, which has now been in operation since 2010. This experience will be applied in the planning of the day-to-day operation, inspection and maintenance of the Whale Tail Pit Haul Road. Agnico Eagle will have a road supervisor who will be responsible for the ongoing road inspection and maintenance of the road.

The road supervisor will conduct periodic inspections (minimally on a weekly basis) of the road to ensure that the road is maintained for safe travel of personnel, equipment, and supplies. Environment department also conduct weekly inspection of the road. These inspections will be recorded and any deficiency recorded and followed up by a corrective plan. These periodic inspections will include an inspection of the bridge abutments and a visual observation of the road surfaces to assess the status of the road's foundation.

During the summer period, the road surface will be maintained with gravel being spread as required and regular grading of the road. In the fall, winter and spring time the maintenance will be adjusted according to the weather conditions. Snow clearing along the road will be done to ensure that the road can be operated safely. The manner in which the snow is cleared will also take into account the road configuration to ensure that snow accumulation will not cause any particular problem during the freshet. Particular attention will be put on clearing adequately water crossings along the haul road to ensure proper flow and avoid blockage at freshet.

The entire road will be inspected for signs of accumulation of ponded water either on the road surface or along the sides of the road. Where noticed, the Agnico Eagle road supervisor will evaluate and monitor the accumulation to determine why water is accumulating in these areas. Based on these evaluations and to avoid erosion or washing out of the road, the road supervisor will take remedial action where and when necessary to correct the cause of such ponding, such as grading of the road surface to remove areas of ponding or installation of additional culverts if the road is causing excessive water ponding.

7.1 Watercourse Crossings Inspections and Maintenance

The watercourse crossing inspection and maintenance program has three main components:

- A regular inspection program to identify issues relating to watercourse crossings, such as structural integrity and hydraulic function;
- An event inspection program to track the impacts of large storm events on watercourse crossings, such as structural integrity and hydraulic function; and
- A culvert location inspection program to ensure that pipe or corrugated culverts have been installed in the right location with respect to the watercourse and that their capacity is adequate to ensure that the culvert(s) pass the water under all hydraulic conditions. In most cases for circular, corrugated culverts, they will be installed in multiples at different elevations at each stream crossing to ensure that these culverts can adequately pass normal summer flows as well as spring freshet and heavy rainfall flows.

7.1.1 Regular Crossing Inspection and Maintenance

Just prior to spring freshet, all culverts and stream crossings will be inspected to confirm that they are in good state to accommodate the rapid spring thaw that is seen in the north. During the freshet period, crossings inspections will be performed daily (mid-May thru June) and weekly during the remainder of the ice-free period prior to fall freeze-up (July through October) by the road supervisor and/or an environmental technician. An annual geotechnical inspection of the road will be conducted by a qualified engineer.

These inspection activities for each watercourse crossing will consist of:

- Visual inspection of its infrastructure to identify defects, cracks or any other risks to structural integrity. Particular attention will be paid to the inlet and outlet structures of culverts, and to bridge abutments and their foundations, as required;
- Visual inspection to identify sediment or other debris accumulation impeding the free flow of water through the crossings. Maintenance operations will consist of hand removal of accumulated debris and repairing damages as soon as possible;
- At the request of DFO, annually during the springtime, inspect flows at the embedded culvert at km 126.1 to ensure small bodied fish passage continues to be possible; and
- Visual inspection of upstream and downstream channel to identify bed erosion or scour around the watercourse crossing structure. Particular attention will be paid to abutments and their foundations as they will be vulnerable to scour and erosion during flood events. Particular attention will also be paid to potential sources of sediment transport at the crossing.

Inspection results will be recorded by Agnico Eagle to help track changes in conditions over time. Maintenance operations will consist of undertaking remediation of any detected problems and repairing damage as soon as possible.

7.1.2 Event Crossing Inspection and Maintenance

Inspection frequency will increase just after heavy or prolonged rainfall storm events. Visual inspection of each watercourse crossing will be completed to identify potential risks to the crossing's structural integrity, debris accumulation and whether erosion and scour have occurred. Water accumulation along the road will also be monitored. Results will be recorded by Agnico Eagle to help track changes in condition over time. The remediation of any detected problem and any necessary damage repairs will be undertaken as soon as possible, under the direction of Agnico Eagle's road supervisor.

7.1.3 Culvert Location Inspection

Following their installation, the circular, corrugated culvert crossings will be visually inspected to confirm they have been properly executed and installed. The culverts approved for extension with the haul road construction may be installed during winter conditions and thus it is possible that a culvert will not be sited correctly to pass all water through the road, which results in excessive water ponding against the road. The intent is to check for such conditions during the first snow melt and after rain events so that if deemed necessary, adjustments can be made accordingly. Although a conservative estimate of culverts has been installed, if deemed necessary following inspections additional culverts may be installed in locations that may not optimally route water flows.

7.2 Snow Removal and Snow Management

Sections of the road are expected to experience snow drifts because of strong winds over the winter period. As much as possible, this snow will be cleared to the downwind side of the road to limit the wind re-depositing the same snow on the cleared road. Routine spring snow management will include the removal of any snow that accumulates at bridges and culverts so that water at freshet can move freely through the circular culverts, and bridges. In the case of culverts, snow will be removed from both ends but not from the inside.

7.3 Dust Suppression

The amount of dust generated along a road is dependent on the material source used to surface the road, dryness of the road surface, the number of vehicles, weight and speed, and maintenance of the driving surface. Regular grading of the road combined with the addition of granular material from the eskers to the driving surface will be needed. This will improve road safety and also reduce the amount of dust. Dust will also be mitigated by maintaining posted speed limits.

In sections of the road or times identified by the Agnico Eagle road supervisor as being prone to high dust levels, where safe road visibility is impaired, or in areas where dust deposition is potentially impacting traditional land use, fish habitat and/or water quality, the road supervisor will arrange mitigation measures as appropriate and as per Part E, condition 12 of the Water Licence 2AM-WTP1826. This could involve actions such as grading of the road surface, placement of new coarser topping from eskers, and/or watering/ dust suppressant application of the road surface.

As per Part E, condition 1 of the Water License 2AM-WTP1826, the use of water for dust suppression on site and along the road shall not exceed a total of 45,750 m^3 per year. Water for dust suppression shall be from Nemo Lake and from pond along the Whale Tail Haul Road. As per Part I, condition 10 (f), the volume of fresh Water obtained for dust suppressant along the Whale Tail Pit Haul Road will be measured and recorded on a Monthly basis in cubic metres or as otherwise stated.

Based on the modelling of the dust emissions on the road, and the experience and monitoring data of the Meadowbank AWAR from Baker Lake to the mine site, use of chemical dust suppressants is not expected for the Whale Tail Pit Haul Road. However, if there are safety concerns or areas of particular interest, chemical dust suppressants may be only used as a last resort and only in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment (GN, 2014). Please refer to the Air Quality and Dustfall Monitoring Plan for more information regarding dust management.

SECTION 8 • ROAD SAFETY

Agnico Eagle security personnel along with Agnico Eagle's road supervisor will monitor activity on the Whale Tail Pit Haul Road through radio contact with drivers on the road, and through periodic patrols of the road. All Agnico Eagle and contractor vehicles that routinely travel on the road will be equipped with a radio set to the requisite road frequency. Consequently, all traffic on the road will always have radio contact with security and other road traffic. This system will be used to report any unusual conditions along the road such as the location of other Agnico Eagle and contractor vehicles, presence of wildlife on the roadway, presence of snowmobiles, any unsafe practices noticed, any special road conditions, any special weather conditions, etc.

The same safety rules that will apply to all users of the Whale Tail Pit Haul Road, these are:

- Maximum speed limits of 50 km/h;
- Use of seat belts by all drivers and passengers in pickup trucks, haul trucks, etc. is mandatory (bus passengers are an exception);
- Driving under the influence of alcohol or intoxicating drugs is prohibited;
- Wildlife has right-of-way on the road, and no harassment of wildlife is allowed;
- For their safety and protection, traditional land users and hunters are not permitted to drive on the haul road;
- All hunting activity must avoid shooting across the road and should respect a safe shooting distance from the road (suggested at 1 km)[7];
- Hunting is not allowed within 1 km of Meadowbank Mining, Whale Tail Pit, Whale Tail Pit Haul Road and the Amaruq Exploration Site;
- Traditional land users (i.e. hunters on ATVs or snowmobiles) crossing the haul road on identified crossing locations must yield to all Haul Road Traffic;
- Haul Road Traffic approaching traditional land use crossings must be vigilant of the potential use by ATVs or snowmobiles to ensure users protection and safety;
- Vehicles are not to park on the travel surface of the road but pull off the road at a safe location such as bypass pullouts to prevent accidents; and
- Signs will be posted warning of an entry/exit point[8].

[7] Winter travel between Gjoa Haven and Baker Lake may occur, which could lead to the road being crossed by ATVs or snowmobiles. Agnico Eagle will work with local hunters to ensure the preferred snowmobile crossing areas are well identified for both hunters and operators on the road.

[8].

8.1 Road Signage

Agnico Eagle will post appropriate road signs along the road in both English and Inuktitut. Typically, signs will advise drivers of the posted speed limit, of approaching bridges, of approaching curves, traditional land use crossings, and/or areas of lower visibility (blind hills or obstructed curves).

English and Inuktitut signs will be posted at the eastern and western ends of the road, at an appropriate mid-point to advise road operators that they are in a potentially hazardous area due to the presence of truck traffic.

Speed limit signs will be posted at intervals of approximately every 5 km along the road. Reflective flags will be installed along one side of the road to help drivers identify the road shoulder during blizzard, white out conditions or dense fog. Typically, these flags will be black in colour to help them stand out in white-out conditions, and are nominally set at intervals of 50 to 100 m apart. Kilometre markers will be posted at intervals of at least 1 km along the road.

A list of road signage is presented in Table 8-1.

Table 8.1. Road Signage

Element	Approximate Location
Safety precautions and users advice	At the eastern and western ends of the road, and at an appropriate mid-point along the road
Blind hill	200 m ahead of the beginning of a blind hill
Speed limit	Nominally at 5 km intervals
Curve	200 m ahead of a curve
Bridge announcement	200 m ahead of a bridge
Bridge side sign	On each side of the bridge
Traditional Land use crossing signs	At the crossing approach for haul road operators and well-marked stop signs at crossing approaches for ATV or snowmobile operators
Road Markers or flexible delineators (flags)	Nominally at 50 to 100m intervals
Kilometres markers	Nominally at 1 km intervals

8.2 Policing of Road Safety Rules

As a privately operated road, responsibility for "policing" will not fall under the Royal Canadian Mounted Police (RCMP). Responsibility for all operating and maintenance activity on the road will rest solely with Agnico Eagle. All Agnico Eagle employees and its contractors who will use the road will be required to take road safety training before being allowed to venture out on the road. Further, Agnico Eagle will concentrate on maintaining awareness among Agnico Eagle employees and contractors on the safe use of the road.

Agnico Eagle will use its road supervisor and site security to monitor what is occurring on the road. They will monitor activity on the road through periodic patrols of the road, and in conversation with drivers on the road at the time. Agnico Eagle will monitor speed limit infractions by direct observation of drivers seen to be driving too fast. Agnico Eagle will also rely on radio contact with all company and contractor vehicles on the road to monitor unsafe conditions or activity. Agnico Eagle does not have any special policing powers and cannot issue tickets or use other methods to address unsafe operation. Agnico Eagle can record unsafe practices, warn the person causing the infraction, and in severe or repeated cases of violation, in collaboration with the RCMP, will remove all privileges for future access to the road by an offending driver or hunter.

Regulatory inspectors can inspect the road and any associated infrastructure at will. Agnico Eagle will abide with the recommendations and directives provided by the inspectors.

However, it is worth noting that the *Criminal Code* of Canada applies to private roads. For example, if an accident were to occur on a road and alcohol was involved, that person could be charged by the RCMP.

SECTION 9 • ACCIDENTS, SPILLS, MALFUNCTIONS AND EMERGENCY RESPONSE

Emergency response is reactive, while prevention reduces the frequency of emergency responses. Agnico Eagle's emphasis will be on prevention, while at the same time keeping resources close at hand in order to respond to emergencies on the road in a timely manner.

Three possible causes of road emergencies are the road, vehicles and people. The interplay of these three elements leads to either safe use of the road or emergency responses. Agnico Eagle is fully responsible for the design, construction and maintenance of the road. Agnico Eagle will ensure that its vehicles and those of the contractors are in good working order before they venture out on the road. As well, Agnico Eagle will train its employees and contractors on road safety.

Agnico Eagle will lead by example in road safety. Agnico Eagle will train road users in road safety, shaping good driving practices and influencing behaviour on the road. Emphasis will be placed on the use of seat belts; observing posted speed limits; improving visibility for others by wearing reflective clothing at all times; dealing with driver inexperience, etc.

In urgent circumstances and where appropriate, Whale Tail Project operations will request assistance from other parties at the Meadowbank mine or in Baker Lake. However, based on Agnico Eagle's experience with the Meadowbank access and haul roads, Agnico Eagle does not believe that its Whale Tail Pit Haul Road will result in any increased demand on local public service providers (i.e., fire, police, ambulance, medical, and maintenance) in Baker Lake.

9.1 Accidents and Malfunctions

There will be accidents and malfunctions that occur on this road. Such unfortunate events are inevitable; no matter how much effort is devoted to preventing them. However, mitigation measures and response plans will be developed that can be applied to reduce the frequency and severity of such events. The types of events considered likely are as follows:

- Vehicle collisions that may result in personal injury and spillage of potential harmful materials such as fuel, lubricating fluids, antifreeze, etc.;
- Contact between vehicles and wildlife that may result in harm to wildlife, personal injury and spillage of potentially harmful materials, etc.;
- Single-vehicle accidents that may result in personal injury and spillage of potentially harmful materials;
- Risk of people getting stuck on the road in bad weather such as in heavy snow or whiteout conditions, or due to mechanical breakdown; and
- Spills of harmful materials onto the land or into water.

In an effort to prevent these occurrences, the road will be closed under poor weather or road conditions. Furthermore to improve the response in the event of an incident or accident, emergency

responders will be available at Meadowbank and at the Whale Tail site. Emergency spill response seacan are currently in place along the Whale Tail Haul Road at Km 125.5 and Km 147, between Whale Tail Pit and Meadowbank. More environmental sea can are planned to installed at Km 118, 130, 135, 139 and 160. Those sea can will be fully stocked with emergency response equipment and the road supervisor will have an emergency spill response kit in their vehicle.

All employees will be responsible to report, mitigate and clean up small spills. In the case of a larger spill, spill response will be implemented by the ERT based at Meadowbank and the environmental staff, who will advise, document, and report on initial response and clean-up actions. The Spill Contingency Plan will be activated in responding to a spill, as per Part H, condition 1 of Water License 2AM-WTP1826.

Agnico Eagle emergency response team (ERT) personnel are tasked with responding to any vehicle accident resulting in personal injury or spillage of harmful material. Agnico Eagle will initiate extraction and transport to medical assistance at Whale Tail Pit or the Meadowbank mine. In the event of serious injuries, the person or persons will be evacuated by air to the Baker Lake medical centre or a Winnipeg medical facility. The procedures in place in the Risk Management and Emergency Response Plan will be followed, as per Part H, condition 1 of Water License 2AM-WTP1826.

Agnico Eagle will report all reportable scale incidents to the appropriate Government authority (e.g., Mines Inspector, RCMP, Nunavut Water Board (NWB), NU Spill Line, Environment and Climate Change Canada, GN Department of Environment, Fisheries and Oceans Canada (DFO), KIA and Hamlet of Baker Lake).

The following actions are to be taken in the event of an accident on the road (including snowmobiles):

- Check the condition of people involved in the accident and provide immediate first aid if appropriate;
- Call the road or Mine Operations dispatch by radio and report the location and nature of the accident and indicate the type of assistance required (medical help, environmental cleanup, fire and/or mechanical help);
- Secure the accident site so that the vehicles do not continue to present a hazard to others. This may involve moving the vehicles to the nearest pull off in the event of a minor accident, or blocking off the road in both directions in the event of a more serious accident; and
- If safe to do so, secure the site to prevent continued spill or leakage of contaminants into the surrounding environment.

Upon receiving the accident call, the road dispatch will initiate the emergency response procedure passing along the information to the emergency response coordinator. The emergency response coordinator will then call out the required emergency response personnel to assist at the accident site.

Once the accident site is secured and all people requiring assistance have been removed to medical care, the emergency coordinator will turn the scene over to the Meadowbank Mine or Whale Tail Pit safety personnel so that an appropriate accident investigation can be initiated.

In the event of an incident involving contact with wildlife, the road dispatch will notify the site security personnel and the environmental representatives. Security and the site environmental team will then initiate an appropriate accident investigation. The Environmental Department will ensure that appropriate reporting of such incidents is made on a timely basis to the KIA, the Baker Lake HTO, and the GN Conservation Officer in Baker Lake. Any animal carcasses will be removed from the scene of the accident and will be incinerated or delivered to the GN officer.

In the event of a serious accident, the RCMP will be contacted and advised of the incident. The RCMP will then decide on whether they will become involved or take the lead on any subsequent accident investigation.

SECTION 10 • WILDLIFE MANAGEMENT

Wildlife is expected to occasionally be observed on or immediately next to the road. Caribou and other wildlife will have the right-of-way at all times. In case of problems (e.g. small herds or aggregations of caribou), the environmental department will be in charge of managing the situation and, with the collaboration of the security department, will advise road users by patrolling the road. Site personnel will notify and be notified by dispatch radio if any wildlife is observed on the road or if extra vigilance is needed along a specific area of the road.

The Terrestrial Ecosystem Management Plan has been updated to include adaptive management, mitigation, monitoring, and stakeholder engagement for the protection of wildlife habitat, ungulates, predatory mammals, small mammals and birds during the construction, operation and closure of the Whale Tail Pit Haul Road. The monitoring and management program described in the Terrestrial Ecosystem Management Plan will be implemented on the Whale Tail Pit Haul Road, and regularly reviewed and updated per discussions with the Terrestrial Advisory Group which includes representatives from the Government of Nunavut, Kivalliq Inuit Association and the Hunters and Trappers Organization of Baker Lake.

As per the Terrestrial Ecosystem Management Plan, the haul road embankment slopes will present an inclination of 4 horizontal: 1 vertical in order to facilitate wildlife crossing along the road, as well as for safety purposes, when possible

SECTION 11 • CLOSURE AND RECLAMATION

The Whale Tail Pit Haul Road will be decommissioned and reclaimed by Agnico Eagle if exploration on the Amaruq property fails to find sufficient ore resources to support mining, once post-closure monitoring requirements are completed for the Project, or if Agnico Eagle fails to obtain the necessary authorizations to proceed with further mining development. Closure and reclamation of the road would be initiated within a year following the completion of post-closure monitoring activities at the Project.

Specific details of the reclamation and closure activities are described in the Whale Tail Pit Interim Closure and Reclamation Plan.

Decommissioning of the road will be accomplished by loosening compacted surfaces, flattening side slopes, removing all culverts, and bridges, and other potential obstructions to drainages paths. The objective will be to make the road surface impassable by vehicular traffic by ripping the entire road bed and removing all bridges and culverts along the route.

The loosening of compacted surfaces will be accomplished by ripping of the roadbed utilizing a dozer with a “ripper” attachment on the back. Successive passes with the dozer longitudinally along the road bed will eliminate the level road surface and make travel difficult. It is anticipated that, in this way, the abandoned road will not be useable by wheeled vehicles (i.e. pick-up trucks). The road bed would still be useable by ATV or snowmobile and, thus, even after final reclamation, the reclaimed roadbed would offer similar passage as that which currently exists.

Road decommissioning works will be carried out as necessary to stabilize any slopes where potential for slope erosion may exist. Stabilization measures may require pulling back of side-cast fills on locally steep slopes or buttressing and/or re-contouring of steepened out slopes using non-acid generating material.

These measures would also be applicable to borrow pits located adjacent to the roadway that remained open following road construction. As much as practical, deactivated surfaces will be graded to blend with the existing topography.

To the extent practical, the reclamation would also restore the natural pre-road hydrology. Natural drainage courses would be restored primarily through the removal of all culverts and bridges, and through rehabilitation of channels and banks at the crossing sites. Cross-drain structures (cross-ditches) will also be installed where necessary between culvert sites. Where armouring rock (rip-rap) is required, this rock will be non ARD/ML for the protection of aquatic life. Where affected watercourses are fish bearing, the timing of work will have to be restricted to within the designated Fisheries and Oceans Canada fisheries work window. All in-stream works will be carried out using best management practices for erosion and sediment control.

Decommissioning of the road will start from the Whale Tail Pit road end of the road and progress southeast towards the Meadowbank mine. Stream crossings will be rehabilitated as they are encountered during the progression of the work.

11.1 Reclamation of Borrow Pits Sites

All borrow pit sources developed during the construction of the road will be selected to generate only non-acid generating/low metal leaching materials. Water quality monitoring and testing will be undertaken periodically during the construction and operational period of the road to measure the quality of water draining from the open borrow pit sites and from the road base materials.

The borrow pits will have gently sloping walls and be designed for positive drainage wherever possible. With prudent initial design, the borrow pits should require little reclamation following completion of the road. Loose material will be pulled to the floor of the borrow pit and the entrance blocked.

SECTION 12 ● REFERENCES

Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC). 2008. Northern Land Use Guidelines, Pits and Quarries.

Agnico Eagle, 2018. Terrestrial Ecosystem Management Plan. Version 6. March 2019

Agnico Eagle, 2016a. Final Environment Impact Statement (FEIS) Volumes 1 to 8, Whale Tail Pit Project, Meadowbank Division.

Agnico Eagle 2016b. Amaruq Exploration Access Road Management Plan v 2. Agnico Eagle. June 2016.

Government of Nunavut, Department of Environment 2014. Guideline: Dust Suppression on Unpaved Roads

Nunamit Stantec Limited 2016. Archaeological Baseline Report. Agnico Eagle Mines: Meadowbank Division – Whale Tail Pit and Haul Road. Submitted to Agnico Eagle January 2016.

MEND 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geological Materials. MEND Report 1.20.1, Natural Resources Canada.

Operational ARD-ML Sampling and Testing Plan – Whale Tail Pit, Version 4

AGNICO EAGLE

Meadowbank Division

Operational ARD-ML Sampling and Testing Plan – Whale Tail Pit Addendum

MARCH 2019
VERSION 4
WT023

EXECUTIVE SUMMARY

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) will develop the Whale Tail Pit and Haul Road Project (Project), a satellite deposit located on the Amaruq property, to continue mine operations and milling at Meadowbank Mine.

The Amaruq property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of Meadowbank Mine in the Kivalliq Region of Nunavut. The deposit will be mined as an open pit (i.e., Whale Tail Pit), and ore will be hauled to the approved infrastructure at Meadowbank Mine for milling.

Mining facilities include accommodation buildings, two ore stockpiles, one overburden stockpile, one rock storage facility area planned to receive waste rock and waste overburden, a water management system that includes collection ponds, water diversion channels, and retention dikes/berms, and a waste water treatment plant.

Waste rock, overburden and lake sediment were sampled and tested as part of a geochemical program presented in Golder (2016). Among the 8 lithologies tested, 2 have low acid generating and metal leaching potential, while the remaining lithologies are either potentially acid generating and/or metal leaching rock. The overburden is non-potentially acid generating and non-metal leaching while the lake sediment is potentially acid generating and metal leaching. Testing will be completed on waste rock to identify material that is non-potentially acid generating and low leaching that can be used as construction and closure rock.

An approach is proposed to define if the waste rock lithologies can be used as construction/closure material or must be piled in the Whale Tail Waste Rock Storage Facility.

DOCUMENT CONTROL

Version	Date	Section	Page	Revision	Author
1	June 2016			The Operational ARD-ML Sampling and Testing Plan as Supporting Document for Type A Water Licence Application, submitted to Nunavut Water Board for review and approval	Golder Associates Ltd.
2	June 2018	All	All	Updated to address Term and Condition 8 (NIRB project certificate 008; March 15, 2018). Includes update to project nomenclature to reflect current usage.	Golder Associates Ltd.
3	November 2018	All	All	Update to address recommendation of CIRNAC and ECCC	Agnico Eagle
4	March 2019	All	All	2018 Annual report updated version	Agnico Eagle

TABLE OF CONTENT

EXECUTIVE SUMMARY ..... **i**

DOCUMENT CONTROL ..... **ii**

TABLE OF CONTENT ..... **iii**

Acronyms ..... **v**

Units ..... **v**

Section 1 • INTRODUCTION **1**

Section 2 • WASTE ROCK MANAGEMENT **3**

2.1 Lithologies 3

2.2 Waste Rock Segregation 3

2.2.1 Whale Tail Waste Rock Storage Facility Design 4

Section 3 • ASSESSMENT OF ARD/ML POTENTIAL AT WHALE TAIL PIT **5**

3.1 Field Sampling 5

3.2 Evaluation of ARD/ML Potential at Whale Tail Pit 6

3.2.1 ARD Testing and Classification of ARD Potential (PAG / NPAG) 6

3.2.2 Metal Leaching Potential Testing and Evaluation 7

3.2.3 Quality Assurance / Quality Control (QA/QC) 7

3.3 Waste Rock Delineation and Tracking 8

3.4 WRSF thermal cover material sampling/testing program 9

Section 4 • PLAN REVIEW, PERFORMANCE MONITORING & REPORTING **10**

4.1 Plan Review 10

4.2 Performance Monitoring 10

4.2.1 Water Quality Monitoring 10

4.2.2 Permafrost Development 10

Section 5 • ADAPTIVE MANAGEMENT **11**

5.1 Management Actions 11

Section 6 • REFERENCES **13**

Appendix A • Summary of the ARD/ML Potential of Whale Tail Mine Wastes **14**

Appendix B • Flow Chart for Waste Rock Delineation and Segregation 16

LIST OF TABLES

Table 2.0 Anticipated ARD/ML Potential of Waste Rock Types at Whale Tail (Golder 2016)..... 3

Table 3.0 Recommended Sampling Frequency by Rock Type..... 5

Table 3.1 ARD Classification of Whale Tail Pit Waste Rock and Overburden 7

Table 3.2 ARD Guidelines used to Classify Whale Tail Pit Waste Rock and Overburden..... 8

Table 5.1 Adaptive Management Actions Associated with the ARD/ML Plan 12

Table A.0-1 Summary of ARD/ML Potentials of Whale Tail Pit Waste Types 15

LIST OF FIGURES

Figure 1.1 Location of the Project 2

ACRONYMS

ABA	Acid-Base Accounting
Agnico Eagle	Agnico Eagle Mines Limited – Meadowbank Division
ARD	Acid Rock Drainage
HCT	Humidity Cell Test
LOM	Life of Mine
MEND	Mine Environment Neutral Drainage
MPA	Maximum Potential Acidity
ML	Metal (and arsenic) Leaching
NML	Not Metal Leaching
NIRB	Nunavut Impact Review Board
NWB	Nunavut Water Board
NP	Neutralization Potential
NPR	Net Potential Ratio
NPAG	Non-Potentially Acid Generating
PAG	Potentially Acid Generating
Project	Whale Tail Pit
QA/QC	Quality Assurance / Quality Control
SFE	Shake Flask Extraction
TDS	Total Dissolved Solids
TIC	Total Inorganic Carbon
WRSF	Waste Rock Storage Facility

UNITS

%	percent
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
mg/kg	milligram per kilogram
Mt	million tonne(s)
ppm	parts per million
t	tonne(s)
µg/g	micrograms per gram
wt%	weight percent

SECTION 1 • INTRODUCTION

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is proposing to develop Whale Tail Pit and Haul Road (Project), a satellite deposit located on the Amaruq property, to continue mine operations and milling at Meadowbank Mine. Agnico Eagle is seeking approval to extend Meadowbank Mine to include development of resources from Whale Tail Pit. Concurrent with the reconsideration of the Project Certificate by the Nunavut Impact Review Board (NIRB), Agnico Eagle is seeking an amendment to Meadowbank Mine Type A Water Licence (No. 2AM-MEA1525; NWB 2015) to include mining of Whale Tail Pit and construction and operations of associated infrastructure from the Nunavut Water Board (NWB).

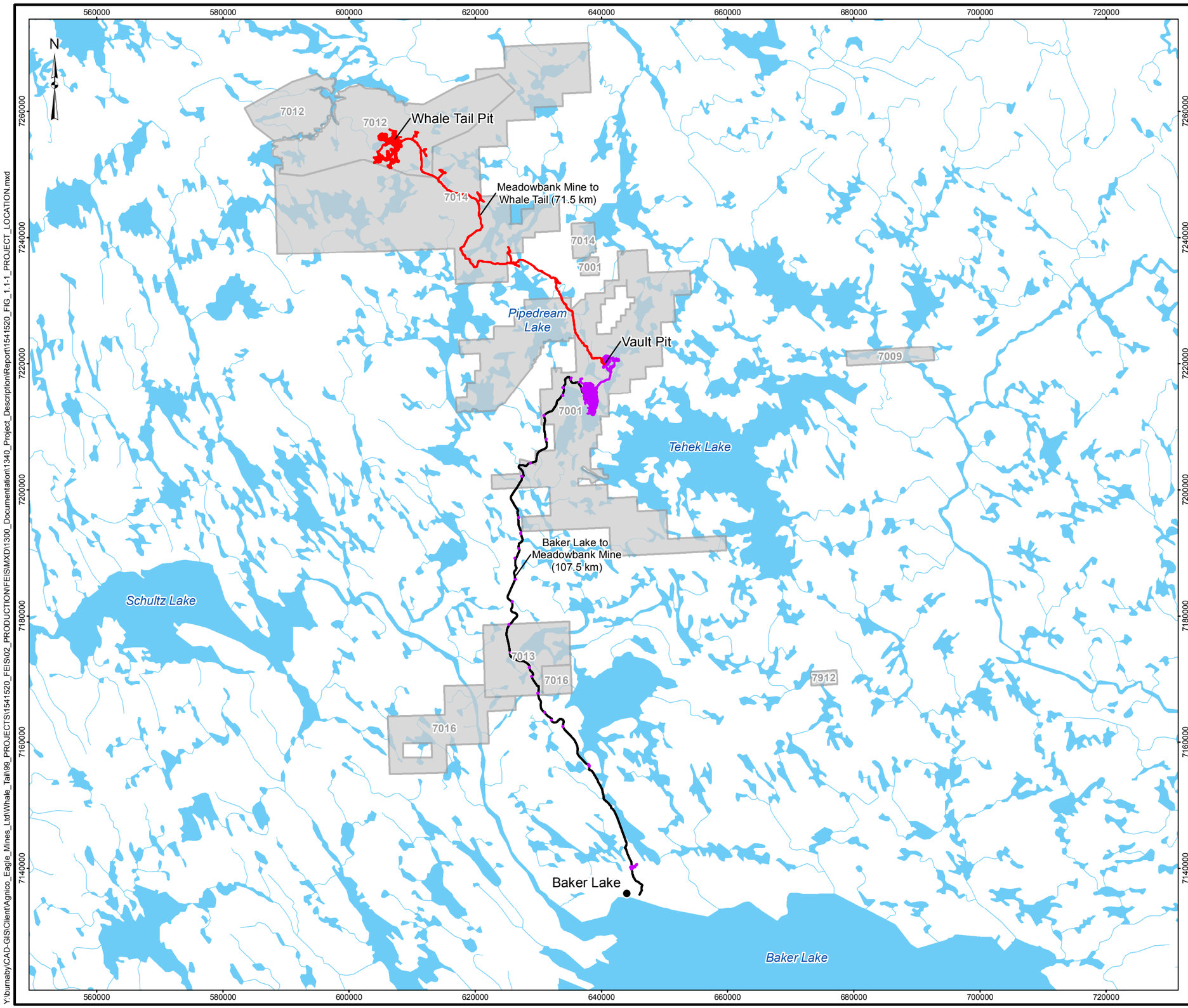
The Amaruq property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of Meadowbank Mine in the Kivalliq Region of Nunavut. The deposit will be mined as an open pit (i.e., Whale Tail Pit), and ore will be hauled to the approved infrastructure at Meadowbank Mine for milling.

The general mine site location for the Project is presented in Figure 1.1.

This document presents an update to the Operational Acid Rock Drainage (ARD) and Metal Leaching (ML) Sampling and Testing Plan (Plan) to address NIRB Project Certificate 008 Term and Condition No. 8 (NIRB 2018), with the exception of thermal monitoring of waste rock, which will be covered in the Thermal Monitoring Plan (Agnico Eagle 2018). The Plan is closely associated with the Whale Tail Pit – Waste Rock Management Plan (Agnico Eagle 2018, Version 2) and the Water Management Plan (Agnico Eagle 2016).

The objectives of the Plan are to define the sampling, analysis, and testing procedures that are to be implemented to define the acid generating and metal leaching potential of waste rock for the Project. This characterization is to be used by mine staff to ensure that waste rock, overburden (till), and lake sediments are identified, managed, segregated and disposed of in an environmentally appropriate manner, as designated in the Plan. The Plan will also define if the waste rock, the overburden, and the lake sediment can be used as construction/closure material.

This Plan will be updated as required to reflect any changes in operation or economic feasibility occurs, and to incorporate new information and latest technology, where appropriate.



LEGEND

- COMMUNITY
- PROPOSED HAUL ROAD
- ALL WEATHER ROAD
- WHALE TAIL PIT
- MEADOWBANK OPERATION AND INFRASTRUCTURE
- CLAIM BOUNDARY
- WATERCOURSE
- WATERBODY



REFERENCE

1. HAUL ROAD OBTAINED FROM AGNICO EAGLE MINES LIMITED. 2015-10-14 FROM 6103-117-230-200_R0.dwg
2. CLAIM BOUNDARIES OBTAINED FROM AGNICO EAGLE MINES LIMITED.
3. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
4. INSET MAP DATA OBTAINED FROM ESRI.

DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

12 0 12
KILOMETRES

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

LOCATION OF THE PROJECT

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	JR	24 Mar. 2016	SCALE AS SHOWN	REV. 0
GIS	CDB	24 Mar. 2016		
CHECK	JR	09 May 2016		
REVIEW	LY	09 May 2016		

FIGURE 1.1

Y:\burnaby\CAD-GIS\Client\Agnico_Eagle_Mines_Ltd\Whale_Tail\99_PROJECTS\1541520_FEIS\02_PRODUCTION\FEIS\MXD\1300_Documentation\1340_Project_Description\Report\1541520_FIG_1.1-1_PROJECT_LOCATION.mxd

SECTION 2 • WASTE ROCK MANAGEMENT

2.1 Lithologies

There are six major bedrock types (or lithologies) found at Whale Tail deposit: komatiite, greywacke, chert, iron formation, basalt, and diorite. Variable thicknesses of overburden and lake sediments are present which will be removed upon mining.

The ARD and ML potential of each waste rock lithology was evaluated through a static and kinetic testing program (Golder 2016) that is on-going. Details on the test methods used and results obtained are provided in Golder (2016; summarized in Appendix A). The anticipated ARD/ML potential for each rock type based on exploration drill core tests are shown in Table 2.1; it is noted that while the bulk of material from each lithology is PAG and/or ML, these lithologies do contain some material that is less reactive and non-potentially acid generating (NPAG) and/or non-metal leaching (NML).

Table 2.0 Anticipated ARD/ML Potential of Waste Rock Types at Whale Tail (Golder 2016)

Rock Type	Rock Unit Code	ARD Potential	ML Potential[1]	Tonnage (t)
Komatiite North	V4a – 0a	No	High	7,907,211
Komatiite South	V4a – 0b	No	Moderate	12,153,743
Greywacke Central	S3C – 3b	Yes	Variable	3,640,167
Greywacke South	S3S – 3b	No	Low	9,790,461
Greywacke North	S3N-3b	Variable	Variable	16,009,050
Chert	S10 – 3b	Yes	Variable	278,068
Iron Formation	S9E – 3b	No	High	8,958,267
Basalt	V3 – 1b	No	Moderate	2,344,027
Diorite	I2 – 8b	No	Low	628,264
Overburden	n.a.	No	Low[2]	5,666,408[3]
Lake sediment	n.a.	Yes	High[2]	

n.a. not applicable

[1] based on large column kinetic test results

[2] based on Shake Flask Extraction results

[3] Overburden and Lake sediment are considered as the same unit in the geological model

The NPAG waste rock tonnage required for the construction of the 4.7 m thermal cover of Whale Tail WRSF is 8,883,000 tonnes.

2.2 Waste Rock Segregation

Overburden generated from the Whale Tail Pit will be placed in the Whale Tail Waste Rock Storage Facility (WRSF). Characterization of ARD/ML potential in the excavated waste rock is required in order to properly segregate it for use or disposal, as follows:

- **General Construction and/or Closure** – Only rock that is NPAG and low leaching can be used for site construction, including dewatering dikes, and WRSF cover construction. It is the responsibility of the Geology Superintendent to ensure that all waste rock being used for

construction or reserved for future use during closure has been characterized and verified as being NPAG and low leaching.

- **Disposal** – All other waste rock (PAG and/or ML), as well as overburden, will be placed within the Whale Tail WRSF for permanent storage.

2.2.1 Whale Tail Waste Rock Storage Facility Design

The majority of waste rock generated at the Whale Tail site will be placed in the Whale Tail WRSF. Under the current plan, the Whale Tail WRSF has an area of approximately 110 hectares. Waste rock and overburden from the Whale Tail Pit not used for site development purposes will be trucked to the Whale Tail WRSF until the end of mine operations.

The Whale Tail WRSF is designed to minimize the potential for ARD and ML. The Whale Tail WRSF will be constructed to encapsulate potentially acid generating (PAG) and ML waste rock inside a layer of NPAG material as a control measure for ARD and ML. The NPAG rock that is placed on the top and sides of the storage pile is needed in the long term to host the thawed layer and prevent liquids from contacting the centre of the pile that contains PAG and ML waste rock. Presently it is anticipated that the cover design will be similar to the Meadowbank Portage WRSF. The cover will consist of a 4.7 m thick NPAG/NML waste rock layer on the top and edges of the facility. The cover is expected to maintain freezing conditions in the pile in the long-term. This rationale is based on results to date on thermal modelling that considers thermistor readings at the Portage waste rock pile (Golder 2018, in preparation). Rock oxidation can still occur in frozen material but will proceed at a slower rate than predicted by laboratory testing because of the cold temperature prevalent for much of the year. Permafrost will retain water as ice, so it was predicted that contaminants will not be transported away from the core of the WRSF in the long-term.

Monitoring will be conducted to measure temperatures throughout the waste rock pile, and to measure the depth of the annual surface thaw (see Section 4.2.2 and the Whale Tail Thermal Monitoring Plan). This information will be used to detail the rock cover design required to close the Whale Tail WRSF. Further information of the Whale Tail WRSF are provided in the Whale Tail Pit – Waste Rock Management Plan (Agnico Eagle 2018, Version 2).

SECTION 3 • ASSESSMENT OF ARD/ML POTENTIAL AT WHALE TAIL PIT

Sampling and testing of waste materials for ARD and ML will be conducted during mine operation in order to segregate suitable waste for use in construction and for closure (Section 2.2) from that which will report directly to the Whale Tail WRSF. This section discusses field sampling methods, analytical testing, ARD/ML evaluation criteria, and the delineation of waste rock.

Appendix B includes a flow diagram of the process to be followed for waste rock sampling, testing, and segregation.

3.1 Field Sampling

Drill holes will be sampled for testing as part of the ARD/ML evaluation (Section 3.2). Sampling will proceed according to the following guidelines that are currently utilized at Meadowbank Mine:

- The default sampling frequency is every fourth drill hole in each drill hole pattern. The shallow benches in Whale Tail Pit will be sampled at a frequency of one sample every two drill holes.
- Drill holes will be spaced to ensure an even distribution of samples throughout the planned blast area.
- Drill cuttings is collected and fully mixed in a sampling stainless steel tray placed beside the drill.
- The sampling stainless steel tray content will be transferred into a clean polyethylene plastic bag.
- Each sample will be collected from drill cuttings and will weigh at least 1 kilogram (kg).
- The samples will be labeled using a convention that is readily traceable back to the production drill hole numbers.

The Geology Superintendent will evaluate the default frequency based on the experience gained during the mining of the Whale Tail pit from previous drilling, sampling analysis results and visual inspections. The sampling frequency will be reviewed periodically and the rationale for any changes will be clearly documented and implemented only with the prior approval of the Nunavut Water Board.

Table 3.0 Recommended Sampling Frequency by Rock Type

Rock Type	Rock Unit Code	Sampling Frequency
Komatiite North	V4a – 0a	Every 4th hole
Komatiite South	V4a – 0b	Every 4th hole
Greywacke Central	S3C – 3b	Every 4th hole
Greywacke South	S3S – 3b	Every 4th hole
Chert	S10 – 3b	Every 4th hole
Iron Formation	S9E – 3b	Every 4th hole
Basalt	V3 – 1b	Every 4th hole
Diorite	I2 – 8b	Every 4th hole

3.2 Evaluation of ARD/ML Potential at Whale Tail Pit

The ARD and ML potential of all samples collected (Section 3.1) will be evaluated through laboratory testing, as described below.

3.2.1 ARD Testing and Classification of ARD Potential (PAG / NPAG)

The most conventional method of characterizing the ARD potential of waste rock is to classify it as PAG and NPAG based on the net potential ratio (NPR) value. The NPR is the ratio of the acid-buffering potential (neutralization potential or NP) and the acid generation (maximum potential acidity or MPA; assumed to be due to sulphide sulphur content, or total sulphur minus sulphate sulphur).

The Whale Tail Pit geochemical characterization study (Golder 2016) examined the use of carbonate NP as a surrogate for bulk NP using data obtained from exploration drilling (Golder 2016). The carbonate NP and bulk NP correlate well (R^2= 0.97), implying that NPR calculated using carbonate NP is a safe assessment of available buffering capacity. Further, MPA is calculated based on the total sulphur content of the samples (rather than sulphide content), which is conservative. This approach to ARD classification is based on observed trends in rock chemistry, mineralogy, and reactivity of neutralizing minerals (Golder 2016).

The Meadowbank onsite assay laboratory is equipped to analyze total sulphur and total inorganic carbon overnight for the samples of drill cuttings. Mine staff will use these results to calculate the NPR value for each sample as follows:

- Total sulphur is converted into **MPA** by multiplying the total sulphur wt% by 31.25, which yields an MPA value in kg $CaCO_3$ equivalent.
- Total inorganic carbon is similarly converted into a carbonate NP (**CaNP)** by multiplying the total wt% inorganic carbon (reported as %C) by 83.34 which yields an NP value in kg $CaCO_3$ equivalent.
- The carbonate NPR for the blast hole drill cutting sample is then calculated as **NPR = CaNP/MPA**.

This approach is consistent with the use of total sulphur and total inorganic carbon to calculate the MPA and CaNP of waste rock material for the Whale Tail Pit geochemical characterization study (Golder 2016).

The ARD potential of waste materials from Whale Tail Pit will be classified first based on total sulphur content and then using the NPR-based guidelines published by MEND (2009). Total sulphur will be used as an initial screening criteria to identify NPAG material, whereby a sample will be considered NPAG when it contains less than 0.1 wt% sulphur, regardless of the NP (Golder 2016). Where total sulphur is above 0.1%, the calculated carbonate NPR value will be used for sample classification, as summarized in Table 3.2.

Table 3.1 ARD Classification of Whale Tail Pit Waste Rock and Overburden

Total Sulphur Screening Criteria	NPR Screening Criteria (based on Carbonate NP)	ARD Potential
Total S < 0.1%	-	Non-potentially acid generating (PAG)
Total S > 0.1%	NPR > 2	
	1 ≤ NPR < 2	Uncertain or low acid generating potential
	NPR < 1	Potentially acid generating (PAG)

3.2.2 Metal Leaching Potential Testing and Evaluation

Waste rock materials can also potentially leach metals (and other elements) when they come into contact with water and air, which is referred to as ML potential and can occur even if the materials are non-acid generating. Arsenic is identified as a parameter of environmental interest based on laboratory leaching tests (Golder 2016).

The amount of arsenic released by leaching has been shown to be proportional to the total arsenic content of the sample (Golder 2016), whereby samples with total arsenic content below approximately 75 ppm (as µg/g or mg/kg) indicate a low potential to leach arsenic. This has been selected as a suitable identifier of arsenic leaching. Total arsenic will be analyzed at the Meadowbank on-site laboratory by hydride generation (Millennium Excalibur, PSA Analytical, 0.001 ppm detection limit), and arsenic leaching potential be inferred based on the total arsenic content.

A surface runoff water monitoring program will be implemented for the Project like it is at the other deposits of Meadowbank to detect ML in site contact waters. Further details on the water quality monitoring program are provided in Section 4.2.1.

3.2.3 Quality Assurance / Quality Control (QA/QC)

Samples from Whale Tail Pit will be subjected to the same quality assurance / quality control (QA/QC) program currently in use at Meadowbank, which includes the use of certified reference materials and duplicate analyses by an accredited external lab. Duplicate analyses include more complex testing described above for ARD classification (Acid Base Accounting or ABA), and metal leaching evaluation (bulk metal content and Shake Flask Extraction or SFE).

For the duplicate samples, the testing frequency of 75 samples per quarter that is currently in place at Meadowbank will be followed, however this frequency will be evaluated and altered as necessary as the database increases. A geostatistical approach will be considered to establish the number of QA/QC samples required by rock type to achieve statistical confidence.

Further, the duplicate test results will be used to confirm the total sulphur (0.1 %) and total arsenic (75 ppm) threshold values in place for waste classification. SFE results from the duplicate analyses will

be evaluated against the proposed Effluent Quality Criteria for arsenic (0.1 mg/L) and the 75 ppm value will be modified as necessary based on the results.

3.3 Waste Rock Delineation and Tracking

Following laboratory analysis, geology staff will classify waste rock into the following types of material as defined in Table 3.3.

Table 3.2 ARD Guidelines used to Classify Whale Tail Pit Waste Rock and Overburden

Waste Type	Criteria for Classification	Frequency of Outlying Data
NPAG/NML	Total S < 0.1% and/or NPR > 2 ***and*** Average Total Arsenic < 75 ppm	• No more than one PAG (S>0.1% and NPR<1) for every 8 NPAG samples. • No more than one uncertain sample (S>0.1% and 1≤NPR<2) for every 4 NPAG samples. • Average total arsenic value is below 75 ppm
PAG/ML	Total S > 0.1% and NPR < 2 ***and/or*** Average Total Arsenic > 75 ppm	• Two or more PAG (S>0.1% and NPR<1) for every 8 NPAG samples. • Two or more uncertain samples (S>0.1% and 1≤NPR<2) for every 4 NPAG samples. • Average total arsenic value is above 75 ppm

NPAG/NML waste can be used for construction (i.e. pads, roads, and dykes) and closure (i.e., Whale Tail WRSF cover material) while waste rock classified as PAG/ML must be stored in the Whale Tail WRSF. The criteria outlined in Table 3.3 can be re-evaluated when judged relevant by the Geology Superintendent in consultation with the mine engineer, as additional test data become available. The ARD/ML classification of all samples will be logged in a database for the Project, and will be available as required for annual reports or upon request. The rationale for any changes will be clearly documented and implemented only with the prior approval of the Nunavut Water Board.

NPR and total arsenic values will be transferred to the mine plans for each specific blast. Once blasting is complete the mine surveyor will identify the two waste categories: 1) suitable for capping and infrastructure (NPAG/NML) and 2) non-suitable material (PAG/NML-ML and NPAG/ML). Outlines from the drill pattern will be used to outline the respective dig limits in the open pit for each type of material. The different material types or packets will be identified in the field using stakes, wire flags and flagging tape so that each type of material can be excavated and sent to the appropriate destination (see Section 2.2).

Both waste types (1) NPAG/NML and 2) PAG/NML-ML and NPAG/ML) will be assigned a unique identification number and tracked in WENCO to their final location in the Whale Tail WRSF.

3.4 WRSF thermal cover material sampling/testing program

The sampling frequency proposed (every fourth hole) will result in 10's of thousands of samples tested to ensure non-PAG and non-metal leaching material is used for the thermal cover. This is far in excess of industry standards, but Agnico Eagle is committing to this sampling frequency to ensure clean cover material is used. In addition, the planned segregation program (Table 3.2) does not tolerate ARD generating material, further decreasing the chance for material with ARD-ML potential in the cover.

Despite the level of effort to segregate rock during mining, Agnico Eagle will also confirm the cover properties after placement. Sampling of cover material would include approximate 80 samples based on MEND (2009) guidance collected from well spaced locations from the sides on top layer of the cover.

Monitoring of thermal properties of the pile and water quality generated from run-off are also included in the monitoring plan (described in Section 4), with results from both used to validate prediction models and determine if any changes will be needed to ensure the cover functions as designed.

SECTION 4 • PLAN REVIEW, PERFORMANCE MONITORING & REPORTING

4.1 Plan Review

The Mine Geology Superintendent will be responsible for implementing the Operational ARD-ML Sampling and Testing Plan. The overall Plan is to be reviewed as required by the Geology Superintendent and updated if necessary to reflect any adaptive changes made in the Operational ARD-ML Sampling and Testing Plan. The changes should be made in consultation with the mine engineer and chief assayer. Revised versions should be sent according to the Distribution List.

4.2 Performance Monitoring

The Operational ARD-ML Sampling and Testing Plan is the primary tool to ensure that all overburden and waste rock generated during the Project is appropriately characterized and managed to prevent the future release of contaminants from the Whale Tail WRSF into the receiving environment.

In addition to the analytical QA/QC procedures outlined in Section 3.0, performance monitoring activities will include those activities outlined below.

4.2.1 Water Quality Monitoring

Water quality will be sampled and monitored by the Agnico Eagle in accordance with the Type A Water Licence. The details of this monitoring program are described in the Water Quality and Flow Management Plan (Agnico Eagle 2018b, Version 3). On-site monitoring locations for site contact water will include the Whale Tail WRSF drainage, the Attenuation Pond, Whale Tail Pit sumps, Industrial Sector and dewatering dikes. The data from this monitoring is to be provided to the NWB through annual reporting, as per the Type A Water Licence.

4.2.2 Permafrost Development

Thermistors will be installed within the Whale Tail WRSF to determine if permafrost formation is observed. More information is provided in the Thermal Monitoring Plan (Agnico Eagle 2018a). Thermal monitoring results are provided in Agnico Eagle's annual report submitted to the NWB.

SECTION 5 • ADAPTIVE MANAGEMENT

5.1 Management Actions

Adaptive management will be achieved through performance monitoring (Section 4) and management actions that will be implemented, should they be triggered. Action level responses taken during the year will be documented in Agnico Eagle's annual report submitted to the NWB.

Table 5.1 outlines the various adaptive management actions associated with the ARD/ML plan.

Table 5.1 Adaptive Management Actions Associated with the ARD/ML Plan

Thresholds	Mitigation Strategies	Potential Issues	Steps	Management Responses
Significant variations from model predictions are observed suggesting potential for ARD/ML Drainage	Use only NPAG/NML waste rock for site construction and closure	Observations of visible sulphide minerals or staining, inferring PAG rock was used in construction material across the site	• Notify management • Note location and estimate dimensions of potential PAG/ML material • Collect samples of material from the observed area for analysis (Section 3.2) • Review results; if samples are PAG/ML, establish a monitoring station down gradient of the location • Review water quality sampling; if elevated metal concentrations are detected, proceed to management response.	• Consider relocation of material to WRSF or cover with additional NPAG/NML rock if possible, otherwise investigate other mitigation strategies. • Review the application of the ARD/ML sampling plan (i.e. sampling frequency, total sulphur and total arsenic threshold value, and material classification)
	Confirm that waste rock being encountered exhibits the anticipated range of behaviour from baseline study	Higher proportion of waste rock is PAG/ML than anticipated	• Geology to document the location and classification of samples to identify trends outside the anticipated geochemical behaviour of the rock types • Notify management if unanticipated trends are observed	• Confirm the availability of sufficient NPAG/NML waste rock for closure • Confirm the availability of sufficient space in the WRSF for PAG/ML waste rock • Initiate a follow-up investigation to evaluate the implications
Significant variations from model predictions are observed in the water quality of the WRSF pond	Manage contact water quality to avoid exceedance to predicted levels	One contact water quality monitoring sample is different than predicted	• Collect and analyze follow up confirmation samples to confirm results • If confirmed, notify management	• Initiate an investigation to reduce the effects of contact water quality, if possible
		Water quality monitoring program identifies trends outside of those predicted, for a significant period of time (i.e. great than two months)	• Increase monitoring frequency • Notify management	• Investigate alternative strategies to control effects to water quality • Investigate strategies to reduce seepage and runoff from identified sources
	Use of thermal cover to minimize water in contact with PAG/ML rock in post-closure	Cover placement is incomplete or not of sufficient thickness	• Monitor the placement of cover material on the WRSF to ensure appropriate thickness of cover • Modify cover thickness with placement of additional material when thickness is not sufficient	• Waste Rock Facility Monitoring program to confirm completeness of cover on WRSF (Agnico Eagle 2018, Version 2)
		Thermal monitoring confirms that the waste rock cover freeze back is not occurring as anticipated	• Notify management	• Investigate effects of the different thermal regimes on water quality • Consider alternative strategies to mitigate impacts to water quality from the PAG/ML material in the WRSF

SECTION 6 • REFERENCES

Agnico Eagle. 2016. Water Management Plan. Volume 8, Appendix 8-B.2 of the Final Environmental Impact Statement and Type A Water Licence Amendments.

Agnico Eagle. 2018. Mine Waste Rock and Tailings Management Plan. Version 2.

Agnico Eagle. 2018a. Whale Tail Pit Project Thermal Monitoring Plan. Version 1.

Agnico Eagle. 2018b. Whale Tail Pit Water Quality and Flow Monitoring Plan. Version 3.

Golder (Golder Associates Ltd.). 2016. Evaluation of the Geochemical Properties of Waste Rock, Ore, Tailing, Overburden and Sediment from the Whale Tail Pit and Road Aggregate Materials, Agnico Eagle Mines, Meadowbank Division. Document No. 042. June 2016.

Golder. 2018, in preparation. Technical Memorandum: Whale Tail Pit Project Waste Rock Storage Facility Cover Thermal Assessment. Prepared for Agnico Eagle Mines Limited. Reference 1789310_177_TM.

NIRB (Nunavut Impact Review Board). 2018. NIRB Project Certificate [No. 008]. March 15, 2018.

NWB (Nunavut Water Board). 2015. Water Licence #2AM MEA1525, Meadowbank Mine. 48p. July 2015.

MEND (Mine Environment Neutral Drainage), 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1. Mining Environment Neutral Drainage Program, Natural Resources Canada. December 2009.

APPENDIX A • SUMMARY OF THE ARD/ML POTENTIAL OF WHALE TAIL MINE WASTES

The acid rock drainage (ARD) and metal leaching (ML) potential of waste material to be produced at Whale Tail Pit has been evaluated through both static and kinetic testing (Golder 2016). The static tests conducted for this purpose included the following:

- Mineralogy;
- Whole rock analysis;
- Elemental solid phase analysis (multi-acid digestion);
- Acid base accounting (ABA);
- Net acid generation tests; and
- Shake Flask Extraction.

Test methods and results are provided in (Golder 2016).

Kinetic testing was conducted on representative samples of waste rock from each lithology using standard 1 kg humidity cell tests, 12 to 60 kg composite column tests, a 40 kg composite submerged column, and two 8 kg field cells. Test methods are provided in (Golder 2016).

Table A.1 summarizes the ARD/ML potential for the overburden (till), lake sediments, and pit rock, based on the results of static and kinetic testing (Golder 2016). ARD potential was evaluated by comparing ABA results to the Canadian guidelines presented in MEND (2009). ML potential was evaluated based on exceedances in kinetic test leachate of the mean monthly Effluent Quality Criteria (EQC) developed for the Project as proposed in the Whale Tail water license application to the Nunavut Water Board (Agnico Eagle 2018b).

Table A.0-1 Summary of ARD/ML Potentials of Whale Tail Pit Waste Types

Waste Type	Unit	ARD Potential[1]			Effluent Quality Criteria Exceedances in Test Leachate[2]	ML Potential[2]
		% PAG	% Uncertain	% NPAG		
Komatiite North	V4a – 0a	5	-	95	As	High
Komatiite South	V4a – 0b	29	-	71	As	Moderate
Greywacke Central	S3C – 3b	58	29	13	As	Variable
Greywacke South	S3S – 3b	-	-	100	-	Low
Greywacke North	S3N – 3b	16.6	16.6	66.6	Ni	Variable
Chert	S10 – 3b	87	4	9	As	Variable
Iron Formation	S9E – 3b	27	4	69	As	High
Basalt	V3 – 1b	-	3	97	As	Moderate
Diorite	I2 – 8b	15	15	70	-	Low
Overburden	n.a.	-	-	100	Al, Cu, Fe	Low
Lake sediment	n.a.	100	-	-	Al, As, Fe, Ni	High

[1]Percentage of total samples analyzed (Golder 2016), where PAG = potentially acid-generating; NPAG = not potentially acid-generating
[2]Based on the results corresponding to the bulk column composite samples (Golder 2016) with the exception of diorite which is based on humidity cell test results and overburden and lake sediment which are based on SFE results
n.a. = not applicable; N/A= not analyzed

APPENDIX B • FLOW CHART FOR WASTE ROCK DELINEATION AND SEGREGATION

ARD/ML Plan Attachment B: Flow Chart

1896037/3200
October 2018

STEP 1: SAMPLE COLLECTION[1,2]

Responsibility: Geology Superintendent

1. Identify rock types to be excavated using block model
2. Define sample frequency per Table
3. Plan and map sample locations to ensure an even distribution throughout the planned blast area, sufficient for packet definition
4. Collect each sample from drill cuttings (>1 kg) and label using production drill hole numbers
5. Document for each sample:
   - Date
   - Blast pattern / GPS location
   - Sample ID
   - Rock Type
6. Submit samples to Assay Lab Manager for analysis.
   - Include documentation (Step 2)
   - CC the Environmental Coordinator on submission

Rock Type	Rock Unit Code	Sampling Frequency
Komatiite North	V4a – 0a	Every 4th hole
Komatiite South	V4a – 0b	Every 4th hole
Greywacke Central	S3C – 3b	Every 4th hole
Greywacke South	S3S – 3b	Every 4th hole
Greywacke North	S3N – 3b	Every 4th hole
Chert	S10 – 3b	Every 4th hole
Iron Formation	S9E – 3b	Every 4th hole
Basalt South	V3S – 1b	Every 4th hole
Basalt North / Gabbro	V3 – 1a / I3A	Every 4th hole
Diorite	I2 – 8b	Every 4th hole

STEP 2: LABORATORY ANALYSIS[1,2]

Responsibility: Assay Laboratory

1. Prep samples (crush and homogenize)
2a. Initiate on-site analysis:
   - Total Sulphur (S)
   - Total Inorganic Carbon (TIC)
   - Total Arsenic
3. Quarterly analysis (minimum of 75 duplicate samples). Send subset of samples to off-site laboratory for QA/QC:
   - Tests: ABA, Bulk Metals, SFE
   - Include Chain of Custody

Copy Environmental Coordinator on COC

STEP 3: DATA EVALUATION AND ROCK CLASSIFICATION[1]

Responsibility: Geology Superintendent

1. Compile on-site data with sample information:
   - Total Sulphur
   - Total Inorganic Carbon
   - Total Arsenic
   - Sample documentation
2. Compare Total Sulphur with Cut-off (0.1%)
3. Calculate CaNPR from Total Sulphur (S) and Total Inorganic Carbon (TIC) to determine ARD potential:

   CaNPR = [TIC%*83.34] / [S%*31.25]
4. Evaluate arsenic leaching potential with Total Arsenic (As)

Send compilation to Environmental Coordinator

- Total S < 0.1% **= NPAG**
- Total S > 0.1% *and* CaNPR>2 **= NPAG**
- Total S > 0.1% and 1≤ CaNPR<2 **= Uncertain**
- Total S > 0.1% and CaNPR<1 **=PAG**
- Total As < 75 ppm **=NML**
- Total As > 75 ppm **= ML**

NPAG/NML Samples | Uncertain Samples | PAG/ML Samples

Data QA/QC See Page 2 (reverse)

STEP 4: ROCK SEGREGATION AND MANAGEMENT[1]

Responsibility: Geology Superintendent, Engineering, Environmental Coordinator, Construction Supervisor

1. Log results in database. Map the distribution of samples and define the groups of material for each blast

NPAG and NML Material

- ≤1 PAG sample per 8 NPAG samples
- ≤1 Uncertain sample per 8 NPAG samples
- Average total arsenic <75 ppm

PAG and/or ML Material

- ≥2 PAG samples per 8 NPAG samples
- ≥2 Uncertain samples per 4 NPAG samples
- Average total arsenic >75 ppm

2. Field Segregation of Waste Types:
   - Outline dig limits using stakes, wire flags, and flagging tape
   - Track in WENCO
3. Record the following with each Packet:
   - Packet number
   - Sample Results (Total S, TIC, As, NPR)
   - Block model rock type
   - Final location in WRSF

No Restrictions for Re-Use as Construction and/ or Cover Material

Suitable for the following:
- Pads
- Roads
- Dykes
- WRSF sides and cover material

Not Approved for Re-Use; must be managed to control ARD/ML

Disposal and Management Requirements:
- Encapsulated within NPAG/NML rock that hosts the thawed layer, and encouraged to freeze
  - Placed on a pad of NPAG/NML rock
  - Placed in centre of the pad (≥4m from edge)
  - Covered with ≥4 m of NPAG/NML rock
- Placed away from permanent water contact
- Monitor temperature and seepage quality

Whale Tail WRSF
IVR WRSF
Waste Rock Exploration Pad

ARD/ML Plan Attachment B: Flow Chart

STEP 3a. DATA QA/QC – EXTERNAL LABORATORY
Responsibility: Geology Superintendent / Environmental Coordinator

1. Confirm ARD Potential using external lab results (ABA). Calculate NPR using the Total Sulphur and Total Inorganic Carbon reported by external lab to compare directly with Meadowbank assay lab data.

↓

2. Confirm arsenic leaching potential using external lab results.

Arsenic leaching potential is considered high if:

- Total arsenic > 75 mg/kg

and

- Leachable arsenic (SFE) > 0.1 mg/L

↓

3. Complete QA/QC of data against onsite results by calculating an RPD value. RPD values below 35% are considered acceptable[3].

↓

4. If the ARD and/or ML designation determined by the external lab data are different than that determined by the onsite lab, a more rigorous QA/QC program is required and refinements must be considered in the block model designation.

↓

5. If required, revisit the cut-off criteria for total arsenic based on updated leach test data.

LIST OF ACRONYMS

ARD: acid rock drainage
PAG: potentially acid generating
NPAG: not potentially acid generating
NPR: net potential ratio
ML: metal leaching
NML: not metal leaching
ABA: acid base accounting
Bulk metals: total metals by ICP
WRA: whole rock analysis
SFE: metal leaching by shake flask extraction
XRF: x-ray fluorescence
ppm = parts per million
S = sulphur
C = carbon
As = arsenic

LIST OF ANALYTES AT EXTERNAL LAB

ABA: acid base accounting by Modified Sobek method. Includes paste pH, Bulk NP, analysis of total S and Total C by C/S analyzer (LECO Furnace), Acid Leachable Sulphate and Sulphide by difference.

Bulk metals: trace metals scan by aqua regia digest and analysis by ICP-MS and ICP-OES. Includes Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Ti, Tl, U, V, Zn

WRA: whole rock analysisor major oxides by Borate Fusion XRF. Includes SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5, MnO, Cr_2O_3, V_2O_5, LOI

SFE: metal leaching by shake flask extraction, 24 hr leach extraction using DI water at 4:1 L/S ratio, and filtered leachate through 0.2 micron filter. Analysis of leachate includes pH, alkalinity, conductivity, anions (Cl, SO4, NO2, NO3, Br), ortho-phosphate, fluoride, mercury (by CVAAS), and trace metals by ICP-MS and ICP-OES (Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Ti, Tl, U, V, Zn).

References:
1-*Operational ARD-ML Sampling and Testing Plan – Whale Tail Pit Addendum (Golder 2016)*
2- Procedure AMQ-ENV-PRO- Quarry and borrow pit ARD-ML Sampling for Construction
3-EPA Guidelines for Inorganic Data Review, 1994

Operation & Maintenance Manual - Sewage Treatment Plant (STP), Version 2

Operation & Maintenance Manual
Sewage Treatment Plant (STP)

Prepared by:
Agnico Eagle Mines Limited – Meadowbank Division – Whale Tail Pit Project

EXECUTIVE SUMMARY

Agnico Eagle has prepared the following document which summarizes the operational and maintenance procedures to be followed at the Sewage Treatment Plant (STP).

This report documents the stand alone Operation & Maintenance Manual – Sewage Treatment Plant, includes the following requirements:

- The manual was prepared in accordance with the "Guidelines for the Preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories, 1996", and adapted for the use of a mechanical contact water treatment facility;
- The manual includes contingency measures in the event of a plant malfunction; and
- The manual includes sludge management procedures.

IMPLEMENTATION SCHEDULE

This Plan will be implemented upon Board approval and subject to any modifications proposed by the NWB as a result of the review and approval process.

DISTRIBUTION LIST

Agnico Eagle Internal:

- Energy & Infrastructures Services Superintendent
- Energy & Infrastructures Services General Foreman
- Environmental Superintendent
- Senior environmental Coordinator
- Environmental Compliance Counselor
- Sewage Treatment Plant Operator

DOCUMENT CONTROL

Version	Date (YMD)	Section	Page	Revision
1	2018/12/30			Operation and Maintenance Manual
2	2019/02/19			Comment from ECCC, CIRNAC

Prepared By:

Thomas Genty

Signature numérique de Thomas Genty
Date : 2019.02.18 12:00:47 -05'00'

Thomas Genty
Water treatment Specialist

REGISTERED PROFESSIONAL ENGINEER
I. GAGNON
LICENSEE
NT/NU
L3940
2019-02-18

Israel Gagnon
Mechanical Eng.

Approved by:

Alain Parent

Signature numérique de Alain Parent
DN : cn=Alain Parent
Date : 2019.02.18 15:50:46 -05'00'

Alain Parent
Amaruq project Construction Superintendent

TABLE OF CONTENTS

1 INTRODUCTION 7

1.1 Purpose 7
1.2 Brief Description of the Project 7
1.3 Contact Information 11

2 DESCRIPTION 12

2.1 Sewage Treatment Plant (STP) 12
2.1.1 Process summary 12
2.1.2 Process description 19
2.1.3 Sludge Management Strategy 20

3 OPERATION AND MAINTENANCE 21

3.1 Pumping 21
3.2 Sewage collection 21
3.3 Sludge disposal 21
3.4 Control 21
3.5 Reagents 22
3.6 Biological operation 23
3.7 Membranne operation 23
3.8 Membrane cleaning 24
3.9 Service water 24
3.10 Operationnal performance Targets 24
3.11 General Operation & Maintenance, Sampling Procedures and Frequency 25
3.12 Troubleshooting and Maintenance Procedures 27
3.13 Record Keeping 28
3.14 Safety Procedures For Operators 29
3.15 Controlling Access to the STP 29

4 EMERGENCY RESPONSE 30

4.1 Fire 30
4.2 Spill 30
4.3 Plant Malfunction 30

LIST OF FIGURES

Figure 1 – Site Layout 8
Figure 2 – Location of STP in the Whail Tail Camp 9
Figure 3 – General Arrangement of STP 10
Figure 4 – Flowsheet 14
Figure 5 – Oils and grease removal, screening and equalization's tank 15
Figure 6 – Biological treatment 16
Figure 7 – Post Biological treatment 17
Figure 8 – Membrane filtration step 18
Figure 9 – Membrane filtration concept 20

LIST OF APPENDICES

Appendix A: MSDS Sheets
Appendix B: Drawings
Appendix C: Operations and Maintenance Manual

1 INTRODUCTION

1.1 PURPOSE

This Sewage Treatment Plant (STP) Operation and Maintenance Manual (OMM) for the Whale Tail Gold Project (the Project) has been prepared based on the "*Guidelines for the Preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories, 1996, prepared by the Department of Municipal and Community Affairs, NWT*". The OMM has been adapted for the use of a mechanical contact water treatment facility.

This manual is a component of the Whale Tail Environmental Management System. The objectives of this plan are summarized as follows:

1. To define the location, design and operating procedures to be used in the treatment of sewage generated at the Project; and
2. To provide monitoring requirements for the STP.

The STP purpose is to treat domestic sewage from the camp and adjacent building which are not connected to the STP directly (sucker truck will discharge sewage from this building directly into the STP).

1.2 BRIEF DESCRIPTION OF THE PROJECT

Agnico Eagle Mines Limited—Meadowbank Division (Agnico Eagle) is developing Whale Tail Pit and Haul Road Project, approximately 55 km north of the Meadowbank mine, on a satellite deposit located on the Amaruq property in the Kivalliq Region of Nunavut (65°24'25" N, 96°41'50" W), to extend mine operations and milling at Meadowbank Mine. The 99,878-hectare Amaruq property is located on Inuit-owned and federal crown land.

A conventional open pit mining operation is forecasted on the Whale Tail deposit. Access to the site is via a 64-kilometer road from Meadowbank mine. On-site facilities will include a power plant, maintenance facilities, tank farm for fuel storage, Arsenic water treatment plant, sewage treatment plant (STP), drinking water treatment plant, as well as accommodation and kitchen facilities for approximately 400 people.

Figures 1, 2 and 3 illustrate the location and general arrangement of the STP.

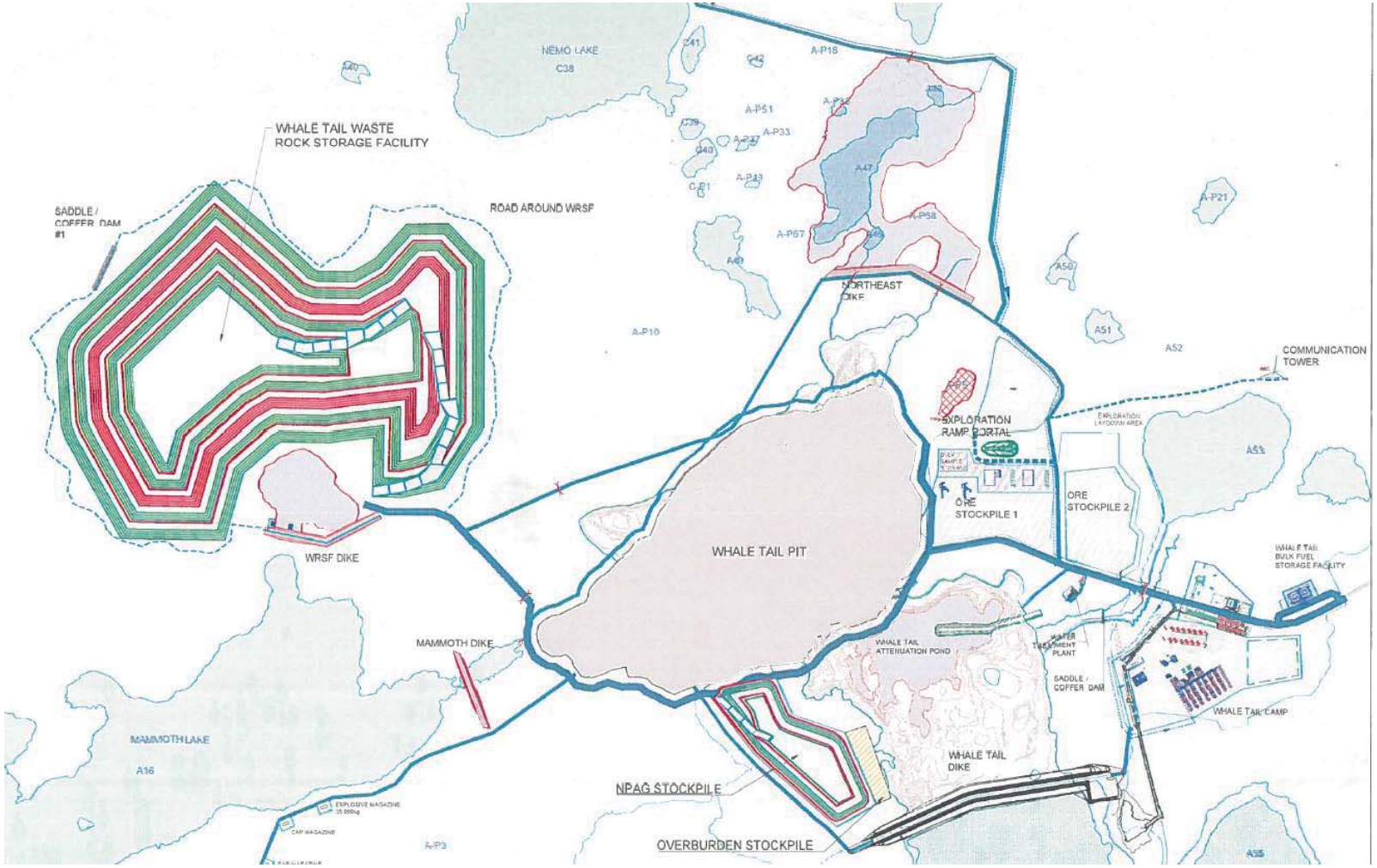


Figure 1 – Site Layout

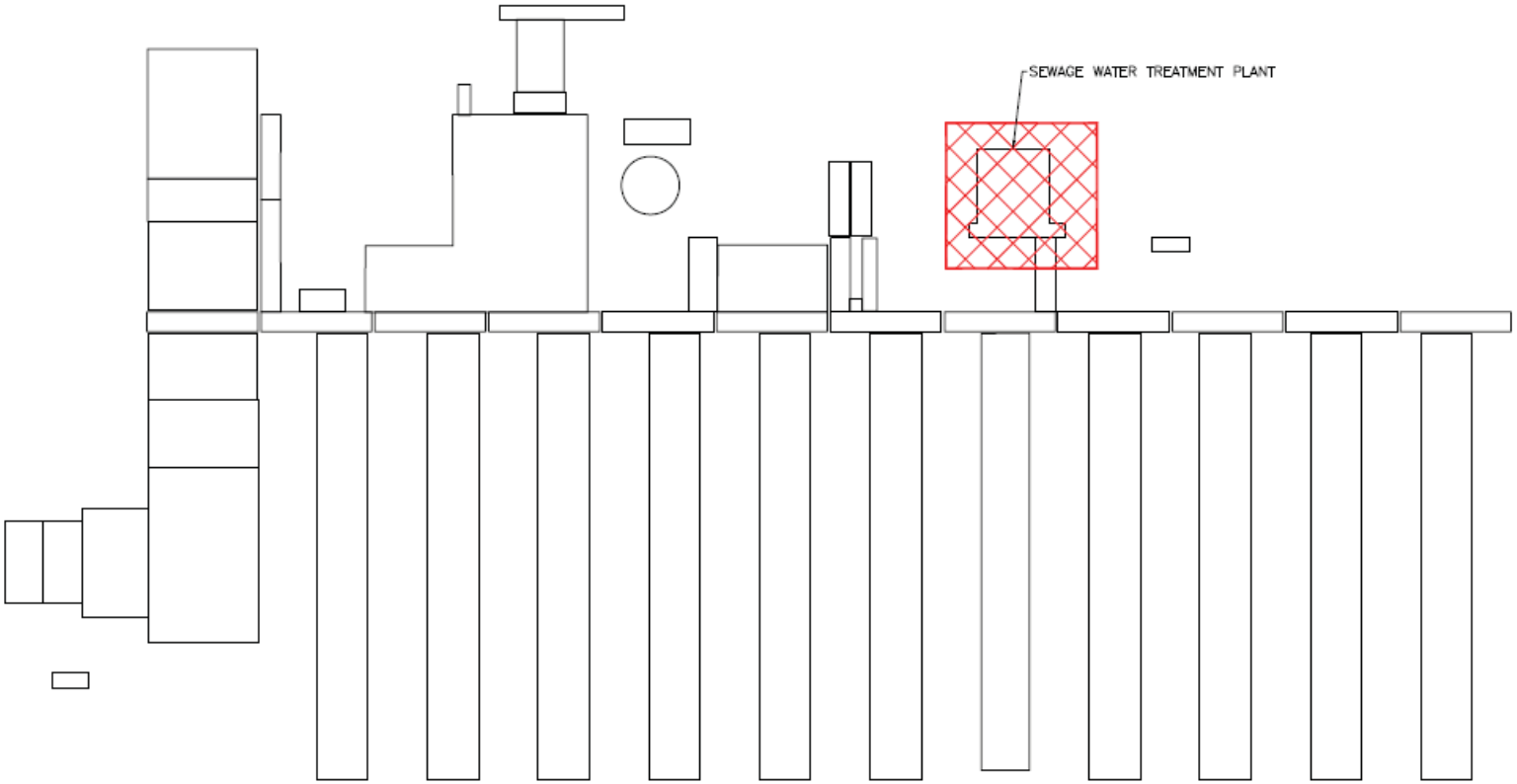


Figure 2 – Location of STP in the Whail Tail Camp

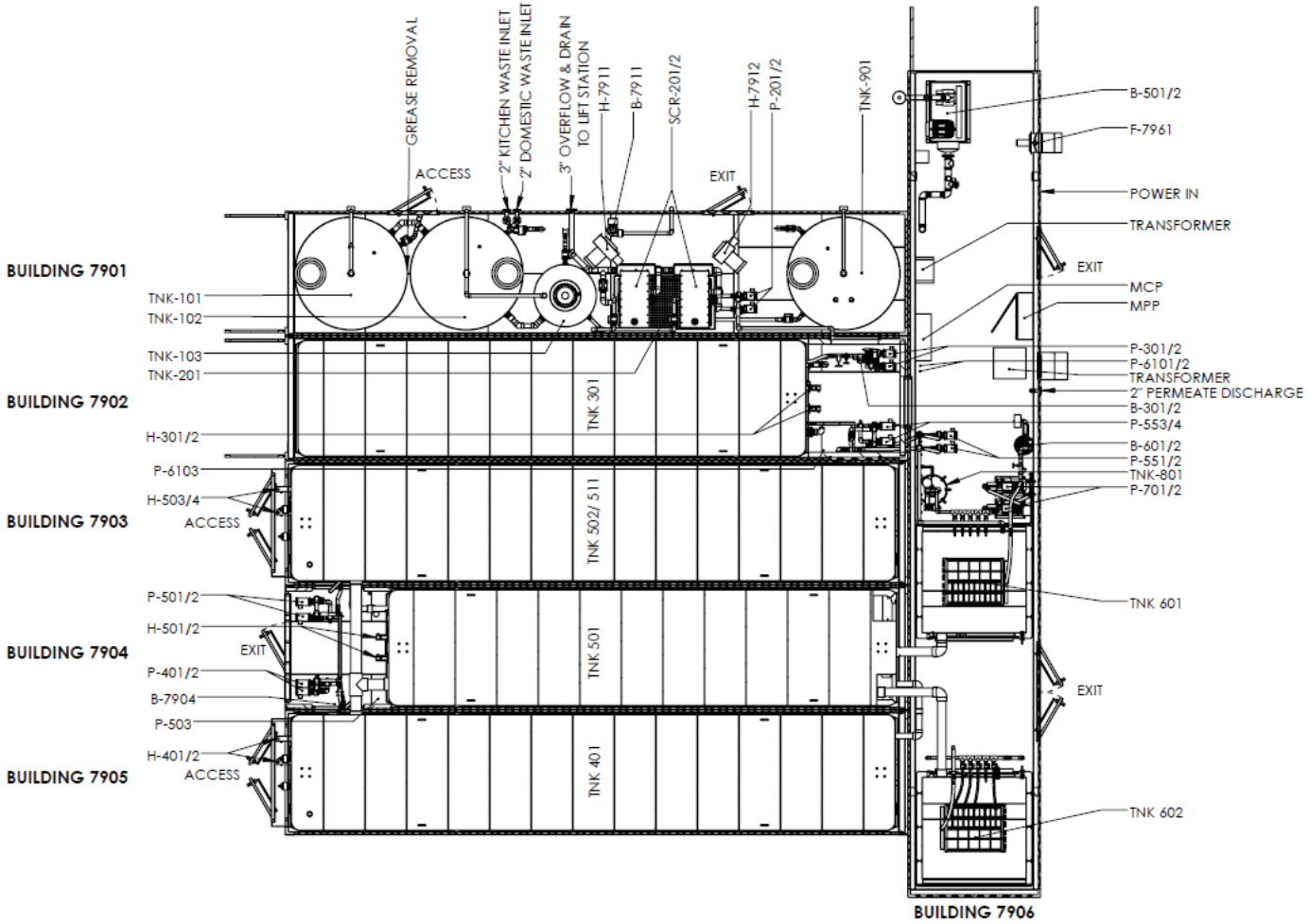


Figure 3 – General Arrangement of STP

1.3 CONTACT INFORMATION

The individuals responsible for the operation of the sewage treatment plant for the Project are the following:

Energy and Infrastructure Superintendent	819-856-3073
Energy and Infrastructure Supervisors	819 759-3555 ext 6731 or 6902

2 DESCRIPTION

2.1 SEWAGE TREATMENT PLANT (STP)

The plant is designed based on the occupation maximum of the camp for 400 persons (240L per day and per person). The design flows are presented in Table 1.

Table 1: Design flow rate

Parameters	Design Value	Unit
Per capita design flow	240	L/p/d
Number of persons	400	People
Average daily flow (ADF)	96	m^3/d
Maximum Daily Flow (MDF)	192	m^3/d
Peak Hourly Flow (PHF)	24	m^3/h
Overall time for speak to occur	2	hours
Maximum number of peak events per day	2	Qty

Table 2 presents the typical sewage composition used for the design (based on Meadowbank sewage quality).

Table 2: Sewage typical chemical composition

Parameters	Unit	Design Value
Biochemical Oxygen Demand (BOD_5)	mg/L	952
Total Suspended Solids (TSS)	mg/L	300
Total Kjeldahl Nitrogen (TKN)	mg/L	130
Ammonia nitrogen (NH_3-N)	mg/L	130
Oil and Grease	mg/L	30
pH	-	6 to 9.5
Water Temperature	^oC	10 to 25
Alkalinity	mg/L as $CaCO_3$	471.1

2.1.1 Process summary

The sewage treatment plant receives two streams of sewage as presented in Figure 4 (basic flowsheet of the STP). The first source is domestic sewage, which is fed directly to the fine screening process to remove any fibers or debris that might damage the membranes. The second source is kitchen sewage which is pre-treated in the oil and grease tanks to remove oil and grease prior to being fed into the fine

screens. The combined screened sewage is pumped to the equalization tank. The equalization tank buffers variability in the influent flow rate and concentrations of influent constituents, maintaining a consistent flow rate and sewage strength through the membrane bioreactor (MBR) system. Sewage is then pumped from the equalization tank to the pre-anoxic tank for denitrification.

In the pre-anoxic tank, screened sewage containing organics is combined with recycled mixed liquor from the aeration tank containing nitrates. Bacteria use some of the organics to drive the denitrification process, converting nitrate into nitrogen gas. This process occurs in an anoxic environment where there is minimal oxygen. As such a pump and eductors are used to mix the tank to prevent addition of oxygen. The denitrification process is used to meet the effluent nitrate operational target, reduce oxygen requirements and to recover alkalinity, thus reducing chemical consumption.

Mixed liquor from the anoxic tank flows by gravity to the first aerobic tank followed by the second aeration tank for aerobic biological degradation of the influent constituents (organics and ammonia). In the aerobic tanks, the nitrification process converts ammonia to nitrate in order to meet the effluent ammonia operational target. This process consumes alkalinity, so a caustic soda or soda ash dosing pump is used to control the pH. Additionally, liquid alum is dosed into the anoxic zone to precipitate phosphorus in order to meet the effluent phosphorus operational target. Mixed liquor flows by gravity from the second aeration tank to the post-anoxic tank for final denitrification polishing. In the post-anoxic tank there are minimal dissolved influent organics to drive the denitrification process. As such, an external carbon source in the form of MicroC is dosed to supplement the organics and drive the denitrification process.

Mixed liquor is pumped from the post-anoxic tank to the membrane tanks. The membrane tanks serve as additional volume for aerobic biological treatment to remove any excess MicroC (which would otherwise increase BOD in the effluent) and house the membrane filters used for solid-liquid separation. A treated effluent is drawn through the membranes by vacuum pumps.

Since the solid-liquid separation process results in an accumulation of solids in the membrane tank, the mixed liquor (containing both solids and filtrate) is continuously recycled to the first aeration tank. This prevents excessive solids build-up in the membrane tank, and maintains sufficient biomass in the anoxic and aeration tanks. The solids that accumulate in the system consist of biomass that has grown from the influent organics and ammonia, as well as non-biodegradable solids from the influent sewage. In order to maintain an optimal concentration of mixed liquor suspended solids (MLSS) (typically 10 g/L), a portion of the mixed liquor is periodically wasted by pumping from the Aeration Tank to the sludge holding tank. Wasted sludge in the sludge holding tank is thickened by decanting supernatant back to the screen tank. Thickened sludge accumulates in the sludge holding tanks until it is eventually pumped out for disposal.

The STP general flow diagram is illustrated in Figure 4 and Piping and Instrumentation Diagram (PID) in Figures 5 to 8. The following sections describe the STP components.

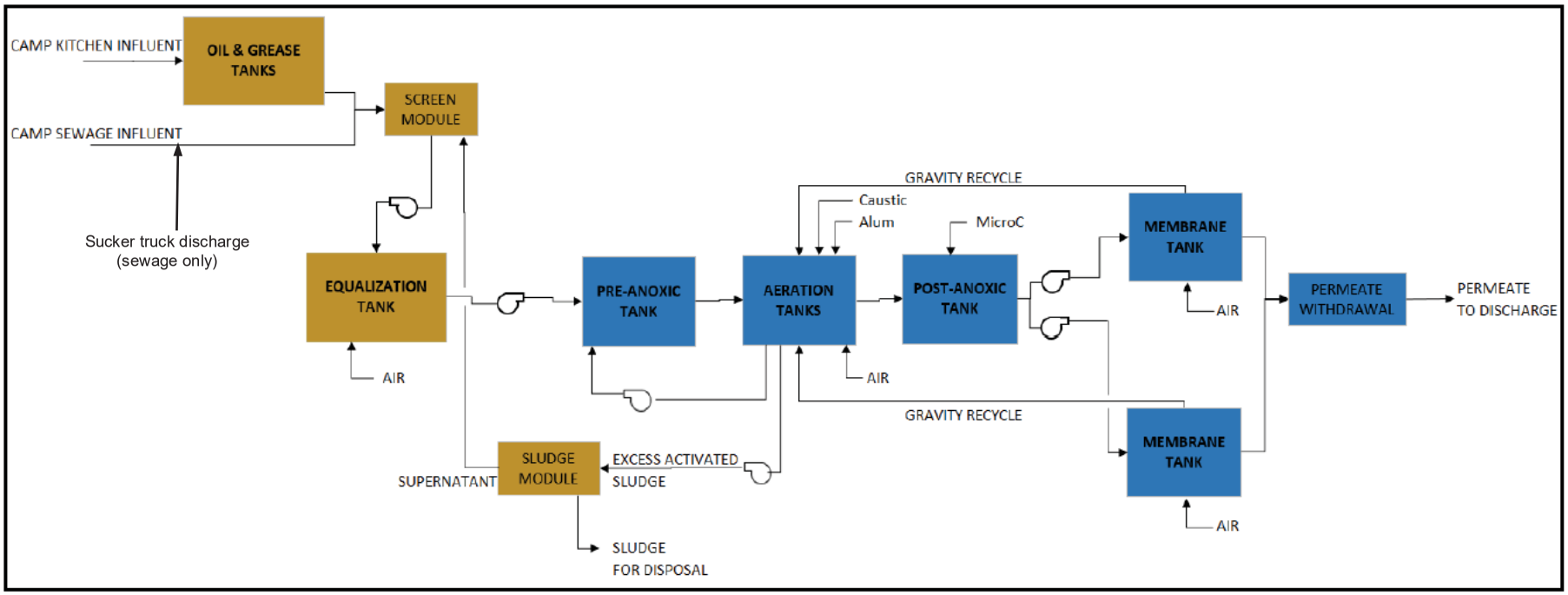


Figure 4 – Flowsheet

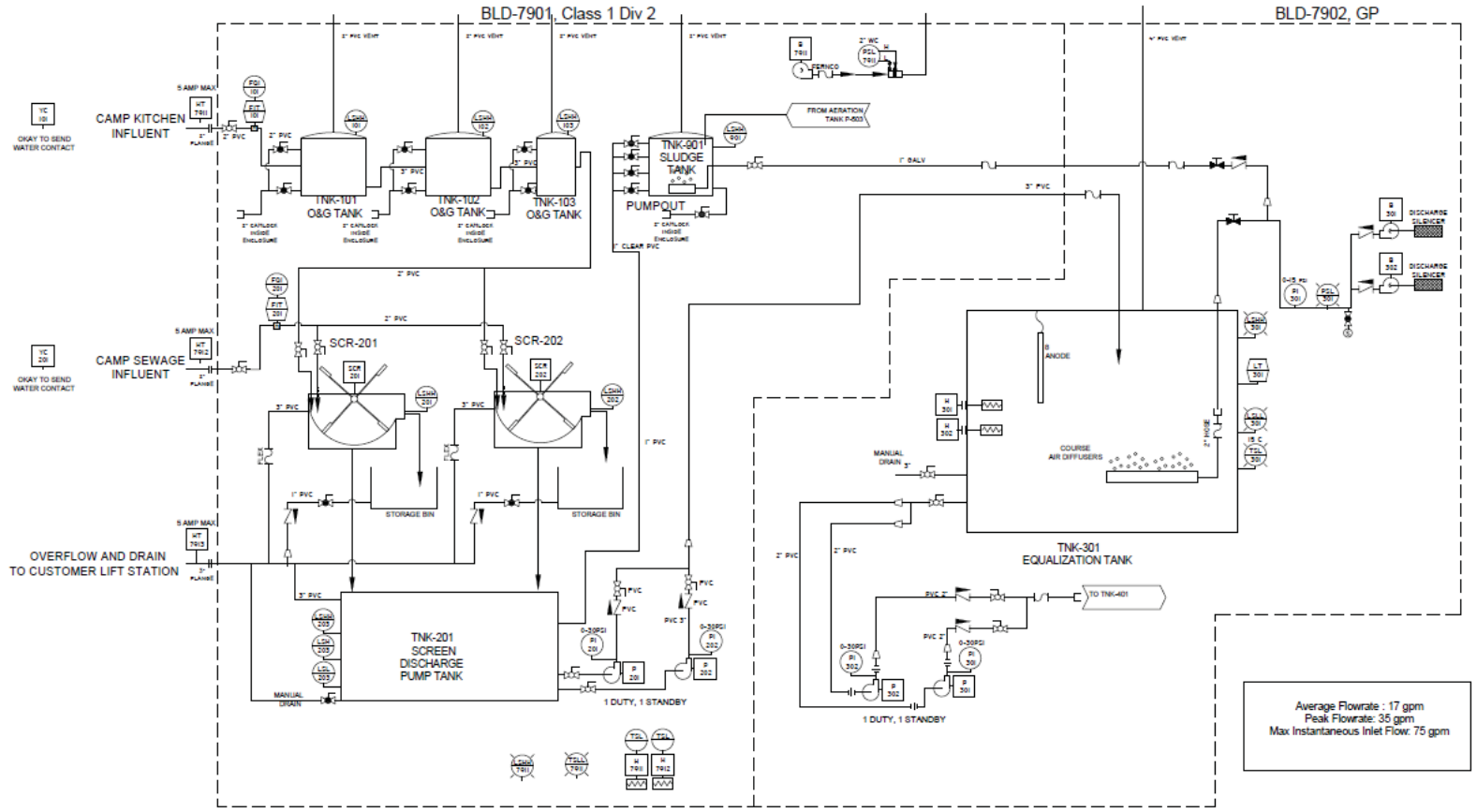


Figure 5 – Oils and grease removal, screening and equalization's tank

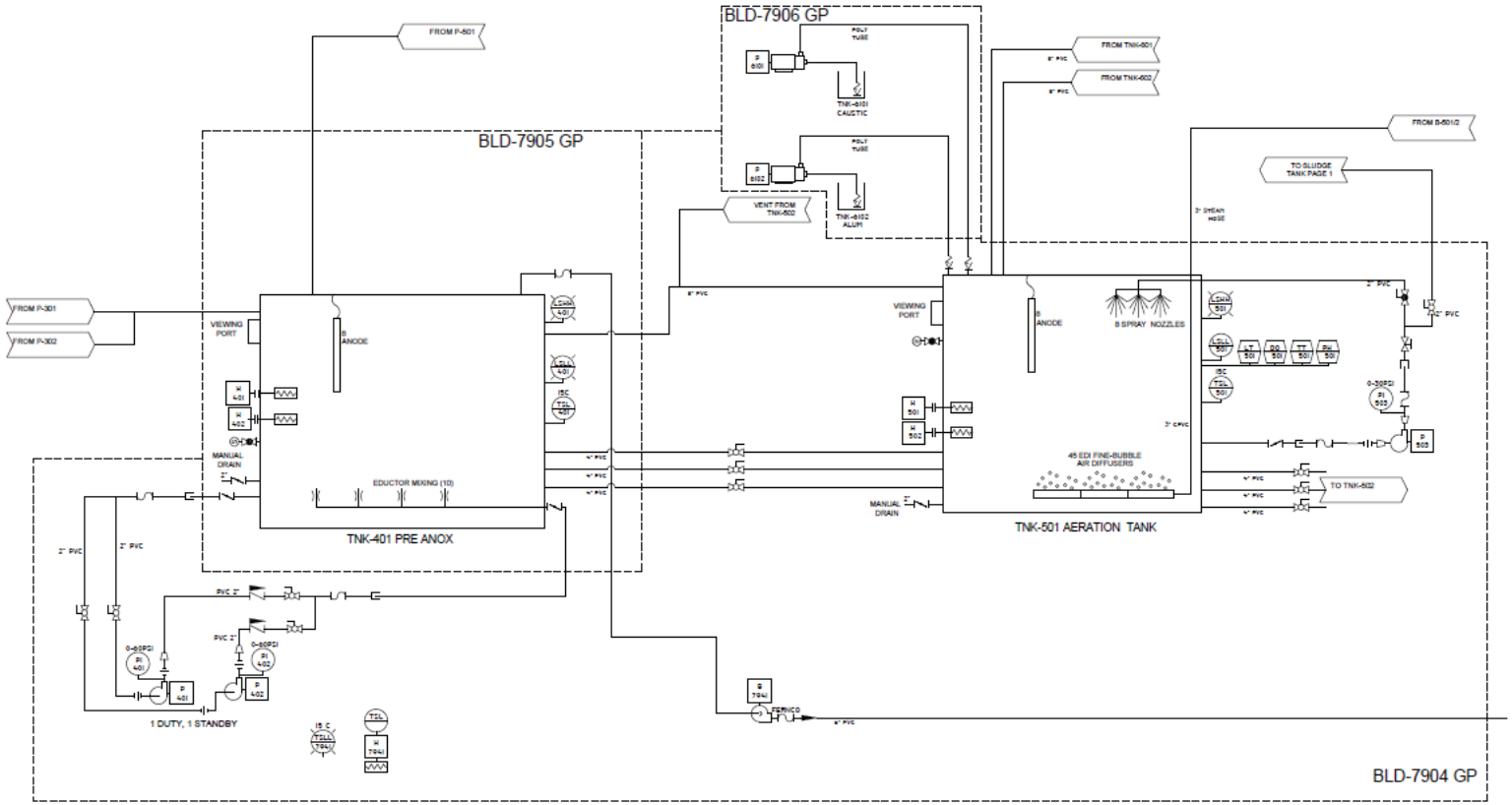


Figure 6 – Biological treatment

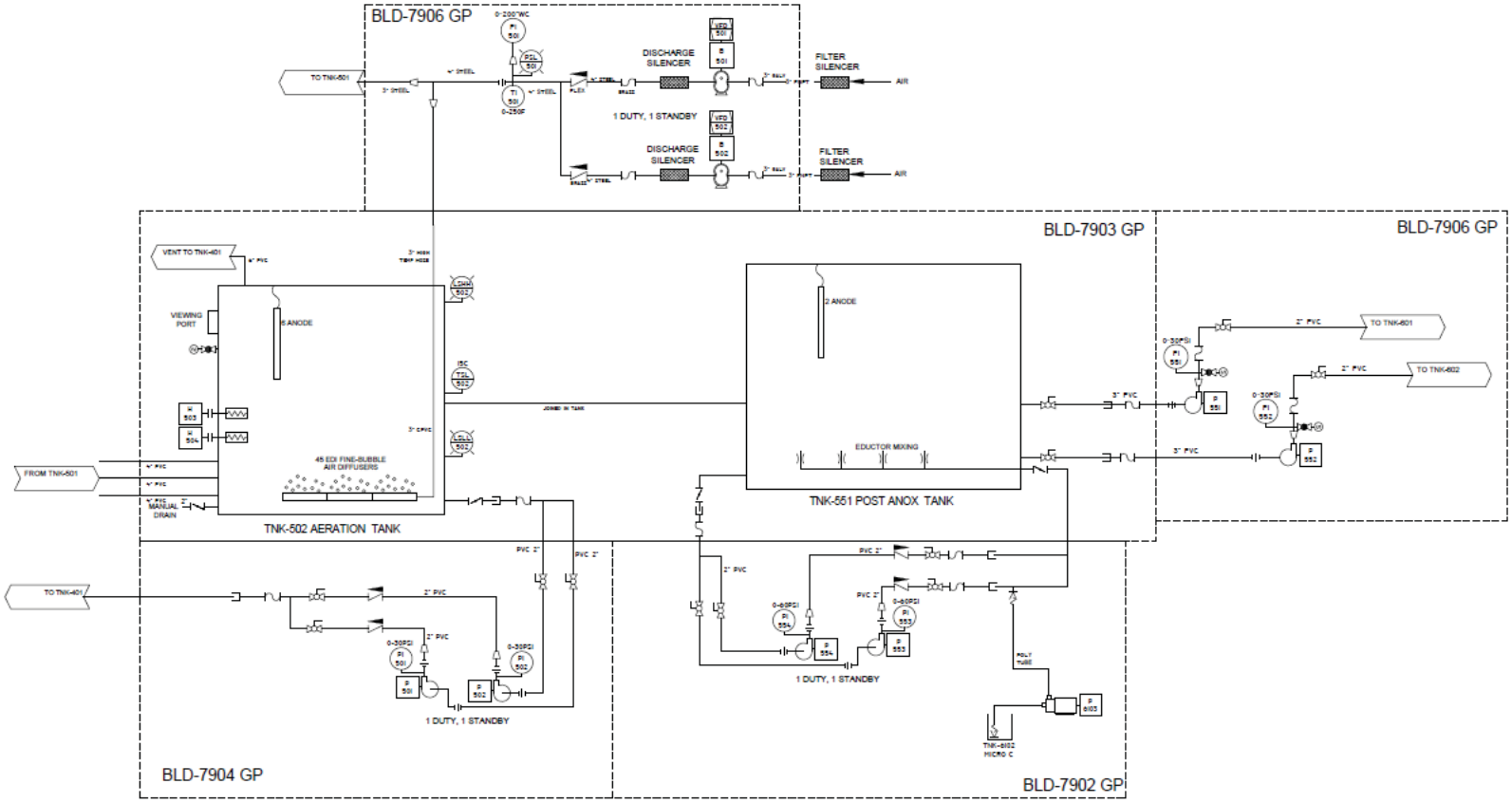


Figure 7 – Post Biological treatment

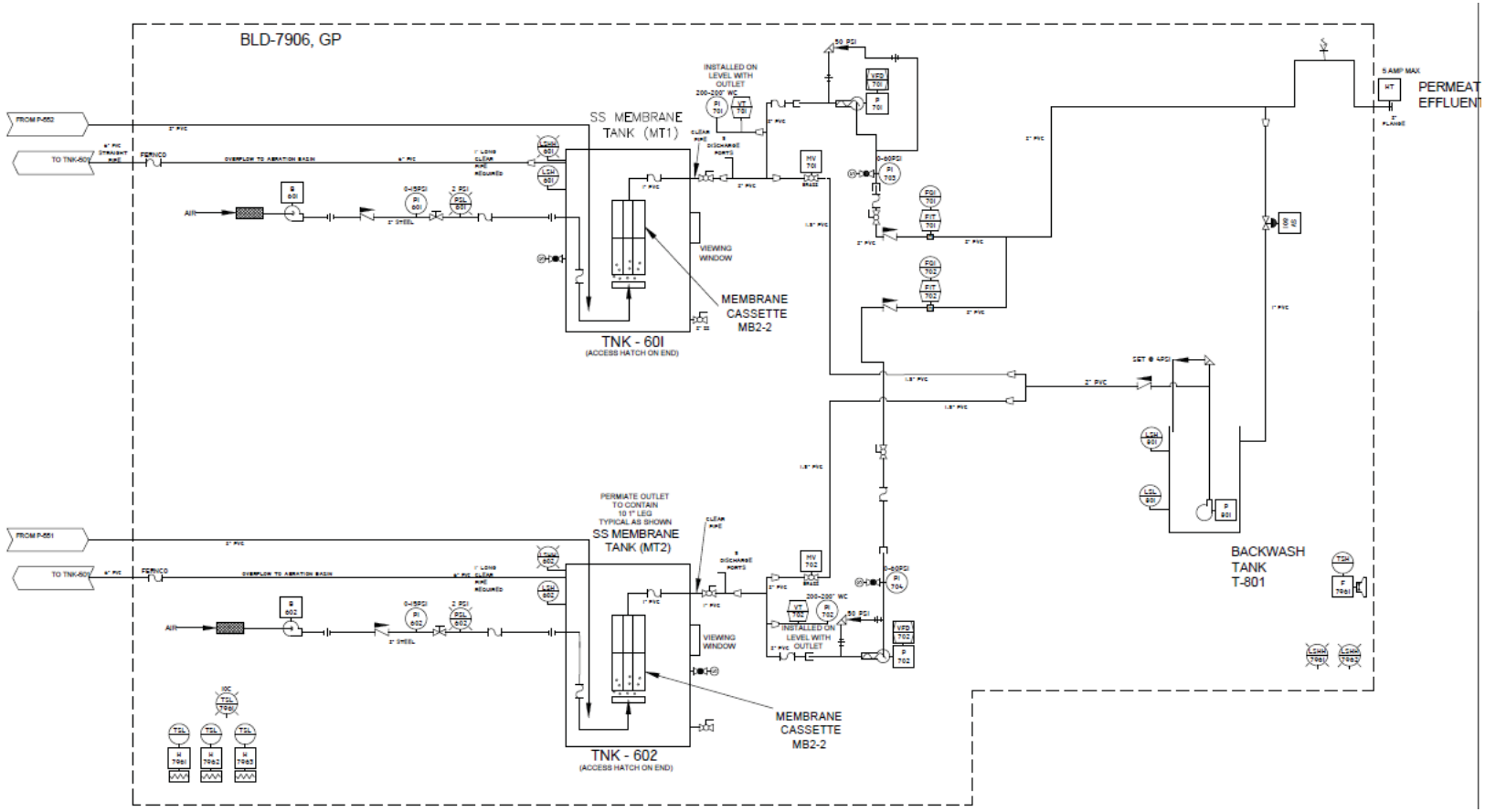


Figure 8 – Membrane filtration step

2.1.2 Process description

Oil and Grease (O/G) removal
Raw sewage from the kitchens entering the system can contain high levels of fats, oils and grease that can damage equipment and membranes downstream. To remove the oil and grease from the system a double trap grease interceptor is installed prior to the kitchen sewage entering the fine screen. Floating grease is removed via a vacuum truck hookup that will be used when the sludge tank is emptied. A pipe and vacuum truck hookup are also used to remove any debris that sunk to the bottom of the tanks. Vacuumed debris, oil and grease are to be disposed at the Meadowbank's tailings storage facility (TSF).

Fine Screening
Raw sewage entering the MBR system contains particulates and solids that could damage the equipment and membranes downstream. 0.5mm wedge wire fine screening protects the downstream equipment by removing large solids and fibrous material. Two screens are used for redundancy so that no unscreened influent enters the EQ tank. Redundant pumps are used to move the screened influent to the equalization tank.

Flow-Equalization
Throughout the day the flow and strength of the sewage will vary. To accommodate this, an equalization tank will buffer the flow and homogenize the loading. The equalization tank is aerated to maintain an aerobic environment to reduce odors and to maintain suspension of solids and pumps transfer sewage to biological treatment. This tank is provided with tank heaters. All wetted materials in this tank are either stainless steel or polypropylene to eliminate the possibility of corrosion. In addition, the tank has two liners, one primary, one secondary, with interstitial monitoring, providing the protection of a double wall tank.

Biological Treatment
In the anoxic zone, the pre-treated sewage is combined with return activated sludge from the aerobic tank and is kept mixed while maintaining a low level of dissolved oxygen (DO). Denitrification occurs as specific microorganisms convert nitrates to nitrogen gas – reducing the total nitrogen (TN) in the mixed liquor. Additionally, the anoxic stage optimizes the biological treatment process, which recovers alkalinity, aids in stabilizing pH, and improves energy efficiency by reducing overall aeration demand. In the aerobic zone, fine bubble diffusers create an aerobic environment where the organics contributing to biological oxygen demand (BOD) and ammonia are oxidized by the biology. Dissolved oxygen is continuously measured and aeration blowers controlled to maintain it in the range of 2 to 3 mg/L for process optimization and energy savings. In the post-anoxic zone, return activated sludge from the aerobic tank is kept mixed while maintaining a low level of dissolved oxygen (DO). The denitrification process continues in the post anoxic zone to reduce the TN even further.

Phosphorous Reduction
Chemical precipitation is used to remove inorganic phosphate. An aluminum sulphate or "Alum" solution is dosed into the mixed liquor causing dissolved phosphate to precipitate and coagulate. The suspended phosphate cannot pass through the Newterra MicroClearUltra Filtration membrane (UF), and the phosphate is eventually removed from the system as a solid with the waste activated sludge (WAS).

Membrane Filtration
After being treated biologically, the treated effluent is separated from the mixed liquor and solids by the Newterra MicroClear membrane modules and the permeate extraction system. The membrane

modules are continually air scoured to induce flow of mixed liquor over the flat sheet membrane surface and prevent fouling and buildup of solids on the membrane surface without the use of chemicals. The mixed liquor is then transferred to the inlet of the biological treatment to maintain even distribution of solids throughout the system and to introduce activated biology to the raw sewage. Newterra MicroClear membranes are produced with true ultrafiltration membrane material with 0.04 µm pore size, which blocks all bacteria and most viruses. Secondary disinfection is not required to exceed effluent requirements. Figure 9 presents a schematic view of the UF process.

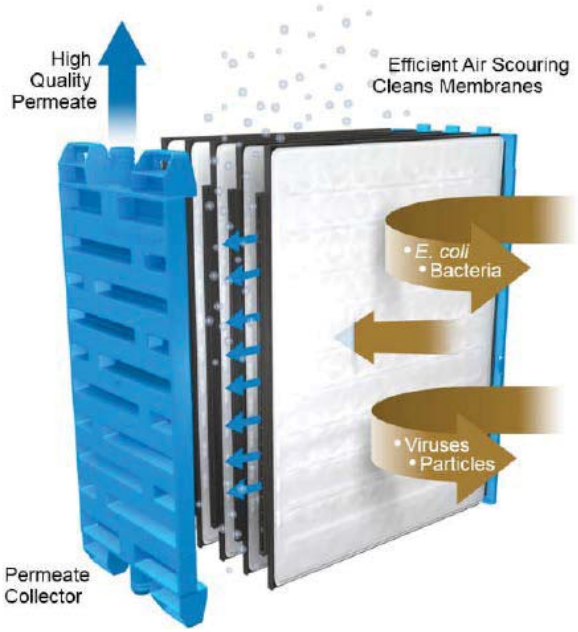


Figure 9 – Membrane filtration concept

2.1.3 Sludge Management Strategy

As solid-laden sewage enters the system and solid-free effluent is discharged, the suspended solids concentration in the mixed liquor suspended solids (MLSS) will increase. To maintain the proper level of MLSS, solids must be removed from the system as Waste Activated Sludge (WAS) which is mixed liquor discharged from the aerobic tank at approximately 0.8% dry. WAS is discharged to a tank for holding and decanting. The holding tank is aerated to maintain an aerobic environment to reduce odors. In the decanting process the WAS is allowed to settle and supernatant is pumped off, and returned to the MBR, thickening the sludge in the holding tank. By thickening the sludge to approximately 2% dry solids by weight, the total volume that must be disposed of is decreased, extending holding time and reducing operational costs. Level control in the tank indicates when the tank should be decanted or a vacuum truck should be scheduled to dispose of the WAS.

3 OPERATION AND MAINTENANCE

3.1 PUMPING

The system includes several pumps for the operation of the STP. All pumps are regularly inspected by the Operator who will ensure the pumps continue to operate efficiently and will address any deficiencies. If the pumps require maintenance, the Operator will report the situation and take appropriate action. Some of the pumps are installed with a standby unit that allows the Operator to switch from one pump to the other if necessary. In some specific situations, it may be necessary to temporarily shutdown the STP for servicing of the equipment.

A preventative maintenance program, as recommended by the pump supplier, will be followed to ensure the pumps are always kept in good working order.

3.2 SEWAGE COLLECTION

The sewage from the kitchen must pass through a grease trap (or similar facility for grease/fat removal). The large amount of oil and fat can harm treatment facility (e.g., clogging pumps and piping and cause foaming in the aeration tank). To avoid premature membrane fouling, maximum O/G concentrations should not exceed 30 mg/L.

The raw wastewater should not contain any of the following substances:

- Hydrocarbons – lubricants, gasoline, diesel, etc.;
- Paints, solvents, silica, silicon and polymers;
- Antibacterial solutions and products with quaternary ammonia;
- Large quantities of chemicals such as water softener, disinfectants, strong acids & alkalis, pesticides or photographic chemicals;
- Silicone based defoamers;
- Non-biodegradable solid waste (plastic, rubber products, disposable diapers, etc.);
- High amount of metals, such as iron, magnesium, calcium, barium and strontium.

3.3 SLUDGE DISPOSAL

Sludge will be disposed at Amaruq or Meadowbank site in the Waste Rock Storage Facility or the Tailings Storage Facility (Meadowbank only) or in a landfarm as a nutrient amendment as per the Water License Part F Item 3.

3.4 CONTROL

MBR (Membrane Bioreactor) treatment technology is an effective combination of an activated sludge biological treatment process with MBR membrane filtration technology. The STP can be operated in either manual or automatic mode. The system is designed to always run in auto mode. The manual option is provided mainly for maintenance purposes.

STP's control and automation system is based on several instruments measuring key parameter of the process, combined with a PLC. The STP don't require continuous operator intervention except for daily inspection and maintenance. The user interface can be accessed on-site from the control panel mounted touch-screen HMIs or remotely from a computer. Alarm messages can be set up to alert operators to issues.

The STP PLC is programmed to:

- Receive analogue and digital input signals from the switches and transmitters being controlled;
- Process the information using the structure and rules entered into the program;
- Generate outputs that control the equipment - turn equipment OFF or ON.
- Generate alarms if critical conditions are present
- Provide a HMI (Human Machine Interface) touch-screen for use of operator process monitoring and control.

More information are provided in the Operation and Maintenance Manual in Appendix.

3.5 REAGENTS

Some chemicals are required for treatment operation and also for Membrane cleaning. Chemicals will be used according to the MSDS recommendation. MSDS are provided in Appendix. Table 3 presents the estimated chemical consumption per year.

Table 3: Chemical consumption

Consumable		Usage Rate			
Purpose	Name	Value	Unit	Value	Unit
Supplemental Alkalinity	Dry Soda Ash	6.28	kg/d	2292	Kg/year
Phosphorus Removal	Liquid Alum, 48%	14.6	L/d	5346	L/year
Nitrate Removal	MicroC 2000	16.5	L/d	6025	L/year
Membrane Cleaning	Sodium Hyprochlorite, 12%	-	L/d	150	L/year

Sodium Carbonate (Soda Ash) is used for pH adjustment in case there is a deficiency in alkalinity in influent sewage and pH drops. It is hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation (lung irritant).

Sodium hypochlorite (NaOCl) and **Citric Acid** ($C_6H_8O_7$) are used for cleaning the membranes.

- Sodium hypochlorite is a common disinfectant, which can be an irritant or corrosive, depending on its concentration. It cannot be mixed with organics, ammonia compounds or acids. Contact with acids produces highly toxic chlorine gas. It has to be mixed only with pure water.
- Citric Acid is hazardous in case of skin contact (irritant, sensitizers), or ingestion, eye contact (irritant) and inhalation (lung irritants).

Aluminum Sulfate ($Al_2(SO_4)_3$) is used for Phosphorus Removal. Mild to moderate irritation can occur from unprotected contact. Aluminum is very poorly absorbed through the skin and toxic effects would not be expected following short-term skin contact. Inhalation of mists can be irritating to the respiratory tract and lungs.

MicroC 2000 is used for nitrate removal. Exposure to eyes may cause slight irritation. Exposure to Skin may cause slight irritation. Inhalation of high mist concentrations may cause irritation of respiratory tract.

3.6 BIOLOGICAL OPERATION

The following table presents target parameters required for a good operation of the STP.

Table 4: Biological system targets operational parameters

Parameter	Recommended	Range	Notes
MLSS (mg/L): Mixed Liquor Suspended Solids	10,000	8,000 – 15,000	Never operate the membranes if MLSS < 3,000 mg/l. Sludge wasting should be undertaken as required to maintain target MLSS
Temperature (°C)	15 - 35	10 – 35	Avoid sudden changes in temperature. Minimum operating temperature is 15 °C
pH	6.8 - 8.5	6.0 – 9.0	Membrane module can handle a change in pH. However it is recommended to keep pH between 6.8 - 8.5
Aeration Tank, DO (mg/L)	≥ 2.0	1.0 – 8.0	This can be maintained by adjusting the volume of air supplied to the aeration tank
Viscosity (mPa-s)	Not applicable	0 – 300	
Aeration Tank to Anoxic Tank Recirculation	400%	200 – 500%	
Membrane Tank to Aeration Tank Recirculation	400%	200 – 600%	
F:M (kg BOD/kg MLSS/d)	0.1	0.03 – 0.2	F:M = [Flow (m3/d) x BOD conc (mg/l)] / [Process volume (m3) x MLSS conc (mg/l)]
F:M (kg COD/kg MLSS/d)	0.15	0.05 – 0.3	F:M = [Flow (m3/d) x COD conc (mg/l)] / [Process volume (m3) x MLSS conc (mg/l)]
SRT : sludge retention time (days)	> 15	12 – 50	

3.7 MEMBRANE OPERATION

This section outlines the operating conditions that are required for proper sewage treatment, and longevity of the membranes.

Generally, the following points can be used to operate the MBR system properly:

- The MBR system is designed to treat wastewater with specified influent characteristics.
- Never operate the MBR tank below the minimum membrane submerged level. It is necessary to maintain a minimum of 250 mm liquid level above the membrane modules to ensure they are wet at all times and to allow for proper filtration.
- Always supply the required amount of air for scouring to the membrane module.
- Always filter sewage at or below design flow rate.
- Periodically, relax the membranes by ending filtration while allowing the membrane aeration scour to operate continuously and initiate backwash operation during membrane relaxation (default relaxation mode preset in PLC - permeation continues for 9 min and stops for 1 min).
- Always operate the MBR in accordance with the parameters listed in the supplier O&M Manual.
- Clean the membranes in-place with a dilute chemical in accordance with the supplier O&M Manual.

3.8 MEMBRANE CLEANING

In order to enhance life duration of the membrane, several cleaning are required as presented below.

In-situ Chemically Enhanced Backflush (CEB)
It is recommended that in-situ CEB be carried out before the trans membrane pressure (TMP) exceeds 0.25 bar (or permeability drops rapidly to 50 LMH/bar) This is typically done once every couple weeks/months depending on biomass characteristics and system operating condition. On certain occasions, membrane module/cassette may need to be physically inspected for membrane integrity if membrane permeability performance is not recovered after the cleaning (i.e., suspect of membrane deterioration). Hypochlorite is used for organic fooling and citric acid for inorganic acid.

Membrane Recovery Cleaning
The membrane recovery cleaning is to be done once a year at a minimum. On certain occasions, membrane cassette may need to be inspected for membrane integrity (suspect of membrane deterioration, membrane permeability performance does not recover after the cleaning, etc.).

- **Cleaning with High pH Solution:** This step is to be done if membrane fouling is a result of high fat, oil and grease. Sodium hydroxide can be used for this cleaning (400 mg/L, pH 12, 1 to 2 hours).
- **Cleaning with Sodium Hypochlorite** (500 mg/L free Cl_2, 12 hours)
- **Cleaning with Citric Acid** only in case of inorganic fouling (2 to 20 g/L during 2 h).
- **Checking Permeability.**

3.9 SERVICE WATER

For better cleaning performance, it is recommended to use:

- Potable water (permeate is acceptable if potable water is unavailable for the CEB cleaning),
- Water temperature is above 20^0C.

3.10 OPERATIONNAL PERFORMANCE TARGETS

The plant is designed to meet the following criteria presented in Table 5. Note that the treated water from STP is not directly discharged to the environment. The target concentrations presented in the following table for the treated water from STP, are set to limit effect on the receiving Environment after mixing with surface water into the Whale Tail attenuation pond and treatment in the AsWTP. There are no Water Licence criteria for the STP treated water. Reaching these values assure Agnico Eagle to operate the STP at a highest level of efficiency.

Table 5: STP treated water quality operational target

Parameters	Unit	Effluent
pH	s.u.	6.5 – 9.5
Oil, Grease	mg/L	<5
Biological Oxygen Demand (BOD)	mg/L	<25
Total Suspended Solids (TSS)	mg/L	<25
Total Kjeldahl Nitrogen (TKN)	mgN/L	-
Unionized Ammonia Nitrogen (NH3-N)	mgN/L	<1.25
Nitrate Nitrogen (NO3-N)	mgN/L	<5
Total Phosphorus (TP)	mgP/L	<0.5
Fecal Coliform	CFU/100 ml	<200
Total Residual Chlorine	mg/L	<0.02

3.11 GENERAL OPERATION & MAINTENANCE, SAMPLING PROCEDURES AND FREQUENCY

To ensure efficiency of STP, samples of water must be collected periodically. Table 6 presents sampling schedule to assess that STP performance comply with operational target values.

More samples can be taken at different locations in the plant to assess any default on STP operation.

Visual inspection is also important to verify STP operation. The following sign must be reported as soon as possible:

- **Plant Visual Checks Noise**
  During normal operation, there is a uniform humming sound at the plant. In case of an unusual noise, it could be an indication that the blower needs maintenance or repairs
- **Smell**
  The MBR is an aerobic system. During normal operation, the system has an earthy smell similar to that of a well-maintained compost pile. If other odors are noticed, the aeration process may not be operating or the system has been overloaded. Check the DO manually and the blower to verify the proper operation.
- **Effluent Aspect**
  Normally, the effluent is reasonably clear, colorless, and odorless. If the effluent becomes turbid, there is a pin hole in the membrane or a leakage in the piping. Take the unit out of operation and investigate. Check uniformity of membrane air distribution periodically to ensure air scouring is effective across all membrane plates.

Table 6: Monitoring program for operational efficiency assessment.

Parameters	Sewage	Aeration tank	Membrane tank	Effluent
Flow	daily			daily
Oil and Grease	As required			As required
Alkalinity	As required			
Biological Oxygen Demand	Weekly			Weekly
Total Suspended Solids	Weekly			Weekly
Total Kjeldahl Nitrogen / Total Nitrogen	Monthly			As required
Ammonia Nitrogen				As required
Nitrate				As required
Total Phosphorus	Weekly			Weekly
Mixed Liquor Suspended Solids (MLSS)			Weekly	
Mixed Liquor Volatile Suspended Solids (MLVSS)			As required	
Temperature		daily		
pH	As required	daily		Weekly
Dissolved Oxygen		daily		
Filterability			3 times weekly	
Turbidity				As required
Fecal Coliform / E-Coli				Weekly

Table 7 summarizes also Routine Operation and Maintenance Checkups. More details are provided in the supplier O&M Manual.

According to the water licence, Group 1 Parameters shall be analyzed four times per calendar year during operation and closure. The parameters are presented herein:

- pH, turbidity, hardness, alkalinity, chloride, fluoride, sulphate, total dissolved solids (TDS), total suspended solids (TSS), ammonia nitrogen, nitrite, nitrate, orthophosphate, total phosphorus, Total Metals (aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium and zinc).

Table 7: Routine Operation and Maintenance Checkups

Location	Item	Action	Comments
Grease trap	Periodic cleaning	As needed	Waste sent to Meadowbank TSF
Process	Visual check	Daily	Performance evaluation
	Flow rate in and out	Daily	
	Sampling	Daily / as requested	For water quality and performance evaluation
	Vacuum pressure on membrane	Daily	Evaluate Membrane fouling
Mechanical & process	Inspect Membrane	Weekly	
	Sensor cleaning and calibration	Weekly / yearly	
	Valves, fittings	Weekly	Prevent spill
	Membrane Cleaning	Quarterly/Yearly	Permeability recovery
	Aeration diffuser	Yearly	Process efficiency
	Pumps	Quarterly	Prevent spill
	Blower	Monthly	Process efficiency
	Screening device	Daily/ Weekly/ Quarterly	Prevent clogging, remove solid waste and dispose it
	Dosing pumps	Quarterly	Prevent spill
	Fan and heaters	Yearly	Health and safety of operator
Electrical	Leads	Quarterly	Health and safety of operator and Process efficiency
	Panel fan filter, inspection breaker, fuses, motor bold, clean dust	Monthly	Health and safety of operator Process efficiency
	PLC functionality	Weekly	Process efficiency

3.12 TROUBLESHOOTING AND MAINTENANCE PROCEDURES

MBR operation relies critically on the ability of the membrane unit to pass all flow incoming to the plant. If membrane permeability is impaired, the MBR plant cannot process all flow with potentially negative results even though effluent quality remains consistently high. Membrane fouling (and associated reduction of flux or increase of TMP) remains as an operational challenge.

Membrane fouling in MBR is a result of the interaction between the incoming water quality, mixed liquor filterability, system operation condition, and membrane material. There are four categories of membrane fouling.

Microbial/Biological Fouling
Microbial fouling is a result of the formation of biofilms on membrane surfaces. This structure protects bacterial cells from hydraulic shearing and from chemical attacks of biocides such as chlorine. Chemical cleaning would be required to restore permeability.

Particulate/Colloid Fouling
This type of fouling may be associated with high concentrations of colloidal solids present in mixed liquor. In most cases, particles and colloids do not really foul the membrane because the flux decline caused by their accumulation on the membrane surface is largely reversible by hydraulic cleaning measures such as backwash and air scouring. However, the accumulation of solids between the membranes can create increased membrane resistance to permeation and permanent physical membrane damage.

Inorganic Fouling
Inorganic fouling or precipitative fouling is caused by the accumulation of inorganic precipitates such as metal hydroxides, and “scales” on membrane surface or within pore structure. Chemical cleaning will be required in that case.

Organic Fouling
Organic fouling is the attachment of materials such as oil or grease to the membrane surface. Oil and grease trap will prevent this type of fouling and chemical cleaning is also achievable to restore permeability.

Excessive foaming (white foam accumulating over the liquid surface) in aeration and/or membrane tanks could also reduce performance of the STP. Remediation should be taken to eliminate foaming agent or restore design parameters of the plant.

Permeate bad quality can also indicate default in MBR membrane and operation.

Finally, biological system can also indicate default in operation.

- Black color of biomass indicates a lack of aeration,
- Increase of bacteria quantity in the reactor indicates a low sludge wasting,
- Unpleasant odor can indicate overload of the system, blower failure, etc.
- Water quality not achieved: Mixed liquor characteristics are not within proper operating standards.

Further details are available in the manufacturer’ operating manuals in Appendix.

3.13 RECORD KEEPING

Records of the operational, maintenance and sampling procedures will be kept daily in order to assist in the evaluation of the effectiveness of the STP.

The following will be recorded on a daily basis:

- Volume of effluent discharged to the whale tail attenuation pond;
- Sewage volume collected;
- Details of any maintenance undertaken at site;
- Volume of sewage sludge removed from the STP;
- Locations and methods of sewage sludge disposal;
- Water quality parameter results required to follow the STP performance.

The record sheets will be kept in the STP office.

3.14 SAFETY PROCEDURES FOR OPERATORS

Operators working in the STP facility must be trained prior to work so that they are aware of the health and safety risks as well as the operational procedures associated with the STP. The following are important safety considerations:

- The wastewater contains a mixture of viable bacteria and other biological organisms. A wastewater treatment plant poses a number of bacterial hazards and consequently potential health risk. Immunization protects operator against infection. The use of proper hygiene measures, protective equipment, good housekeeping and common sense prevent contact with pathogens. Ensure that hands are washed with an antibacterial soap and warm water and dried by disposable towels on a regular basis, especially prior eating. Do not expose cuts or open sores to wastewater. Any concern about possible infection should be brought to the attention of medical physician immediately.
- Follow local laws and regulations with respect to entering a confined space.
- Working within the plant, especially with chemicals, requires adequate personal protective equipment (PPE) for Operators. This includes wearing steel toed boots, hard hat, rubber aprons, safety glasses with side shields and gloves.
- Operators are required to conduct good housekeeping of the working area to minimize the risk of incidents.
- Lock-out/tag-out procedures must be applied when servicing equipment.
- The MSDS for reagents used in the STP will be readily available for the operator at all times.
- Eyewash stations are located within proximity of reagent systems in the STP.

3.15 CONTROLLING ACCESS TO THE STP

Access to the STP will be restricted to authorized personnel only. Signs will be posted at the STP entrance.

4 EMERGENCY RESPONSE

4.1 FIRE

In case of fire at the STP, the on-site emergency response team (ERT) will be notified as per Agnico Eagle's protocol. Instructions from the on-site emergency response team will be followed by all personnel at the STP. Further details of fire response are provided in the "*Risk Management & Emergency Response Plan*". The STP will include the necessary fire safety protection measures in accordance with the Nunavut and North West Territories Mine Act.

4.2 SPILL

In the event of a spill at the STP, the Environment Department will be notified immediately and provide support, as required. In the event of a large spill, the on-site ERT will be notified as per Agnico Eagle's protocol. Instructions from the ERT will be followed by all personnel at the STP. All spill will be reported and treated according to the "*Spill Contingency Plan".*

4.3 PLANT MALFUNCTION

If there is a major problem or failure in the STP it would be most likely due to changes in the influent (raw sewage) (i.e. high strength sewage (BOD high) killing bacteria in the STP) or membrane failure. In this case, there would be visible effluent problems (part of daily operational checks), poor water quality, and increased odours that the operator would note. If this occurs, a sample will be taken to try to determine the source of the problem.

The following other contingent measures can be applied by Agnico Eagle in the event of a malfunction at the STP:

- Cut back on allowable camp water until the malfunction is corrected and use the equalization tank to retard the peak flow;
- Shut down the malfunctioning unit until the malfunction is repaired and use only one of the two parallel units until repairs are completed (for equipment in parallel);
- Bypassing untreated STP influent around the malfunctioning unit. Sucker truck can collect sewage from the equalization tank and carry it to Meadowbank facilities. Sewage would then be stored into the Tailing storage facility or would be treated into the sewage treatment plant (STP) at Meadowbank depending on the available capacity remaining.
- Shut down temporarily all water use in the camp until the repairs are completed;

Appendix A: Reagent MSDS Sheets

SAFETY DATA SHEET

NC00525
MICROC 2000

Preparation Date: 09/Mar/2018 Version: 1

1. IDENTIFICATION

Product identifier

Product Name MICROC 2000

Other means of identification

Product Code(s) NC00525

Synonyms none

Recommended use of the chemical and restrictions on use

Recommended Use Reducing agent for biological purposes

Restricted Uses No information available

Initial Supplier Identifier
Univar Canada Ltd.
9800 Van Horne Way
Richmond, BC V6X 1W5
Telephone: 1-866-686-4827

Emergency telephone number

24 Hour Emergency Phone Number (CANUTEC): 1-888-226-8832 (1-888-CAN-UTEC)

2. HAZARD IDENTIFICATION

Hazardous Classification of the substance or mixture

none

Label elements

Hazard pictograms None

Hazard statements

SAFETY DATA SHEET

SDS00221
Sodium Hypochlorite 12%

Preparation Date: 09/Feb/2018 Version: 4

1. IDENTIFICATION

Product identifier

Product Name Sodium Hypochlorite 12%

Other means of identification

Product Code(s) SDS00221

Synonyms Sodium oxychloride; Soda bleach liquor; Javel water; Clorox; Javex.

Recommended use of the chemical and restrictions on use

Recommended Use Chemical intermediate Bleaching agent Laboratory reagent. Pulp and paper. Water treatment. Disinfectant

Restricted Uses No information available

Initial Supplier Identifier
Univar Canada Ltd.
9800 Van Horne Way
Richmond, BC V6X 1W5
Telephone: 1-866-686-4827

Emergency telephone number

24 Hour Emergency Phone Number (CANUTEC): 1-888-226-8832 (1-888-CAN-UTEC)

2. HAZARD IDENTIFICATION

Hazardous Classification of the substance or mixture

Corrosive to metals	Category 1
Skin corrosion/irritation	Category 1
Sub-category B	
Serious eye damage/eye irritation	Category 1

Label elements

Hazard pictograms



Signal Word: Danger

Hazard statements
May be corrosive to metals
Causes severe skin burns and eye damage

Precautionary Statements

Prevention
Do not breathe dust/fume/gas/mist/vapors/spray
Wash face, hands and any exposed skin thoroughly after handling
Wear protective gloves/protective clothing/eye protection/face protection

Immediately call a POISON CENTER or doctor
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower
Wash contaminated clothing before reuse
IF INHALED: Remove person to fresh air and keep comfortable for breathing
IF SWALLOWED: Rinse mouth. DO NOT induce vomiting

Storage
Store locked up
Store in a well-ventilated place. Keep container tightly closed

Disposal
Dispose of contents/container to an approved waste disposal plant

Very toxic to aquatic life with long lasting effects

3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance

Not applicable.

Mixture

Chemical Name	CAS No	Weight-%	Synonyms
Water	7732-18-5	80 - 90%	Water
Sodium Hypochlorite, Solution	7681-52-9	10 - 20%	Sodium Hypochlorite, Solution

4. FIRST AID

Description of first aid measures

General advice
Immediate medical attention is required. Show this safety data sheet to the doctor in attendance.

Inhalation
Remove to fresh air. If breathing has stopped, give artificial respiration. Get medical attention immediately. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. If breathing is difficult, (trained personnel should) give oxygen. Delayed pulmonary edema may occur.

Eye contact
Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Keep eye wide open while rinsing. Do not rub affected area. Remove contact lenses, if present and easy to do. Continue rinsing. Get immediate medical advice/attention.

Skin contact
Wash off immediately with soap and plenty of water while removing all contaminated clothes and shoes. Get immediate medical advice/attention.

Ingestion
Do NOT induce vomiting. Clean mouth with water and drink afterwards plenty of water. Never give anything by mouth to an unconscious person. Get immediate medical advice/attention.

Self-protection of the first aider
Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and prevent spread of contamination. Avoid contact with skin, eyes or clothing. Avoid direct contact with skin. Use barrier to give mouth-to-mouth resuscitation. Wear personal protective clothing (see section 8).

Most important symptoms and effects, both acute and delayed:
Causes irritation of the mouth, nose and throat. Corrosive Causes burns to the mouth, throat and stomach. May cause severe skin irritation. Corrosive to the respiratory passage. Corrosive to eye tissue and may cause severe damage and blindness. Causes vomiting, nausea, and diarrhea. Repeated and/or prolonged exposures may cause productive cough, running nose, bronchopneumonia, pulmonary edema (fluid build-up in lungs) and reduction of pulmonary function. Coma, shock and death may occur. May cause whitening or bleaching of the skin. If mixed with acids or warmed to temperatures greater than 40 °Celsius, Sodium hypochlorite solutions release chlorine gas. This gas can cause severe irritation of the nose and throat. Exposures to high levels of chlorine gas may result in severe lung damage. Prolonged contact may lead to burns and blisters and may aggravate dermatitis.

Indication of any immediate medical attention and special treatment needed:

Note to physicians
Due to the severely irritating or corrosive nature of the material, swallowing may lead to ulceration and inflammation of the upper alimentary tract with hemorrhage and fluid loss. Also, perforation of the esophagus or stomach may occur, leading to mediastinitis or peritonitis and the resultant complications.

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media
Use extinguishing media appropriate for surrounding fire.

Specific hazards arising from the substance or mixture
Closed containers may explode in fire. Keep containers cool to prevent rupture and release of material. Spilled material may cause floors and contact surfaces to become slippery.

Hazardous combustion products
Chlorine. Oxides of sodium. Oxygen. When heated to decomposition, it emits acrid smoke and irritating fumes.

Special protective equipment for fire-fighters
Firefighters should wear self-contained breathing apparatus and full firefighting turnout gear. Use personal protection equipment.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Attention! Corrosive material. Avoid contact with skin, eyes or clothing. Ensure adequate ventilation. Use personal protective equipment as required. Evacuate personnel to safe areas. Keep people away from and upwind of spill/leak.

Environmental precautions

Prevent further leakage or spillage if safe to do so. Should not be released into the environment. Do not allow to enter into soil/subsoil. Prevent product from entering drains.

Methods and materials for containment and cleaning up

Prevent further leakage or spillage if safe to do so.

7. HANDLING AND STORAGE

Precautions for safe handling

For industrial use only. Handle and open containers with care. Avoid contact with eyes, skin and clothing. Do not ingest. Avoid inhalation of chemical. Empty containers may contain hazardous product residues. Keep the containers closed when not in use. Protect against physical damage. Use appropriate personnel protective equipment. When diluting, add this product to water in small amounts to avoid spattering. Never add water to this material.

Conditions for safe storage, including any incompatibilities

Store in a cool, dry, well ventilated area, away from heat and ignition sources. Keep away from direct sunlight. Do not freeze. Store away from organic chemicals, strong bases, metal powders, carbides, sulfides, and any readily oxidizable material. Storage area should be equipped with corrosion-resistant floors, sumps and should have controlled drainage to a recovery tank. Store below 29 °C. Store in a sealed polyethylene lined container.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Limits This product, as supplied, does not contain any hazardous materials with occupational exposure limits established by the region specific regulatory bodies.

Chemical Name	Alberta OEL	British Columbia OEL	Ontario	Quebec OEL	Exposure Limit - ACGIH	Immediately Dangerous to Life or Health - IDLH
Water 7732-18-5	Not available	Not available	Not available	Not available	Not available	Not available
Sodium	Not available	Not available	Not available	Not available	Not available	Not available

Hypochlorite, Solution 7681-52-9						

Consult local authorities for recommended exposure limits

Appropriate engineering controls

Engineering controls
Local exhaust ventilation as necessary to maintain exposures to within applicable limits. Make up air should always be supplied to balance air exhausted (either generally or locally). Ventilation required when spraying or applying in a confined area. Ventilation should be explosion proof. Eliminate ignition sources.

Individual protection measures, such as personal protective equipment

Eye/face protection
Chemical safety goggles and/or full face shield to protect eyes and face, if product is handled such that it could be splashed into eyes.

Hand protection
Nitrile gloves. Neoprene gloves. Impervious gloves. Rubber gloves.

Skin and body protection
Neoprene coated apron or chemical resistant clothing. Impervious boots.

Respiratory protection
NIOSH approved supplied air respirator when airborne concentrations exceed exposure limits. Wear a NIOAH approved full facepiece respirator for acid gases or a self-contained breathing apparatus for air concentration levels up to 5 ppm.

General hygiene considerations
Avoid contact with skin, eyes or clothing. Wear suitable gloves and eye/face protection. Do not eat, drink or smoke when using this product. Remove and wash contaminated clothing and gloves, including the inside, before re-use. Contaminated work clothing should not be allowed out of the workplace. Regular cleaning of equipment, work area and clothing is recommended. Wash hands before breaks and immediately after handling the product.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance

Physical state	Liquid
Color	Clear Green to yellow.
Odor	Chlorine
Odor threshold	No information available

PROPERTIES	**Values**	**Remarks • Method**
pH	11.5 - 13	
Melting point / freezing point	-25 °C / -13 °F	
Initial boiling point/boiling range	No data available	None known
Flash point	No data available	None known
Evaporation rate	No data available	None known
Flammability (solid, gas)	No data available	None known
Flammability Limit in Air		
Upper flammability limit:	No data available	
Lower flammability limit:	No data available	
Vapor pressure	17.5 mmHg	
Relative vapor density	No data available	None known

Specific Gravity	1.175	
Water solubility	Soluble in water	
Solubility in other solvents	No data available	
Partition coefficient	No data available	
Autoignition temperature	No data available	None known
Decomposition temperature	No data available	None known
Kinematic viscosity	No data available	None known
Dynamic viscosity	No data available	None known
Explosive properties	No information available.	
Oxidizing properties	No information available.	
Molecular weight	No information available	
VOC Percentage Volatility	No information available	
Liquid Density	No information available	
Bulk density	No information available	

10. STABILITY AND REACTIVITY

Reactivity/Chemical Stability
Unstable above 40°C / 104 °F.

Possibility of hazardous reactions
Hypochlorites may react with primary amines to form nitrogen trichloride which explodes spontaneously in air. Hypochlorite bleach reacts with urea to form nitrogen trichloride which explodes spontaneously in air. Some metals accelerate the decomposition of Sodium Hypochlorite. Nickel. Copper. Tin. Iron and its alloys. Manganese.

Hazardous polymerization
Will not occur.

Conditions to avoid
High temperatures. Exposure to light.

Incompatible materials
Strong oxidizers. Acids. Reducing agents. Ammonia. Metals.

Hazardous decomposition products
Chlorine. Oxides of sodium. Oxygen. When heated to decomposition, it emits acrid smoke and irritating fumes.

11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure

Inhalation
Causes irritation of the mouth, nose and throat. Corrosive to the respiratory passage. Repeated and/or prolonged exposures may cause productive cough, running nose, bronchopneumonia, pulmonary edema (fluid build-up in lungs) and reduction of pulmonary function. If mixed with acids or warmed to temperatures greater than 40 °Celsius, Sodium hypochlorite solutions release chlorine gas. This gas can cause severe irritation of the nose and throat. Exposures to high levels of chlorine gas may result in severe lung damage.

Eye contact
Corrosive to eye tissue and may cause severe damage and blindness.

Skin contact
Corrosive. May cause severe skin irritation. May cause whitening or bleaching of the skin. Prolonged contact may lead to burns and blisters and may aggravate dermatitis.

Ingestion
Causes burns to the mouth, throat and stomach. Corrosive. Causes vomiting, nausea, and diarrhea. Coma, shock and death may occur.

Information on toxicological effects

Symptoms
Corrosive effects on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Aspiration may cause lung damage.

Numerical measures of toxicity

Acute toxicity

The following values are calculated based on chapter 3.1 of the GHS document .

ATEmix (oral) 68,333.00 mg/kg
ATEmix (dermal) 83,417.00 mg/kg

Unknown acute toxicity No information available

Chemical Name	Oral LD50	Dermal LD50	Inhalation LC50
Water 7732-18-5	> 90 mL/kg (Rat)	Not available	Not available
Sodium Hypochlorite, Solution 7681-52-9	= 8.91 g/kg (Rat)	> 10000 mg/kg (Rabbit)	Not available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Skin corrosion/irritation
Corrosive. May cause severe skin irritation. May cause whitening or bleaching of the skin. Prolonged contact may lead to burns and blisters and may aggravate dermatitis.

Serious eye damage/eye irritation
Corrosive to eye tissue and may cause severe damage and blindness.

Respiratory or skin sensitization
No information available.

Germ cell mutagenicity
No information available.

Carcinogenicity
No information available.

The table below indicates whether each agency has listed any ingredient as a carcinogen.

Chemical Name	ACGIH	IARC	NTP	OSHA
Water 7732-18-5	Not available	Not available	Not available	Not available
Sodium Hypochlorite, Solution 7681-52-9	Not available	Group 3	Not available	Not available

Legend
IARC (International Agency for Research on Cancer)
Group 3 - Not Classifiable as to Carcinogenicity in Humans

Reproductive toxicity
No information available.

Specific target organ systemic toxicity - single exposure

No information available.

Specific target organ systemic toxicity - repeated exposure
No information available.

Aspiration hazard
No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity

.

Chemical Name	Ecotoxicity - Freshwater Algae Data	Ecotoxicity - Fish Species Data	Toxicity to microorganisms	Crustacea
Water 7732-18-5	Not available	Not available	Not available	Not available
Sodium Hypochlorite, Solution 7681-52-9	Not available	0.06 - 0.11 mg/L LC50 (Pimephales promelas) 96 h flow-through 4.5 - 7.6 mg/L LC50 (Pimephales promelas) 96 h static 0.4 - 0.8 mg/L LC50 (Lepomis macrochirus) 96 h static 0.28 - 1 mg/L LC50 (Lepomis macrochirus) 96 h flow-through 0.05 - 0.771 mg/L LC50 (Oncorhynchus mykiss) 96 h flow-through 0.03 - 0.19 mg/L LC50 (Oncorhynchus mykiss) 96 h semi-static 0.18 - 0.22 mg/L LC50 (Oncorhynchus mykiss) 96 h static	Not available	EC50: 0.033 - 0.044mg/L (48h, Daphnia magna)

Persistence and degradability No information available.

Bioaccumulation No information available.

Chemical Name	Partition coefficient
Water 7732-18-5	Not available
Sodium Hypochlorite, Solution 7681-52-9	Not available

Other adverse effects No information available.

13. DISPOSAL CONSIDERATIONS

Waste treatment methods

Dispose of in accordance with local regulations. Dispose of waste in accordance with environmental legislation.

Do not reuse empty containers.

14. TRANSPORT INFORMATION

TDG (Canada):

UN Number	UN1791
Shipping name	HYPOCHLORITE SOLUTION
Class	8
Packing Group	III
Marine pollutant	Not available.

DOT (U.S.)

UN Number	UN1791
Shipping name	HYPOCHLORITE SOLUTION
Class	8
Packing Group	III
Marine pollutant	Not available

15. REGULATORY INFORMATION

Safety, health and environmental regulations/legislation specific for the substance or mixture

NSF International

Certified to NSF/ANSI 60

Additional information
Maximum use for potable water 95 mg/L. Only products bearing the NSF Mark on the product, product packaging, and/or documentation shipped with the product are Certified.

U.S. Regulatory Rules

Chemical Name	CERCLA/SARA - Section 302:	SARA (311, 312) Hazard Class:	CERCLA/SARA - Section 313:
Water - 7732-18-5	Not Listed	Not Listed	Not Listed
Sodium Hypochlorite, Solution - 7681-52-9	Not Listed	Listed	Not Listed

International Inventories

TSCA	Complies
DSL/NDSL	Complies

Legend:
TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List

16. OTHER INFORMATION, INCLUDING DATE OF PREPARATION OF THE LAST REVISION

NFPA:	**Health hazards** 3	**Flammability** 0	**Instability** 0	**Physical and chemical properties** -
HMIS Health Rating:	**Health hazards** 3	**Flammability** 0	**Physical hazards** 0	**Personal protection** X

Legend Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

TWA	TWA (time-weighted average)	STEL	STEL (Short Term Exposure Limit)
Ceiling	Maximum limit value	*	Skin designation

Prepared By: The Environment, Health and Safety Department of Univar Canada Ltd.

Preparation Date: 09/Feb/2018
Revision Date: 09/Feb/2018

Disclaimer

NOTICE TO READER:

Univar expressly disclaims all express or implied warranties of merchantability and fitness for a particular purpose, with respect to the product or information provided herein, and shall under no circumstances be liable for incidental or consequential damages.

Do not use ingredient information and/or ingredient percentages in this SDS as a product specification. For product specification information refer to a Product Specification Sheet and/or a Certificate of Analysis. These can be obtained from your local Univar Sales Office.

All information appearing herein is based upon data obtained from the manufacturer and/or recognized technical sources. While the information is believed to be accurate, Univar makes no representations as to its accuracy or sufficiency. Conditions of use are beyond Univar's control and therefore users are responsible to verify this data under their own operating conditions to determine whether the product is suitable for their particular purposes and they assume all risks of their use, handling, and disposal of the product, or from the publication or use of, or reliance upon, information contained herein. This information relates only to the product designated herein, and does not relate to its use in combination with any other material or in any other process.

©2015 Univar Inc. All rights reserved. Univar, the hexagon, the Univar logo and MasterLine are the registered trademarks of Univar Inc.

End of Safety Data Sheet

The mixture does not meet the criteria for classification.

Prevention
Wash hands thoroughly after handling
Wear protective gloves/protective clothing/eye protection/face protection
In case of inadequate ventilation wear respiratory protection

Response
Read the label and safety data sheet before use.
Flush eyes with plenty amounts of water.
If eye irritation persists: Get medical advice/attention
Wash skin with plenty of water.
If skin irritation occurs: Get medical advice/attention
Move person to fresh air.
Do NOT induce vomiting. Never give anything by mouth to an unconscious or convulsing person. Seek immediate medical attention. If vomiting occurs spontaneously, keep head below hips to prevent aspiration of liquid into the lungs.

Storage
Store in accordance with good industrial practices.

Disposal
Disposal of all wastes must be done in accordance with municipal, provincial and federal regulations

3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance

Not applicable.

Mixture

Chemical Name	CAS No	Weight-%	Synonyms
Glycerine	56-81-5	70 - 80%	Glycerine
Water	7732-18-5	20 - 30%	Water
Sodium Chloride	7647-14-5	0 - 10%	Sodium Chloride
Methanol	67-56-1	0 - 10%	Methanol

4. FIRST AID

Description of first aid measures

Inhalation
Remove to fresh air.

Eye contact
Rinse thoroughly with plenty of water for at least 15 minutes, lifting lower and upper eyelids. Consult a physician.

Skin contact
Wash skin with soap and water.

Ingestion
Clean mouth with water and drink afterwards plenty of water.

Most important symptoms and effects, both acute and delayed:
May cause slight eye irritation Symptoms include pain, redness and tearing. May cause slight skin irritation. Prolonged or repeated contact may cause discomfort and local redness. High concentrations of mist or vapor may cause irritation of the respiratory tract. May be harmful if swallowed

Indication of any immediate medical attention and special treatment needed:

Note to physicians
Treatment based on sound judgment of physician and individual reactions of patient.

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media
Use extinguishing agent suitable for type of surrounding fire. Water spray. Alcohol foam. Dry chemical or CO2. Water or Foam may cause frothing.

Specific hazards arising from the substance or mixture
No information available.

Hazardous combustion products
See section 10 for more information.

Special protective equipment for fire-fighters
Firefighters should wear self-contained breathing apparatus and full firefighting turnout gear. Use personal protection equipment.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Ensure adequate ventilation. Avoid breathing vapors or mists.

Environmental precautions

See Section 12 for additional Ecological Information.

Methods and materials for containment and cleaning up

Prevent further leakage or spillage if safe to do so. Eliminate all ignition sources.

7. HANDLING AND STORAGE

Precautions for safe handling

Handle in accordance with good industrial hygiene and safety practice. Avoid contact with skin, eyes or clothing. Avoid breathing vapors or mists. Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.

Conditions for safe storage, including any incompatibilities

Keep containers tightly closed in a cool, well-ventilated place. Keep away from sources of ignition.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Limits .

Chemical Name	Alberta OEL	British Columbia OEL	Ontario	Quebec OEL	Exposure Limit - ACGIH	Immediately Dangerous to Life or Health - IDLH
Glycerine 56-81-5	TWA: 10 mg/m^3	TWA: 10 mg/m^3 TWA: 3 mg/m^3	Not available	TWA: 10 mg/m^3	Not available	Not available
Water 7732-18-5	Not available	Not available	Not available	Not available	Not available	Not available
Sodium Chloride 7647-14-5	Not available	Not available	Not available	Not available	Not available	Not available
Methanol 67-56-1	TWA: 200 ppm TWA: 262 mg/m^3 STEL: 250 ppm STEL: 328 mg/m^3 Skin	TWA: 200 ppm STEL: 250 ppm Skin	TWA: 200 ppm STEL: 250 ppm Skin	TWA: 200 ppm TWA: 262 mg/m^3 STEL: 250 ppm STEL: 328 mg/m^3 Skin	250 ppm STEL 200 ppm TLV-TWA	6000 ppm

Consult local authorities for recommended exposure limits

Appropriate engineering controls

Engineering controls
Showers
Eyewash stations
Ventilation systems.

Individual protection measures, such as personal protective equipment

Eye/face protection
Chemical goggles; also wear a face shield if splashing hazard exists.

Hand protection
Use gloves chemically resistant to this material, examples of preferred glove barrier materials include:. Nitrile gloves.

Skin and body protection
Skin contact should be prevented through the use of suitable protective clothing, gloves and footwear, selected for conditions of use and exposure potential. Consideration must be given both to durability as well as permeation resistance.

Respiratory protection
If exposure exceeds occupational exposure limits, use an appropriate NIOSH-approved respirator.

General hygiene considerations
Handle in accordance with good industrial hygiene and safety practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance

Physical state	Liquid
Color	Light brown

Odor	MUSTY to Sweet
Odor threshold	No information available

PROPERTIES	Values	Remarks • Method
pH	4 - 11	
Melting point / freezing point	No data available	None known
Initial boiling point/boiling range	No data available	None known
Flash point	No data available	None known
Evaporation rate	No data available	None known
Flammability (solid, gas)	No data available	None known
Flammability Limit in Air		
Upper flammability limit:	No data available	
Lower flammability limit:	No data available	
Vapor pressure	No data available	None known
Relative vapor density	No data available	None known
Specific Gravity	1.225@ 20°C	
Water solubility	Soluble in water	
Solubility in other solvents	No data available	None known
Partition coefficient	No data available	
Autoignition temperature	No data available	None known
Decomposition temperature	No data available	None known
Kinematic viscosity	45 cPs @ 20C	
Dynamic viscosity	No data available	None known
Explosive properties	No information available.	
Oxidizing properties	No information available.	

Molecular weight	No information available
VOC Percentage Volatility	No information available
Liquid Density	No information available
Bulk density	10.22 lbs/gal

10. STABILITY AND REACTIVITY

Reactivity/Chemical Stability
Stable under normal conditions

Possibility of hazardous reactions
None under normal processing.

Conditions to avoid
Heat, flames and sparks.

Incompatible materials
Oxidizing agents. Nitric acid. Peroxides. Chromates.

Hazardous decomposition products
Oxides of carbon.

11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure

Inhalation
High concentrations of mist or vapor may cause irritation of the respiratory tract.

Eye contact
May cause slight eye irritation.

Skin contact
May cause slight skin irritation.

Ingestion
May be harmful if swallowed.

Information on toxicological effects

Symptoms
Prolonged exposure may cause headaches, nausea, dizziness, eye, skin and respiratory irritation.

Numerical measures of toxicity

Acute toxicity

The following values are calculated based on chapter 3.1 of the GHS document .

ATEmix (oral) 13,548.00 mg/kg
ATEmix (dermal) 13,903.00 mg/kg

Unknown acute toxicity No information available

Chemical Name	Oral LD50	Dermal LD50	Inhalation LC50
Glycerine 56-81-5	= 12600 mg/kg (Rat)	> 10 g/kg (Rabbit)	> 570 mg/m^3 (Rat) 1 h
Water 7732-18-5	> 90 mL/kg (Rat)	Not available	Not available
Sodium Chloride 7647-14-5	= 3 g/kg (Rat)	Not available	> 42 g/m^3 (Rat) 1 h
Methanol 67-56-1	= 6200 mg/kg (Rat)	= 15840 mg/kg (Rabbit)	= 22500 ppm (Rat) 8 h

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Skin corrosion/irritation
May cause slight irritation with discomfort and local redness.

Serious eye damage/eye irritation
Symptoms include pain, redness and tearing.

Respiratory or skin sensitization
No information available.

Germ cell mutagenicity
No information available.

Carcinogenicity
No information available.

Chemical Name	ACGIH	IARC	NTP	OSHA
Glycerine 56-81-5	Not available	Not available	Not available	Not available
Water 7732-18-5	Not available	Not available	Not available	Not available
Sodium Chloride 7647-14-5	Not available	Not available	Not available	Not available
Methanol 67-56-1	Not available	Not available	Not available	Not available

Reproductive toxicity
No information available.

Specific target organ systemic toxicity - single exposure
No information available.

Specific target organ systemic toxicity - repeated exposure
No information available.

Aspiration hazard
No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity

.

Chemical Name	Ecotoxicity - Freshwater Algae Data	Ecotoxicity - Fish Species Data	Toxicity to microorganisms	Crustacea
Glycerine 56-81-5	Not available	51 - 57 mL/L LC50 (Oncorhynchus mykiss) 96 h static	Not available	Not available
Water 7732-18-5	Not available	Not available	Not available	Not available
Sodium Chloride 7647-14-5	Not available	5560 - 6080 mg/L LC50 (Lepomis macrochirus) 96 h flow-through 12946 mg/L LC50 (Lepomis macrochirus) 96 h static 6020 - 7070 mg/L LC50 (Pimephales promelas) 96 h static 7050 mg/L LC50 (Pimephales promelas) 96 h semi-static 6420 - 6700 mg/L LC50 (Pimephales promelas) 96 h static 4747 - 7824 mg/L LC50 (Oncorhynchus mykiss) 96 h flow-through	Not available	EC50: =1000mg/L (48h, Daphnia magna) EC50: 340.7 - 469.2mg/L (48h, Daphnia magna)
Methanol 67-56-1	Not available	28200 mg/L LC50 (Pimephales promelas) 96 h flow-through 100 mg/L LC50 (Pimephales promelas) 96 h static 19500 - 20700 mg/L LC50 (Oncorhynchus mykiss) 96 h flow-through 18 - 20 mL/L LC50 (Oncorhynchus mykiss) 96 h static 13500 - 17600 mg/L LC50 (Lepomis macrochirus) 96 h flow-through	Not available	Not available

Persistence and degradability No information available.

Bioaccumulation No information available.

Component Information

Chemical Name	Partition coefficient
Glycerine 56-81-5	-1.76
Water 7732-18-5	Not available
Sodium Chloride 7647-14-5	Not available
Methanol 67-56-1	-0.77

Other adverse effects No information available.

13. DISPOSAL CONSIDERATIONS

Waste treatment methods

Dispose of in accordance with local regulations. Dispose of waste in accordance with environmental legislation.

Do not reuse empty containers.

14. TRANSPORT INFORMATION

TDG (Canada):

UN Number	Not applicable
Shipping name	Not regulated
Class	Not applicable
Packing Group	Not applicable
Marine pollutant	Not available.

DOT (U.S.)

UN Number	Not applicable
Shipping name	Not regulated
Class	Not applicable
Packing Group	Not applicable
Marine pollutant	Not available

15. REGULATORY INFORMATION

Safety, health and environmental regulations/legislation specific for the substance or mixture

U.S. Regulatory Rules

Chemical Name	CERCLA/SARA - Section 302:	SARA (311, 312) Hazard Class:	CERCLA/SARA - Section 313:
Glycerine - 56-81-5	Not Listed	Not Listed	Not Listed
Water - 7732-18-5	Not Listed	Not Listed	Not Listed
Sodium Chloride - 7647-14-5	Not Listed	Not Listed	Not Listed
Methanol - 67-56-1	Not Listed	Listed	Listed

International Inventories

TSCA	Complies
DSL/NDSL	Complies

Legend:
TSCA - United States Toxic Substances Control Act Section 8(b) Inventory

DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List

16. OTHER INFORMATION, INCLUDING DATE OF PREPARATION OF THE LAST REVISION

NFPA:	**Health hazards** 0	**Flammability** 0	**Instability** 0	**Physical and chemical properties** -
HMIS Health Rating:	**Health hazards** 0	**Flammability** 0	**Physical hazards** 0	**Personal protection** X

Legend Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

TWA	TWA (time-weighted average)	STEL	STEL (Short Term Exposure Limit)
Ceiling	Maximum limit value	*	Skin designation

Prepared By: The Environment, Health and Safety Department of Univar Canada Ltd.

Preparation Date: 09/Mar/2018
Revision Date: 09/Mar/2018

Disclaimer

NOTICE TO READER:

Univar expressly disclaims all express or implied warranties of merchantability and fitness for a particular purpose, with respect to the product or information provided herein, and shall under no circumstances be liable for incidental or consequential damages.

Do not use ingredient information and/or ingredient percentages in this SDS as a product specification. For product specification information refer to a Product Specification Sheet and/or a Certificate of Analysis. These can be obtained from your local Univar Sales Office.

All information appearing herein is based upon data obtained from the manufacturer and/or recognized technical sources. While the information is believed to be accurate, Univar makes no representations as to its accuracy or sufficiency. Conditions of use are beyond Univar's control and therefore users are responsible to verify this data under their own operating conditions to determine whether the product is suitable for their particular purposes and they assume all risks of their use, handling, and disposal of the product, or from the publication or use of, or reliance upon, information contained herein. This information relates only to the product designated herein, and does not relate to its use in combination with any other material or in any other process.

©2015 Univar Inc. All rights reserved. Univar, the hexagon, the Univar logo and MasterLine are the registered trademarks of Univar Inc.

End of Safety Data Sheet

SAFETY DATA SHEET

SDS00404
ALS Aluminum Sulphate

Preparation Date: 07/Nov/2017 Version: 3

1. IDENTIFICATION

Product identifier

Product Name ALS Aluminum Sulphate

Other means of identification

Product Code(s) SDS00404

Synonyms none

Recommended use of the chemical and restrictions on use

Recommended Use Water treatment (potable and waste water). Paper applications.

Restricted Uses No information available

Initial Supplier Identifier
Univar Canada Ltd.
9800 Van Horne Way
Richmond, BC V6X 1W5
Telephone: 1-866-686-4827

Emergency telephone number

24 Hour Emergency Phone Number (CANUTEC): 1-888-226-8832 (1-888-CAN-UTEC)

2. HAZARD IDENTIFICATION

Hazardous Classification of the substance or mixture

Corrosive to metals	Category 1
Serious eye damage/eye irritation	Category 1

Label elements

Hazard pictograms



Signal Word: Danger

Hazard statements
May be corrosive to metals
Causes serious eye damage

Precautionary Statements

Prevention
Wash face, hands and any exposed skin thoroughly after handling
Keep only in original container
Wear eye/face protection

Response

IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
If eye irritation persists: Get medical advice/attention
IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower
IF SWALLOWED: Call a POISON CENTER or doctor if you feel unwell
Rinse mouth

In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish

Storage
Store locked up
Store in a well-ventilated place. Keep container tightly closed

Disposal
Disposal of all wastes must be done in accordance with municipal, provincial and federal regulations

Other Information
Unknown acute toxicity No information available

3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance

Chemical Name	CAS No	Weight-%	Synonyms
Sulfuric acid, aluminum salt	10043-01-3	20 - 30%	Sulfuric acid, aluminum salt

4. FIRST AID

Description of first aid measures

General advice
Show this safety data sheet to the doctor in attendance.

Inhalation
Remove to fresh air.

Eye contact
Rinse thoroughly with plenty of water for at least 15 minutes, lifting lower and upper eyelids. Consult a physician.

Skin contact
Wash with soap and water. Take off contaminated clothing and wash before reuse. Get medical attention if irritation develops and persists.

Ingestion
Do NOT induce vomiting. Clean mouth with water and drink afterwards plenty of water. Never give anything by mouth to an unconscious person. Call a physician.

Most important symptoms and effects, both acute and delayed:
May cause digestive tract irritation. May cause respiratory tract irritation May cause moderate skin irritation. Direct contact may cause moderate irritation.

Indication of any immediate medical attention and special treatment needed:

Note to physicians
Treatment based on sound judgment of physician and individual reactions of patient.

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media
Use extinguishing media appropriate for surrounding fire.

Specific hazards arising from the substance or mixture
Use water spray to cool fire-exposed containers and structures. Under fire conditions, toxic, corrosive fumes are emitted.

Hazardous combustion products
Thermal decomposition: after completely dry and heated to decomposition will produce sulphur oxides and aluminum oxides.

Special protective equipment for fire-fighters
Firefighters should wear self-contained breathing apparatus and full firefighting turnout gear. Use personal protection equipment.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Use personal protective equipment as required. Wash thoroughly after handling.

Environmental precautions

Prevent further leakage or spillage if safe to do so. Prevent from entering into soil, ditches, sewers, waterways and/or groundwater. Consult local authorities.

Methods and materials for containment and cleaning up

Small spills: soak up with absorbent material and scoop into containers. Large spills : prevent contamination of waterways. Dike and pump into suitable containers. Clean up residual with absorbent material, place in appropriate container and flush with water. Neutralize with lime or limestone powder.

7. HANDLING AND STORAGE

Precautions for safe handling

Empty containers may contain hazardous product residues. Use appropriate personnel protective equipment. Wash thoroughly after handling. Avoid contact with eyes, skin and clothing.

Conditions for safe storage, including any incompatibilities

Place away from incompatible materials. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid). Suitable material: Stainless steel, rubber-coated steel, plastic, plastic with fiberglass reinforcement. Unsuitable material: Common metal. Do not store in aluminum, copper, copper alloys and galvanized containers. Shelf life: 12 months in original, sealed container. Keep at temperatures between 0 and 30 °C. Reason: Quality.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Limits .

Chemical Name	Alberta OEL	British Columbia OEL	Ontario	Quebec OEL	Exposure Limit - ACGIH	Immediately Dangerous to Life or Health - IDLH
Sulfuric acid, aluminum salt 10043-01-3	TWA: 2 mg/m^3	Not available	Not available	TWA: 2 mg/m^3	Not available	Not available

Consult local authorities for recommended exposure limits

Appropriate engineering controls

Engineering controls
Local exhaust ventilation as necessary to maintain exposures to within applicable limits.

Individual protection measures, such as personal protective equipment

Eye/face protection
Chemical goggles; also wear a face shield if splashing hazard exists.

Hand protection
Appropriate chemical resistant gloves should be worn.

Skin and body protection
Skin contact should be prevented through the use of suitable protective clothing, gloves and footwear, selected for conditions of use and exposure potential. Consideration must be given both to durability as well as permeation resistance.

Respiratory protection
If exposure exceeds occupational exposure limits, use an appropriate NIOSH-approved respirator.

General hygiene considerations
Handle in accordance with good industrial hygiene and safety practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance

Physical state	Liquid
Color	Colorless Clear
Odor	Slight ACIDIC
Odor threshold	No information available

PROPERTIES	Values	Remarks • Method
pH	<2.5	
Melting point / freezing point	-13 °C / 9 °F	
Initial boiling point/boiling range	110 °C / 230 °F	None known
Flash point	No data available	None known
Evaporation rate	similar to water	
Flammability (solid, gas)	No data available	None known
Flammability Limit in Air		None known
Upper flammability limit:	No data available	
Lower flammability limit:	No data available	
Vapor pressure	40 mmHg @ 35°C	
Relative vapor density	No data available	None known
Specific Gravity	1.2 - 1.36	
Water solubility	Completely soluble	
Solubility in other solvents	No data available	
Partition coefficient	No data available	None known
Autoignition temperature	No data available	None known
Decomposition temperature	No data available	None known
Kinematic viscosity	No data available	None known
Dynamic viscosity	No data available	None known
Explosive properties	No information available.	
Oxidizing properties	Not oxidizing.	
Molecular weight	No information available	
VOC Percentage Volatility	No information available	
Liquid Density	No information available	
Bulk density	No information available	

10. STABILITY AND REACTIVITY

Reactivity/Chemical Stability
Stable under normal conditions

Possibility of hazardous reactions
No additional remark.

Conditions to avoid
Avoid contact with mineral acids, excessive heat and bases/alkalis.

Incompatible materials
Metals such as iron or steel which are subject to corrosion. Carbon steel, aluminum, carbon, brasses and nylon.

Hazardous decomposition products

Thermal decomposition: after completely dry and heated to decomposition will produce sulphur oxides and aluminum oxides. Decomposition : 650 °C/ 1202 °F.

11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure

Inhalation
May cause respiratory tract irritation.

Eye contact
Direct contact may cause moderate irritation.

Skin contact
May cause moderate skin irritation.

Ingestion
May cause digestive tract irritation.

Information on toxicological effects

Symptoms
No additional information available.

Numerical measures of toxicity

Acute toxicity

The following values are calculated based on chapter 3.1 of the GHS document .
ATEmix (oral) 1,930.00 mg/kg

Unknown acute toxicity No information available

Chemical Name	Oral LD50	Dermal LD50	Inhalation LC50
Sulfuric acid, aluminum salt 10043-01-3	= 1930 mg/kg (Rat)	Not available	Not available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Skin corrosion/irritation
May cause moderate skin irritation.

Serious eye damage/eye irritation
Direct contact may cause moderate irritation.

Respiratory or skin sensitization
No information available.

Germ cell mutagenicity
No information available.

Carcinogenicity
No information available.

Chemical Name	ACGIH	IARC	NTP	OSHA
Sulfuric acid, aluminum salt 10043-01-3	Not available	Not available	Not available	Not available

Reproductive toxicity
No information available.

Specific target organ systemic toxicity - single exposure
No information available.

Specific target organ systemic toxicity - repeated exposure
No information available.

Aspiration hazard
No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity
May lower pH of waterways and adversely effect aquatic life.

Chemical Name	Ecotoxicity - Freshwater Algae Data	Ecotoxicity - Fish Species Data	Toxicity to microorganisms	Crustacea
Sulfuric acid, aluminum salt 10043-01-3	Not available	Not available	Not available	Not available

Persistence and degradability No information available.

Bioaccumulation No information available.

Chemical Name	Partition coefficient
Sulfuric acid, aluminum salt 10043-01-3	Not available

Other adverse effects No information available.

13. DISPOSAL CONSIDERATIONS

Waste treatment methods

Dispose of in accordance with local regulations. Dispose of waste in accordance with environmental legislation.

Do not reuse empty containers.

14. TRANSPORT INFORMATION

TDG (Canada):

UN Number	UN3264
Shipping name	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. (ALUMINUM SULPHATE)
Class	8
Packing Group	III
Marine pollutant	Not available.

DOT (U.S.)

UN Number	UN3264
Shipping name	CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. (ALUMINUM SULPHATE)
Class	8

Packing Group	III
Marine pollutant	Not available

15. REGULATORY INFORMATION

Safety, health and environmental regulations/legislation specific for the substance or mixture

NSF International



Additional information
Maximum use for potable water 400 mg/L. Only products bearing the NSF Mark on the product, product packaging, and/or documentation shipped with the product are Certified.

U.S. Regulatory Rules

Chemical Name	CERCLA/SARA - Section 302:	SARA (311, 312) Hazard Class:	CERCLA/SARA - Section 313:
Sulfuric acid, aluminum salt - 10043-01-3	Not Listed	Listed	Not Listed

International Inventories

TSCA	Complies
DSL/NDSL	Complies

Legend:
TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List

16. OTHER INFORMATION, INCLUDING DATE OF PREPARATION OF THE LAST REVISION

NFPA:	**Health hazards** 1	**Flammability** 0	**Instability** 0	**Physical and chemical properties** -
HMIS Health Rating:	**Health hazards** 1	**Flammability** 0	**Physical hazards** 0	**Personal protection** X

Legend Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

TWA	TWA (time-weighted average)	STEL	STEL (Short Term Exposure Limit)
Ceiling	Maximum limit value	*	Skin designation

Prepared By: The Environment, Health and Safety Department of Univar Canada Ltd.

Preparation Date: 07/Nov/2017
Revision Date: 07/Nov/2017

Disclaimer
NOTICE TO READER:
Univar expressly disclaims all express or implied warranties of merchantability and fitness for a particular purpose, with respect to the product or information provided herein, and shall under no circumstances be liable for incidental or consequential damages.

Do not use ingredient information and/or ingredient percentages in this SDS as a product specification. For

product specification information refer to a Product Specification Sheet and/or a Certificate of Analysis. These can be obtained from your local Univar Sales Office.

All information appearing herein is based upon data obtained from the manufacturer and/or recognized technical sources. While the information is believed to be accurate, Univar makes no representations as to its accuracy or sufficiency. Conditions of use are beyond Univar's control and therefore users are responsible to verify this data under their own operating conditions to determine whether the product is suitable for their particular purposes and they assume all risks of their use, handling, and disposal of the product, or from the publication or use of, or reliance upon, information contained herein. This information relates only to the product designated herein, and does not relate to its use in combination with any other material or in any other process.

©2015 Univar Inc. All rights reserved. Univar, the hexagon, the Univar logo and MasterLine are the registered trademarks of Univar Inc.

End of Safety Data Sheet

SAFETY DATA SHEET

SDS00256
SODA ASH 58% DENSE

Preparation Date: 10/Jan/2018 Version: 2

1. IDENTIFICATION

Product identifier

Product Name SODA ASH 58% DENSE

Other means of identification

Product Code(s) SDS00256

Synonyms Sodium carbonate, anhydrous. Carbonic acid, disodium salt; Disodium carbonate; Soda ash

Recommended use of the chemical and restrictions on use

Recommended Use Soda salts. Manufacture of glass. Soap Cleaners and water softeners. Pulp and paper. Photographical agent. Water treatment. pH adjustment

Restricted Uses No information available

Initial Supplier Identifier
Univar Canada Ltd.
9800 Van Horne Way
Richmond, BC V6X 1W5
Telephone: 1-866-686-4827

Emergency telephone number

24 Hour Emergency Phone Number (CANUTEC): 1-888-226-8832 (1-888-CAN-UTEC)

2. HAZARD IDENTIFICATION

Hazardous Classification of the substance or mixture

Serious eye damage/eye irritation	Category 1
Specific target organ toxicity (single exposure)	Category 3

Label elements

Hazard pictograms



Signal Word: Danger

Hazard statements
Causes serious eye damage
May cause respiratory irritation

Precautionary Statements

Prevention
Do not breathe dust/fume/gas/mist/vapors/spray
Wash face, hands and any exposed skin thoroughly after handling
Wear protective gloves/protective clothing/eye protection/face protection

IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower
IF INHALED: Remove person to fresh air and keep comfortable for breathing
IF SWALLOWED: Rinse mouth. DO NOT induce vomiting

Storage
Store locked up
Store in a well-ventilated place. Keep container tightly closed

Disposal
Disposal of all wastes must be done in accordance with municipal, provincial and federal regulations

Direct skin contact may cause slight or mild, transient irritation. Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.

Unknown acute toxicity No information available

3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance

Chemical Name	CAS No	Weight-%	Synonyms
Sodium Carbonate	497-19-8	90 - 100%	Sodium Carbonate

4. FIRST AID

Description of first aid measures

General advice
Immediate medical attention is required. Show this safety data sheet to the doctor in attendance.

Inhalation
Remove to fresh air. If breathing has stopped, give artificial respiration. Get medical attention immediately. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. If breathing is difficult, (trained personnel should) give oxygen. Delayed pulmonary edema may occur.

Eye contact
Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Keep eye wide open while rinsing. Do not rub affected area. Remove contact lenses, if present and easy to do. Continue rinsing. Get immediate medical advice/attention.

Skin contact
Wash off immediately with soap and plenty of water while removing all contaminated clothes and shoes. Get immediate medical advice/attention.

Ingestion
Do NOT induce vomiting. Clean mouth with water and drink afterwards plenty of water. Never give anything by mouth to an unconscious person. Get immediate medical advice/attention.

Self-protection of the first aider
Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and prevent spread of contamination. Avoid contact with skin, eyes or clothing. Avoid direct contact with skin. Use barrier to give mouth-to-mouth resuscitation. Wear personal protective clothing (see section 8).

Most important symptoms and effects, both acute and delayed:
May cause gastrointestinal irritation, nausea, vomiting and diarrhea. May cause severe eye irritation. Symptoms include redness, swelling, itching and pain. Material is irritating to mucous membrane and upper respiratory tract. Exposure can cause coughing, chest pains and difficulty in breathing Effects may include pain, marked redness and swelling.

Indication of any immediate medical attention and special treatment needed:

Note to physicians
Treatment based on sound judgment of physician and individual reactions of patient.

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media
Use extinguishing media appropriate for surrounding fire. Does not burn.

Specific hazards arising from the substance or mixture
Not flammable.

Hazardous combustion products
Carbon dioxide. Decomposition temperature: >400°C / 752 °F.

Special protective equipment for fire-fighters
Firefighters should wear self-contained breathing apparatus and full firefighting turnout gear. Use personal protection equipment.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Attention! Corrosive material. Avoid contact with skin, eyes or clothing. Ensure adequate ventilation. Use personal protective equipment as required. Evacuate personnel to safe areas. Keep people away from and upwind of spill/leak.

Environmental precautions

Prevent further leakage or spillage if safe to do so. Should not be released into the environment. Do not allow to enter into soil/subsoil. Prevent product from entering drains.

Methods and materials for containment and cleaning up

Stop leak if you can do it without risk. Shovel, sweep up or use industrial vacuum cleaner to pick up. Sweep up and place in an appropriate closed container. Avoid raising dust.

7. HANDLING AND STORAGE

Precautions for safe handling

Use good personal hygiene. Avoid prolonged contact with eyes or prolonged skin contact. Avoid breathing in dust. When dissolving, add to water cautiously while stirring; solutions can get hot.

Conditions for safe storage, including any incompatibilities

Store in a cool, dry, well ventilated area. Prolonged storage may cause product to cake and become damp from atmospheric moisture. Store away from acids.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Limits This product, as supplied, does not contain any hazardous materials with occupational exposure limits established by the region specific regulatory bodies.

Chemical Name	Alberta OEL	British Columbia OEL	Ontario	Quebec OEL	Exposure Limit - ACGIH	Immediately Dangerous to Life or Health - IDLH
Sodium Carbonate 497-19-8	Not available	Not available	Not available	Not available	Not available	Not available

Consult local authorities for recommended exposure limits

Appropriate engineering controls

Engineering controls
Local exhaust ventilation as necessary to maintain exposures to within applicable limits.

Individual protection measures, such as personal protective equipment

Eye/face protection
Safety glasses with side shields or chemical goggles.

Hand protection
Appropriate chemical resistant gloves should be worn. Break through time >8 hours. Butyl rubber gloves. Natural rubber gloves. Neoprene gloves. Nitrile gloves. Polyvinylchloride (PVC) gloves. Viton gloves. Silver Shield (R). NOTICE: The selection of a specific glove for a particular application and duration of use in a workplace should also take into account all relevant workplace factors such as, but not limited to: Other chemicals which may be handled, physical requirements (cut/puncture protection, dexterity, thermal protection), potential body reactions to glove materials as well as the instructions/specifications provided by the glove supplier.

Skin and body protection
As a minimum, wear long-sleeve shirts, trousers, and gloves for routine product use.

Respiratory protection
For dusty or misty conditions, wear NIOSH-approved dust or mist respirator.

General hygiene considerations
Avoid contact with skin, eyes or clothing. Wear suitable gloves and eye/face protection. Do not eat, drink or smoke when using this product. Remove and wash contaminated clothing and gloves, including the inside, before re-use. Contaminated work clothing should not be allowed out of the workplace. Regular cleaning of equipment, work area and clothing is recommended. Wash hands before breaks and immediately after handling the product.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance	
Physical state	Solid
Color	White
Odor	Odorless
Odor threshold	No information available

PROPERTIES	Values	Remarks • Method
pH	11.3-11.4 (1% solution), 11.6 (5% solution), 11.7 (10% solution) @ 20°C	
Melting point / freezing point	851 °C / 1563.8 °F	
Initial boiling point/boiling range	No data available	None known
Flash point	No data available	None known
Evaporation rate	No data available	None known
Flammability (solid, gas)	No data available	None known
Flammability Limit in Air		
Upper flammability limit:	No data available	
Lower flammability limit:	No data available	
Vapor pressure	No data available	None known
Relative vapor density	No data available	None known
Specific Gravity	2.533 @ 20°C	
Water solubility	Soluble in water	
Solubility in other solvents	No data available	
Partition coefficient	No data available	
Autoignition temperature	No data available	None known
Decomposition temperature	>400°C/752°F	
Kinematic viscosity	No data available	None known
Dynamic viscosity	No data available	None known
Explosive properties	No information available.	
Oxidizing properties	No information available.	

Molecular weight	105.99
VOC Percentage Volatility	No information available
Liquid Density	No information available
Bulk density	No information available

10. STABILITY AND REACTIVITY

Reactivity/Chemical Stability
Stable

Possibility of hazardous reactions
Contact with acids will release carbon dioxide gas. Can react violently with red hot aluminum metal; fluorine gas; lithium; and 2,4,6-trinitrotoluene.

Hazardous polymerization
Will not occur.

Conditions to avoid
Hygroscopic (absorbs moisture from the air). Simultaneous exposure to soda ash and lime dusts (CaO). In the presence of moisture (i.e. perspiration) the two materials combine to form corrosive caustic soda (NaOH) which may cause burns.

Incompatible materials
Acids. Soda Ash is corrosive to aluminum, lead, and zinc and zinc brasses when in solution and to aluminum when high humidity is present. Silver nitrate. Magnesium. Fluorine. Lithium. Calcium hypochlorite.

Hazardous decomposition products
Carbon dioxide. Decomposition temperature: >400°C / 752 °F.

11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure

Inhalation
Material is irritating to mucous membrane and upper respiratory tract. Exposure can cause coughing, chest pains and difficulty in breathing.

Eye contact
Causes serious eye damage. Effects may include pain, marked redness and swelling.

Skin contact
Symptoms include redness, swelling, itching and pain.

Ingestion
May cause gastrointestinal irritation, nausea, vomiting and diarrhea.

Information on toxicological effects

Symptoms
Excessive contact may produce "soda ulcers" on hands and perforation of the nasal septum. Sensitivity reactions may occur from prolonged and repeated exposure.

Numerical measures of toxicity

Acute toxicity

The following values are calculated based on chapter 3.1 of the GHS document .
ATEmix (oral) 4,098.00 mg/kg

Unknown acute toxicity No information available

Chemical Name	Oral LD50	Dermal LD50	Inhalation LC50
Sodium Carbonate 497-19-8	= 4090 mg/kg (Rat)	Not available	= 2300 mg/m³ (Rat) 2 h

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Skin corrosion/irritation
Symptoms include redness, swelling, itching and pain.

Serious eye damage/eye irritation
Causes serious eye damage. Effects may include pain, marked redness and swelling.

Respiratory or skin sensitization

No information available.

Germ cell mutagenicity
No information available.

Carcinogenicity
No information available.

Chemical Name	ACGIH	IARC	NTP	OSHA
Sodium Carbonate 497-19-8	Not available	Not available	Not available	Not available

Reproductive toxicity
No information available.

Specific target organ systemic toxicity - single exposure
May cause respiratory irritation.

Specific target organ systemic toxicity - repeated exposure
No information available.

Aspiration hazard
No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity

.

Chemical Name	Ecotoxicity - Freshwater Algae Data	Ecotoxicity - Fish Species Data	Toxicity to microorganisms	Crustacea
Sodium Carbonate 497-19-8	Not available	310 - 1220 mg/L LC50 (Pimephales promelas) 96 h static 300 mg/L LC50 (Lepomis macrochirus) 96 h static	Not available	EC50: =265mg/L (48h, Daphnia magna)

Persistence and degradability No information available.

Bioaccumulation No information available.

Chemical Name	Partition coefficient
Sodium Carbonate 497-19-8	Not available

Other adverse effects No information available.

13. DISPOSAL CONSIDERATIONS

Waste treatment methods

Disposal of all wastes must be done in accordance with municipal, provincial and federal regulations.

Do not reuse empty containers.

14. TRANSPORT INFORMATION

TDG (Canada):

UN Number	Not applicable
Shipping name	Not regulated
Class	Not applicable
Packing Group	Not applicable
Marine pollutant	Not available.

DOT (U.S.)

UN Number	Not applicable
Shipping name	Not regulated
Class	Not applicable
Packing Group	Not applicable
Marine pollutant	Not available

15. REGULATORY INFORMATION

Safety, health and environmental regulations/legislation specific for the substance or mixture

NSF International

Certified to NSF/ANSI 60

Additional information
Only products bearing the NSF Mark on the product, product packaging, and/ordocumentation shipped with the product are Certified. Maximum use of potable water 100 mg/L.

U.S. Regulatory Rules

Chemical Name	CERCLA/SARA - Section 302:	SARA (311, 312) Hazard Class:	CERCLA/SARA - Section 313:
Sodium Carbonate - 497-19-8	Not Listed	Not Listed	Not Listed

International Inventories

TSCA	Complies
DSL/NDSL	Complies

Legend:
TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List

16. OTHER INFORMATION, INCLUDING DATE OF PREPARATION OF THE LAST REVISION

NFPA:	**Health hazards** 3	**Flammability** 0	**Instability** 0	**Physical and chemical properties** -
HMIS Health Rating:	**Health hazards** 3	**Flammability** 0	**Physical hazards** 0	**Personal protection** X

Legend Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

TWA	TWA (time-weighted average)	STEL	STEL (Short Term Exposure Limit)
Ceiling	Maximum limit value	*	Skin designation

Prepared By: The Environment, Health and Safety Department of Univar Canada Ltd.

Preparation Date: 10/Jan/2018
Revision Date: 10/Jan/2018

Disclaimer

NOTICE TO READER:

Univar expressly disclaims all express or implied warranties of merchantability and fitness for a particular purpose, with respect to the product or information provided herein, and shall under no circumstances be liable for incidental or consequential damages.

Do not use ingredient information and/or ingredient percentages in this SDS as a product specification. For product specification information refer to a Product Specification Sheet and/or a Certificate of Analysis. These can be obtained from your local Univar Sales Office.

All information appearing herein is based upon data obtained from the manufacturer and/or recognized technical sources. While the information is believed to be accurate, Univar makes no representations as to its accuracy or sufficiency. Conditions of use are beyond Univar's control and therefore users are responsible to verify this data under their own operating conditions to determine whether the product is suitable for their particular purposes and they assume all risks of their use, handling, and disposal of the product, or from the publication or use of, or reliance upon, information contained herein. This information relates only to the product designated herein, and does not relate to its use in combination with any other material or in any other process.

©2015 Univar Inc. All rights reserved. Univar, the hexagon, the Univar logo and MasterLine are the registered trademarks of Univar Inc.

End of Safety Data Sheet

MATERIAL SAFETY DATA SHEET

Revision date: *06/15/2011* **Revision number:** *3*

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name BioRemove 5895

Contact Manufacturer
Novozymes Biologicals Inc.
5400 Corporate Circle
Salem, VA, USA 24153

Information Telephone Number 1-540-389-9361

Emergency Telephone Number 1-800-424-9300 (Chemtrec) 24 hours every day

Health Hazard	1
Fire Hazard	0
Reactivity	0

2. HAZARDS IDENTIFICATION

CAUTION

Emergency Overview

Contact may cause eye and skin irritation

Appearance Opaque **Physical State** Liquid **Odor** Slight fermentation odor

Potential Health Effects

Principle Routes of Exposure Eye contact, Skin contact, Inhalation

Acute Effects

Eyes May cause slight irritation
Skin Substance may cause slight skin irritation
Inhalation May cause irritation of respiratory tract
Ingestion Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhoea

Chronic Effects

Chronic Toxicity No information available

See Section 11 for additional Toxicological information.

Aggravated Medical Conditions No information available

Potential Environmental Effects There is no known ecological information for this product
See Section 12 for additional Ecological information

3. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous Components

Chemical Name	CAS-No	Weight %
Water	7732-18-5	95-100%
Viable Bacteria Cultures	Not Applicable	1-5%

Ingredients not listed are either non-hazardous or under reportable concentrations

4. FIRST AID MEASURES

Eye Contact Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician

Skin Contact Wash off immediately with soap and plenty of water

Inhalation Move to fresh air

Ingestion Clean mouth with water and afterwards drink plenty of water

Notes to Physician Treat symptomatically

5. FIRE-FIGHTING MEASURES

Flammable Properties	Slightly flammable according to HMIS criteria
Suitable Extinguishing Media	Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.
Unsuitable Extinguishing Media	None
Hazardous Combustion Products	None
Specific Hazards Arising from the Chemical	May cause allergic respiratory reaction.
Protective Equipment and Precautions for Firefighters	Self-contained breathing apparatus and standard turn-out apparel

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions	For personal protection see section 8
Environmental Precautions	Spilled preparation should be removed immediately to avoid formation of dust from dried preparation. Take up by mechanical means preferably by a vacuum cleaner equipped with a high efficiency filter. Flush remainder carefully with plenty of water. Avoid splashing and high pressure washing (avoid formation of aerosols). Ensure sufficient ventilation. Wash contaminated clothing. .
Methods for cleaning up	Avoid formation of dust and aerosols Spilled preparation should be removed immediately to avoid formation of dust from dried preparation. Take up by mechanical means preferably by a vacuum cleaner equipped with a HEPA (High Efficiency Particulate Air) filter. Flush remainder carefully with plenty of water. Avoid splashing, high pressure washing or compressed air cleaning to avoid formation of aerosols. Ensure sufficient ventilation. Wash contaminated clothing.

For personal protection see section 8

7. HANDLING AND STORAGE

Handling	Avoid formation of dust and aerosols Ensure adequate ventilation
General Precautions	The Substance should be handled under conditions of good industrial hygiene and in conformity with any local regulations in order to avoid unnecessary exposure..
Storage	Keep tightly closed in a dry and cool place.
Temperature	Keep in a dry, cool and well-ventilated place.
Storage Conditions	In unbroken packaging - dry and protect from the sun. The product has been formulated for optimal stability. Extended storage or adverse conditions such as higher temperatures or higher humidity may lead to a higher dosage requirement.
Conditions To Avoid	Avoid Temperatures above 45 C to preserve biological stability. Avoid freezing temperatures. Strong Acids or alkali compounds may inactivate biological cultures. Avoid strong oxidizing agents.
Incompatible Materials	Strong acids or alkali compounds may inactivate biological cultures

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Engineering Controls	Ensure adequate ventilation, especially in confined areas Maintain good conditions of industrial hygiene. Some processes may require enclosures, local exhaust ventilation, or other engineering controls to control airborne levels. Additional handling and healthy/safety information is available upon request

Personal Protective Equipment

Respiratory Protection	In case of insufficient ventilation wear suitable respiratory equipment that meets HEPA/P100 specifications
Eye Protection	Safety glasses with side-shields
Skin Protection	Long sleeved clothing
Hand Protection	Protective gloves
General Hygiene Considerations	Handle in accordance with good industrial hygiene and safety practices
Environmental exposure controls	Local authorities should be advised if significant spillages cannot be contained

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Opaque
Physical State	Liquid
Odor	Slight fermentation odor
pH	7.0-8.0
Boiling Point/Range	No information available
Melting Point/Range	No information available
Flash Point	No information available
Flammability (solid, gas)	No information available
Explosive Properties	No information available
Oxidizing Properties	No information available
Vapor Pressure	No information available
Relative density	No data available
Solubility	No information available
Partition Coefficient (n-octanol/water)	No information available

The physical data presented above are typical values and should not be construed as a specification

10. STABILITY AND REACTIVITY

Chemical stability	Stable under recommended storage conditions
Conditions to Avoid	Stable under normal conditions Excessive temperature variations below 32F or above 155F
Materials to avoid	None
Hazardous Decomposition Products	None
Possibility of Hazardous Reactions	None

11. TOXICOLOGICAL INFORMATION

Acute Toxicity

Ingestion, LD50 Rat Oral (mg/kg):	Not Determined
Inhalation, LC50 Rat inhalation (mg/l/4hr)	Not Determined
Skin, LD50 Rat Dermal (mg/kg)	Not Determined
Eye Irritation	Not Determined

Chronic Toxicity

Sensitization	According to our experience and to the information provided to us, the product does not have any harmful effects if it is used and handled as specified

This product is formulated using a range of microorganisms specially selected from the natural environment

12. ECOLOGICAL INFORMATION

Ecotoxicity

This product is not expected to pose an environmental hazard. No Toxicity Data is available specifically for soil organisms, plants and terrestrial animals.

Environmental Effects	The data available do not support any environmental hazard
Persistence/Degradability	The organic components of the product are biodegradable.
Bioaccumulative Potential	According to experience not expected
Mobility	Not available
Other adverse effects	No known effect

13. DISPOSAL CONSIDERATIONS

Waste Disposal Method	Dispose of contents/container in accordance with local regulation.
Contaminated Packaging	Dispose of wastes in an approved waste disposal facility.

14. TRANSPORT INFORMATION

Transport Regulations	Not dangerous goods
IMDG/IMO	Not regulated
RID	Not regulated
ADR	Not regulated
ICAO	Not regulated
IATA	Not regulated
DOT	Not regulated

15. REGULATORY INFORMATION

International Inventories

TSCA	Complies
PICCS	Complies
KECL	Complies
ENCS	Complies
CHINA	Complies
AICS	Complies
DSL/NDSL	Complies

USA, Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and 40 CFR Part 372.

SARA 311/312 Hazardous Categorization

Acute Health Hazard	No
Chronic Health Hazard	No
Fire Hazard	No
Sudden Release of Pressure Hazard	No
Reactive Hazard	No

USA, State Regulations

California Proposition 65 This product contains the following Proposition 65 chemicals:

Canada

WHMIS Hazard Class Controlled product hazard class D2 A (respiratory sensitizer)

WHMIS Statement This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the SDS contains all the information required by the CPR.

16. OTHER INFORMATION

Disclaimer

The information provided on this MSDS is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text. Furthermore, as the conditions of use are beyond the control of Novozymes, it is the responsibility of the customer to determine the conditions of safe use of these products.

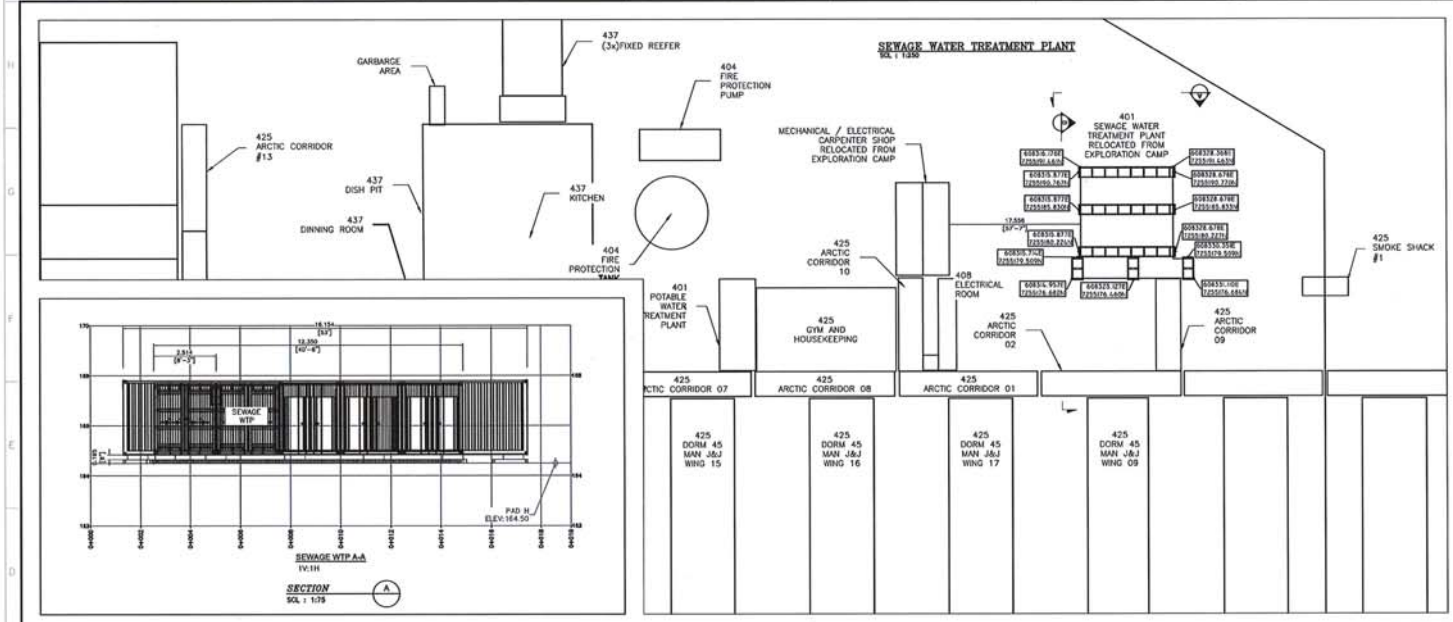


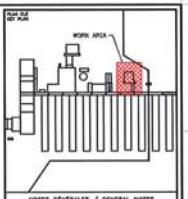
Report version 1 / ANSI / English

End of Material Safety Data Sheet

Appendix B: Drawings

61-401-230-003_R0





NOTES GÉNÉRALES / GENERAL NOTES

- VALIDATE THE LOCATION OF THE SEWAGE WTP DOORS IN RELATION WITH THE ARCTIC CORRIDOR 09.

POUR CONSTRUCTION
FOR CONSTRUCTION
DATE : 2018-12-13

DESSINS DE RÉFÉRENCE / REFERENCE DRAWINGS

TITRE / TITLE	# DWG
A-	A-
A-	A-
A-	A-
A-	A-
A-	A-

AGNICO EAGLE

NO.	DATE	DESCRIPTION	FAIT PAR / DRAWN	APP. / CHECKED
0	2018-11-13	ISSUED FOR CONSTRUCTION	L.R.F.	D.L.

REVISIONS

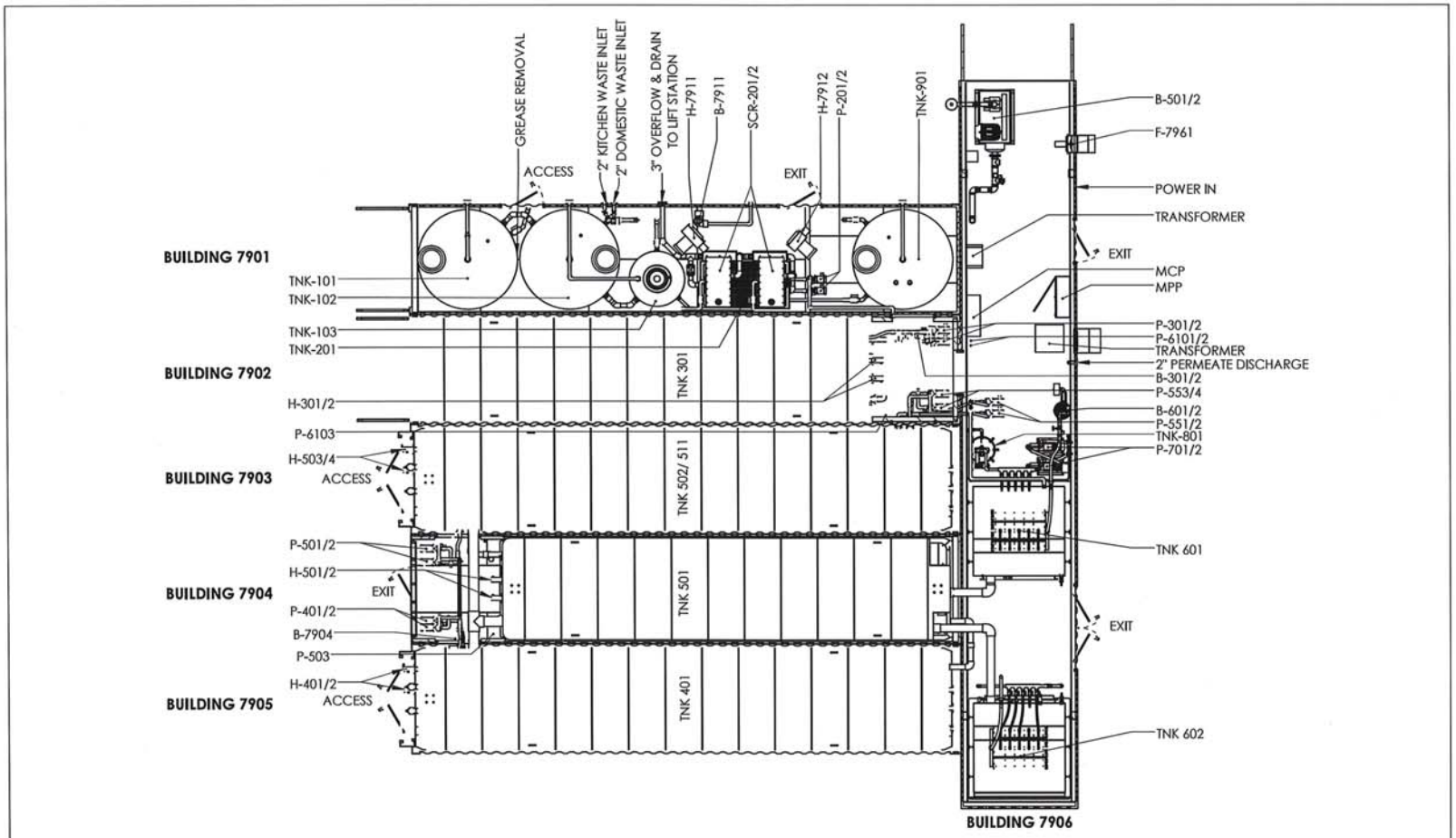
AMARUQ PROJECT

TITRE / TITLE
AGNICO EAGLE – MEADOWBANK DIVISION
401 – WATER
230 – GENERAL EARTH WORKS
PLAN
OPERATION CAMP – SEWAGE WATER TREATMENT PLANT
2018 INSTALLATION PLAN

DESSINÉ PAR / DRAWN BY	L. R. FRENETTE	2018-11-19
VÉRIFIÉ PAR / CHECKED BY	D. LAFLAMME	2018-11-19
APPROUVÉ PAR / APPROVED BY	D. LAFLAMME	2018-11-19
ÉCHELLE / SCALE	AS SHOWN	DATE 2018-11-19

NO. DESSIN / DRAWING NO.
61-401-230-003

NO. PROJET / PROJECT NO.	REVISION	FEUILLE / SHT
6115	0	1 / 1

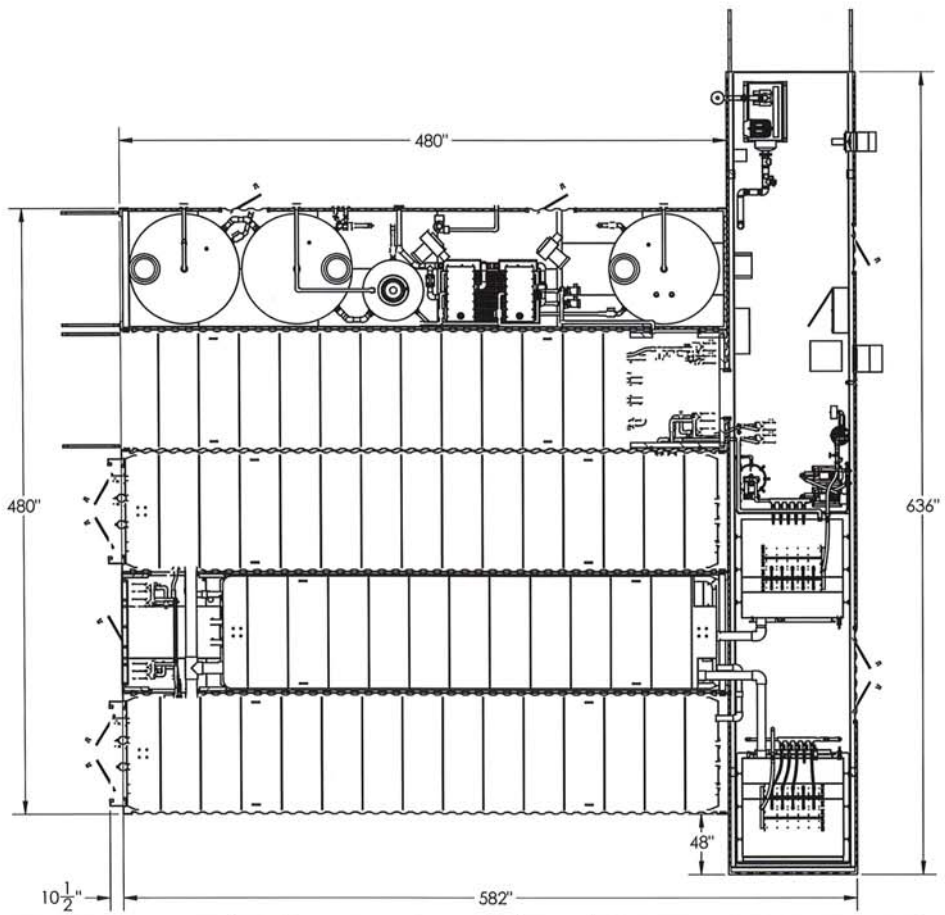


GENERAL TOLERANCES
.XX ± 1/8"
.XXX ± 1/16"
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT WRITTEN CONSENT.

LEVEL	DATE	BY	REVISION
C1	11/08/17	AH	AS BUILT
B1	07/06/17	GH	FOR PRODUCTION
B	06/06/17	GH	FOR PRODUCTION
A2	25/05/17	GH	REVISED LAYOUT
A	19/05/2017	GH	FOR REVIEW

DWG. NO:
PROJECT NUMBER: 1704432
TITLE: SYSTEM LAYOUT
CUSTOMER: AGNICO EAGLE
DRAWN BY: GH
DATE: 19/05/17
SHEET 1 OF 4



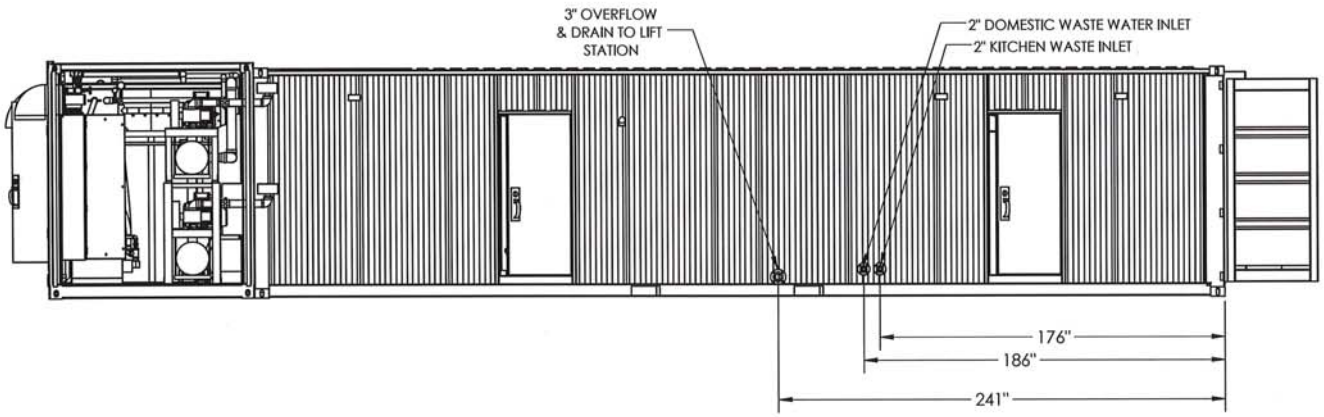
GENERAL TOLERANCES
.XX ± 1/8"
.XXX ± 1/16"
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

newterra

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT WRITTEN CONSENT.

LEVEL	DATE	BY	REVISION
C1	11/08/17	AH	AS BUILT
B1	07/06/17	GH	FOR PRODUCTION
B	06/06/17	GH	FOR PRODUCTION
A2	25/05/17	GH	REVISED LAYOUT
A	19/05/2017	GH	FOR REVIEW

DWG. NO: 1704432
TITLE: SYSTEM LAYOUT
CUSTOMER: AGNICO EAGLE
DRAWN BY: GH
DATE: 19/05/17
SHEET 2 OF 4



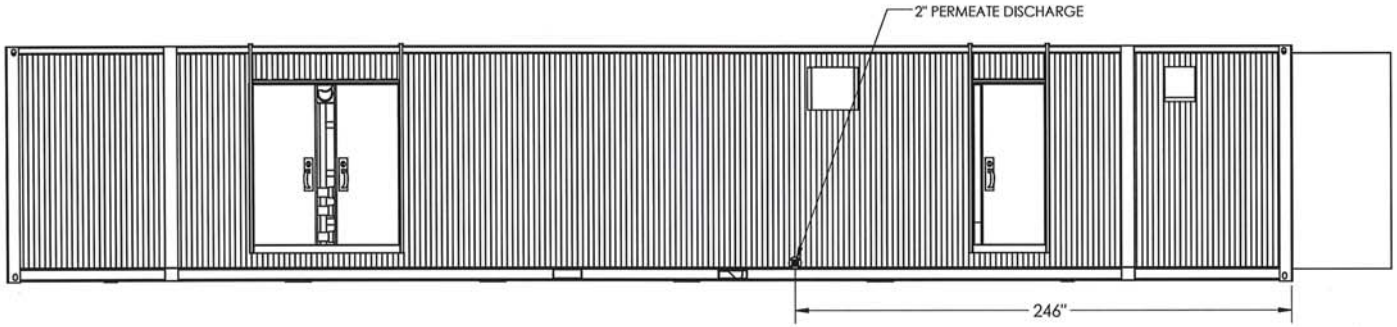
GENERAL TOLERANCES
.XX ± 1/8"
.XXX ± 1/16"
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

newterra

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT WRITTEN CONSENT.

LEVEL	DATE	BY	REVISION
C1	11/08/17	AH	AS BUILT
B1	07/06/17	GH	FOR PRODUCTION
B	06/06/2017	GH	FOR PRODUCTION

DWG. NO:
PROJECT NUMBER: 1704432
TITLE: SYSTEM LAYOUT
CUSTOMER: AGNICO EAGLE
DRAWN BY: GH
DATE: 06/06/17
SHEET 3 OF 4



GENERAL TOLERANCES
.XX ± 1/8"
.XXX ± 1/16"
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT WRITTEN CONSENT.

LEVEL	DATE	BY	REVISION
C1	11/08/17	AH	AS BUILT
B1	07/06/17	GH	FOR PRODUCTION
B	06/08/2017	GH	FOR PRODUCTION

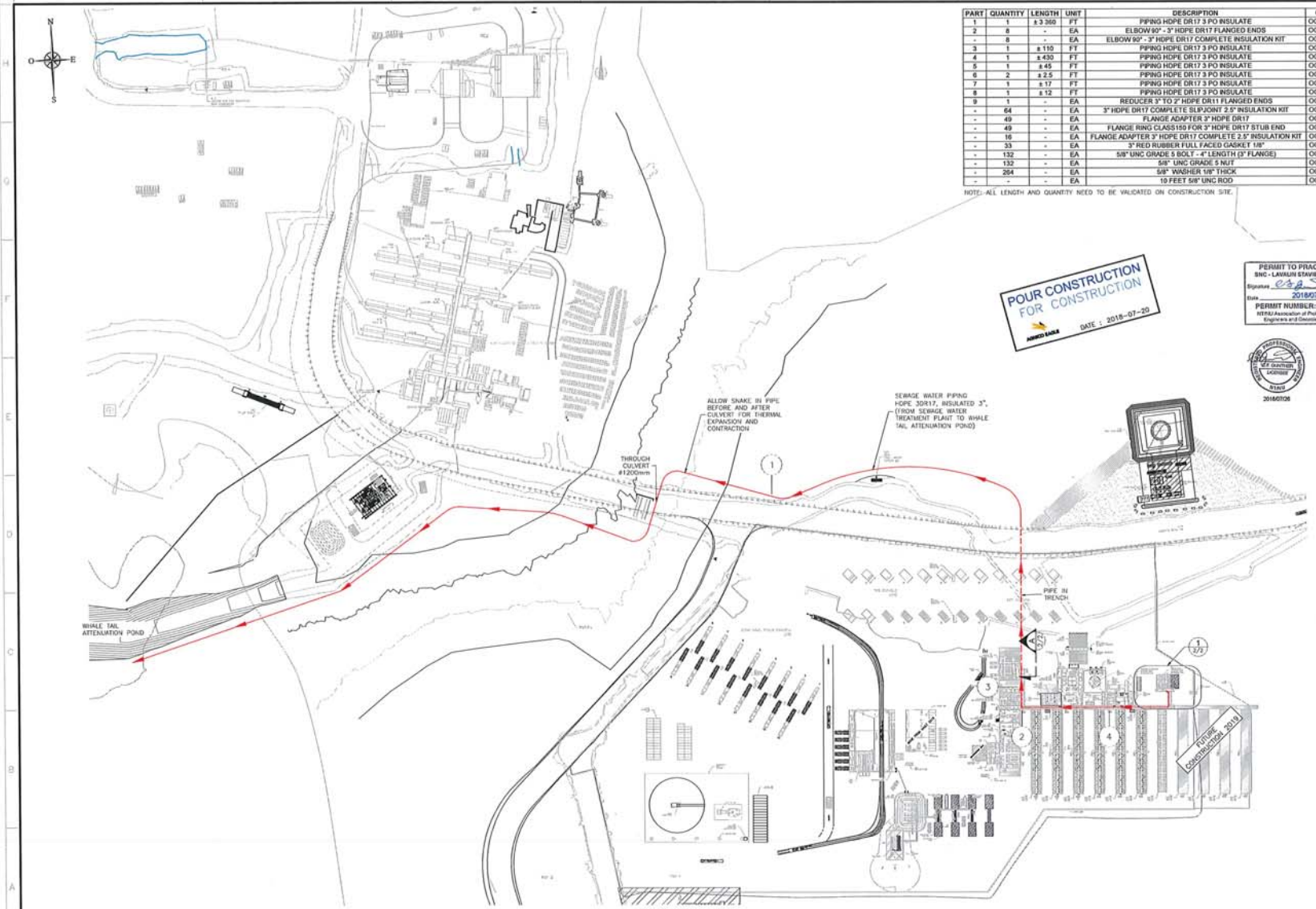
DWG. NO:
PROJECT NUMBER: 1704432
TITLE: SYSTEM LAYOUT
CUSTOMER: AGNICO EAGLE
DRAWN BY: GH
DATE: 06/06/17
SHEET 4 OF 4

NO. DESSIN
DRAWING NO. 61-460-270-201-1_R0

FORMAT ARCH D

PART	QUANTITY	LENGTH	UNIT	DESCRIPTION	ORDER
1	1	± 3 360	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
2	8	-	EA	ELBOW 90° - 3" HDPE DR17 FLANGED ENDS	OC - 707903
-	8	-	EA	ELBOW 90° - 3" HDPE DR17 COMPLETE INSULATION KIT	OC - 707903
3	1	± 110	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
4	1	± 430	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
5	1	± 45	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
6	2	± 2.5	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
7	1	± 17	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
8	1	± 12	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
9	1	-	EA	REDUCER 3" TO 2" HDPE DR11 FLANGED ENDS	OC - 707903
-	64	-	EA	3" HDPE DR17 COMPLETE SLIPJOINT 2.5" INSULATION KIT	OC - 707903
-	49	-	EA	FLANGE ADAPTER 3" HDPE DR17	OC - 707903
-	49	-	EA	FLANGE RING CLASS150 FOR 3" HDPE DR17 STUB END	OC - 707903
-	16	-	EA	FLANGE ADAPTER 3" HDPE DR17 COMPLETE 2.5" INSULATION KIT	OC - 707903
-	33	-	EA	3" RED RUBBER FULL FACED GASKET 1/8"	OC - 707903
-	132	-	EA	5/8" UNC GRADE 5 BOLT - 4" LENGTH (3" FLANGE)	OC - 707903
-	132	-	EA	5/8" UNC GRADE 5 NUT	OC - 707903
-	264	-	EA	5/8" WASHER 1/8" THICK	OC - 707903
-	-	-	EA	10 FEET 5/8" UNC ROD	OC - 707903

NOTE: ALL LENGTH AND QUANTITY NEED TO BE VALIDATED ON CONSTRUCTION SITE.



PLAN VIEW
SCL: N.T.S.

POUR CONSTRUCTION
FOR CONSTRUCTION
AGNICO EAGLE
DATE : 2018-07-20

PERMIT TO PRACTICE
SNC - LAVALIN STAVIBEL INC.
Signature
Date 2018/07/26
PERMIT NUMBER: P 718
NT/NU Association of Professional Engineers and Geoscientists

2018/07/26

PLAN CLÉ
KEY PLAN



NOTES GÉNÉRALES / GENERAL NOTES

1. ALL LENGTH AND QUANTITY NEED TO BE VALIDATED ON CONSTRUCTION SITE.

——— PIPING ON GROUND
- - - - - - PIPING IN TRENCH

THE DESIGN AND MATERIALS ON THIS DRAWING ARE ASSUMED BY AGNICO EAGLE.

SNC-LAVALIN
SNC-Lavalin Stavibel Inc.
155, rue Gamble Ouest
Rouyn-Noranda (Québec) J9X 3N7
Tél. : 819 764-5181 Fax : 819 797-0158
www.snclavalin.com

Project # : 644819-0000

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

TITRE / TITLE	# DWG
-	-
-	-
-	-
-	-
-	-
-	-

AGNICO EAGLE

NO.	DATE	DESCRIPTION	DESSINÉ PAR/DRAWN BY	C.H.D.	C.I.D.	A.P.A.
0	2018-07-20	ISSUED FOR CONSTRUCTION				

REVISIONS

TITRE / TITLE
AGNICO EAGLE – WHALE TAIL (AMARUQ)
460 – SEWAGE WATER TREATMENT PLANT
270 – PIPING
PLAN VIEW
SEWAGE WATER PIPING (ROUTING)
FROM TREATMENT PLANT TO ATTENUATION POND

DESSINÉ PAR / DRAWN BY	NICOLAS BORDELEAU G., TECH.	DATE 2018-06-12
VÉRIFIÉ PAR / CHECKED BY	KEVEN PLANTE-MARQUIS, ING.	2018-07-20
APPROUVÉ PAR / APPROVED BY	CHRISTIAAN VAN GUNTHER, ING.	2018-07-20
ÉCHELLE / SCALE	N.T.S.	DATE 2017-12-01

NO. DESSIN / DRAWING NO. 61-460-270-201

NO. PROJET / PROJECT NO.	REVISION	FEUILLE / SHT
6115	0	1/1

AE-GAR-460X 0

N:\Projet\Amaruq\200 Studies\810 Amaruq Infra Eng Project\For approval\Plan & profile\61-460-270-201-1_R0.dwg

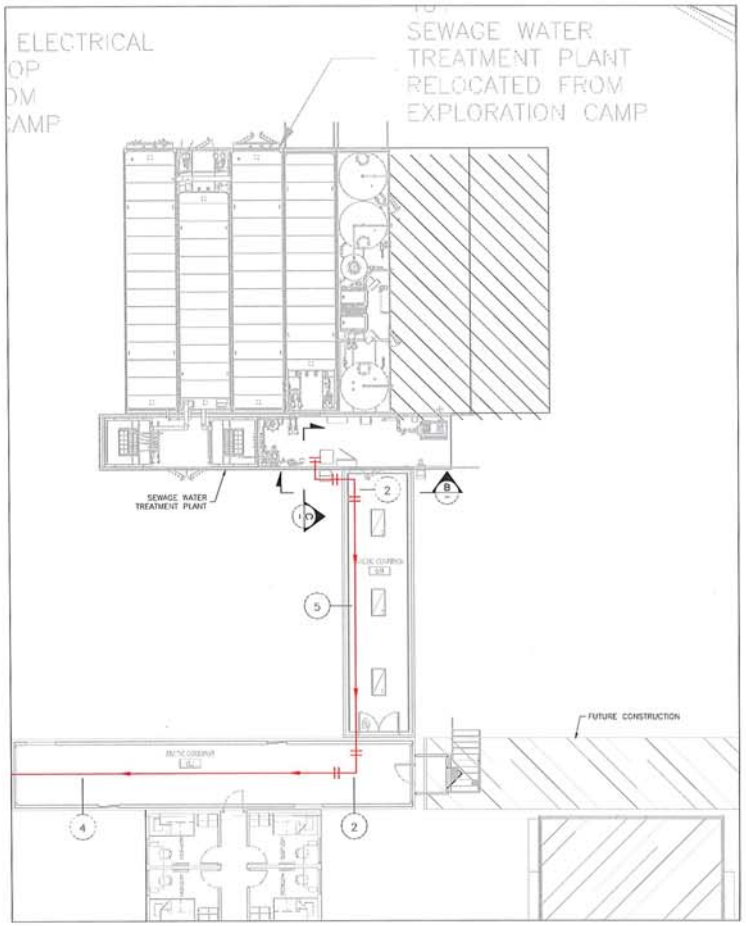
NO. DESSIN DRAWING NO. 61-460-270-201-1_R0

FORMAT ARCH D

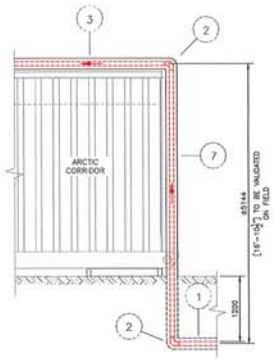
POUR CONSTRUCTION
FOR CONSTRUCTION
AGNICO EAGLE
DATE : 2018-07-20

PART	QUANTITY	LENGTH	UNIT	DESCRIPTION	ORDER
1	1	± 3 360	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
2	8	-	EA	ELBOW 90° - 3" HDPE DR17 FLANGED ENDS	OC - 707903
-	8	-	EA	ELBOW 90° - 3" HDPE DR17 COMPLETE INSULATION KIT	OC - 707903
3	1	± 110	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
4	1	± 430	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
5	1	± 45	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
6	2	± 2.5	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
7	1	± 17	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
8	1	± 12	FT	PIPING HDPE DR17 3 PO INSULATE	OC - 703225
9	1	-	EA	REDUCER 3" TO 2" HDPE DR11 FLANGED ENDS	OC - 707903
-	64	-	EA	3" HDPE DR17 COMPLETE SLIPJOINT 2.5" INSULATION KIT	OC - 707903
-	49	-	EA	FLANGE ADAPTER 3" HDPE DR17	OC - 707903
-	49	-	EA	FLANGE RING CLASS150 FOR 3" HDPE DR17 STUB END	OC - 707903
-	16	-	EA	FLANGE ADAPTER 3" HDPE DR17 COMPLETE 2.5" INSULATION KIT	OC - 707903
-	33	-	EA	3" RED RUBBER FULL FACED GASKET 1/8"	OC - 707903
-	132	-	EA	5/8" UNC GRADE 5 BOLT - 4" LENGTH (3" FLANGE)	OC - 707903
-	132	-	EA	5/8" UNC GRADE 5 NUT	OC - 707903
-	264	-	EA	5/8" WASHER 1/8" THICK	OC - 707903
-	-	-	EA	10 FEET 5/8" UNC ROD	OC - 707903

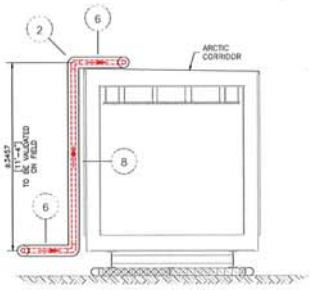
NOTE: ALL LENGTH AND QUANTITY NEED TO BE VALIDATED ON CONSTRUCTION SITE.



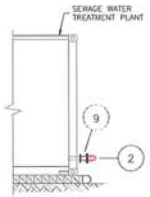
DETAIL
SCALE: N.T.S.
1
1/2



SECTION
SCL. N.T.S.
A
1/2



SECTION
SCL. N.T.S.
B
-



SECTION
SCL. N.T.S.
C
-

PERMIT TO PRACTICE
SNC-LAVALIN STAVIBEL INC.
Signature
Date 2018/07/26
PERMIT NUMBER: P 718
NT/NU Association of Professional Engineers and Geoscientists

2018/07/26



NOTES GÉNÉRALES / GENERAL NOTES

1. ALL LENGTH AND QUANTITY NEED TO BE VALIDATED ON CONSTRUCTION SITE.

——— PIPING ON GROUND
- - - - - - PIPING IN TRENCH

THE DESIGN AND MATERIALS ON THIS DRAWING ARE ASSUMED BY AGNICO EAGLE.

SNC-LAVALIN
SNC-Lavalin Stavibel inc.
135, rue Gamble Ouest
Rouyn-Noranda (Québec) J9X 2R7
Tél. : 819 763-5181 Fax : 819 797-0708
www.snclavalin.com

Project # : 644819-0000

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

NUMÉRO / TITLE	# DWG
-	-
-	-
-	-
-	-
-	-
-	-

AGNICO EAGLE

REV.	DATE	DESCRIPTION	DRAWN	APP.	CLIENT
0	2018-07-20	ISSUED FOR CONSTRUCTION	N.B.G.	E.J.G.	K.P.M.

REVISIONS

TITRE / TITLE

AGNICO EAGLE – WHALE TAIL (AMARUQ)
460 – SEWAGE WATER TREATMENT PLANT
270 – PIPING
DETAILS & SECTIONS
SEWAGE WATER PIPING (ROUTING)
FROM TREATMENT PLANT TO ATTENUATION POND

DESSINÉ PAR / Drawn BY	NICOLAS BORDELEAU G., TECH.	DATE 2018-06-12
VÉRIFIÉ PAR / CHECKED BY	KEVEN PLANTE-MARQUIS, ING.	2018-07-20
APPROUVÉ PAR / APPROVED BY	CHRISTIAN WH GUNTHER, ING.	2018-07-20
ÉCHELLE / SCALE	N.T.S.	DATE 2017-12-01

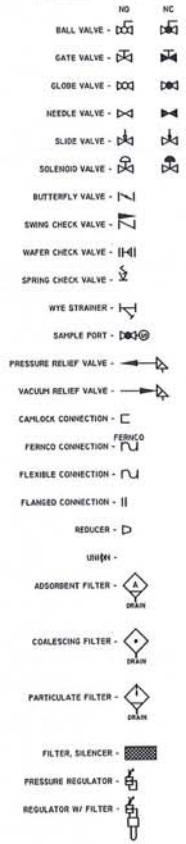
NO. DESSIN / DRAWING NO. 61-460-270-201

NO. PROJET / PROJECT NO.	REVISION	FEUILLE / SHT
6115	0	2 / 2

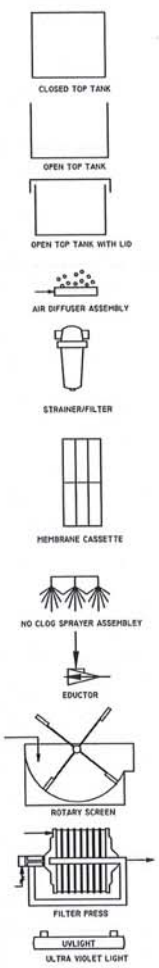
AE-GWT-460H 0

N:\Projet\Amaruq\6000 Studies\6115 Amaruq Infra Eng Project\For approval\Plot & scale\61-460-270-201-1_R0.dwg

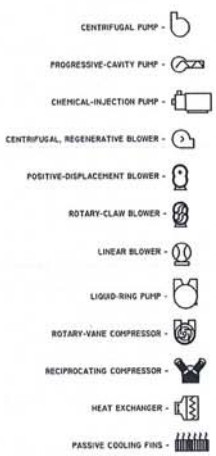
VALVES AND PIPING



EQUIPMENT



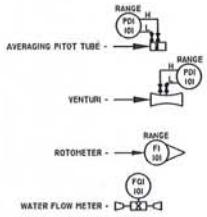
EQUIPMENT



EQUIPMENT

AV - ACTUATED VAVLE
B - BLOWER
F - FAN
H - HEATER
MBR - MEMBRANE BIOLOGICAL REACTOR
MV - MODULATED VALVE
P - PUMP
SV - SOLENOID VALVE
TNK - TANK
UV - ULTRA VIOLET LIGHT
VFD - VARIABLE FREQUENCY DRIVE

FLOW MEASUREMENT



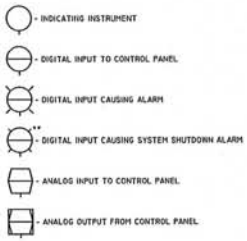
INSTRUMENT DESIGNATION

	INPUT	1ST MODIFIER	2ND MODIFIER	3RD MODIFIER	OUTPUT	1ST MODIFIER	
A							A
B						BLOWER	B
C	CYCLE					COMPRESSOR	C
D		DIFFERENTIAL				AIR DRYER	D
E							E
F	FLOW					FAN	F
G	GAS (LEL)		GAUGE				G
H				HIGH	HAND	HEATER	H
I	CURRENT		INDICATOR				I
J							J
K							K
L	LEVEL			LOW			L
M					MOTORIZED		M
N							N
O							O
P	PRESSURE				PNEUMATIC	PUMP	P
Q		QUANTITY					Q
R							R
S	SPEED		SWITCH		SOLENOID		S
T	TEMPERATURE		TRANSMITTER				T
U							U
V						VALVE	V
W							W
X							X
Y							Y
Z	POSITION						Z

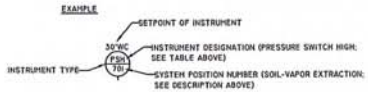
SYSTEM POSITION DESIGNATION

1000 - LIFT STATION
2000 - INLET SCREEN
3000 - EQUALIZATION TANK
4901 - SCREEN DISCHARGE PUMP TANK
5000 - AERATION TANK
5500 - SLUDGE HOLDING TANK
6000 - MBR TANK
6100 - CHEMICAL INJECTION
7000 - PERMEATE
7500 - UV LIGHT
7900 - BUILDING,TRAILER OR SKID
8000 - DISCHARGE TANK
8200 - CONTROL PANEL
8300 - TELEMETRY
9900 - EXTRAS

INSTRUMENT IDENTIFICATION



EXAMPLE





NOTES

newterra

PHONE:
(800) 420-4056

www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
D	T-401 MIX PIPE SIZE	10/10/17	JJK
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

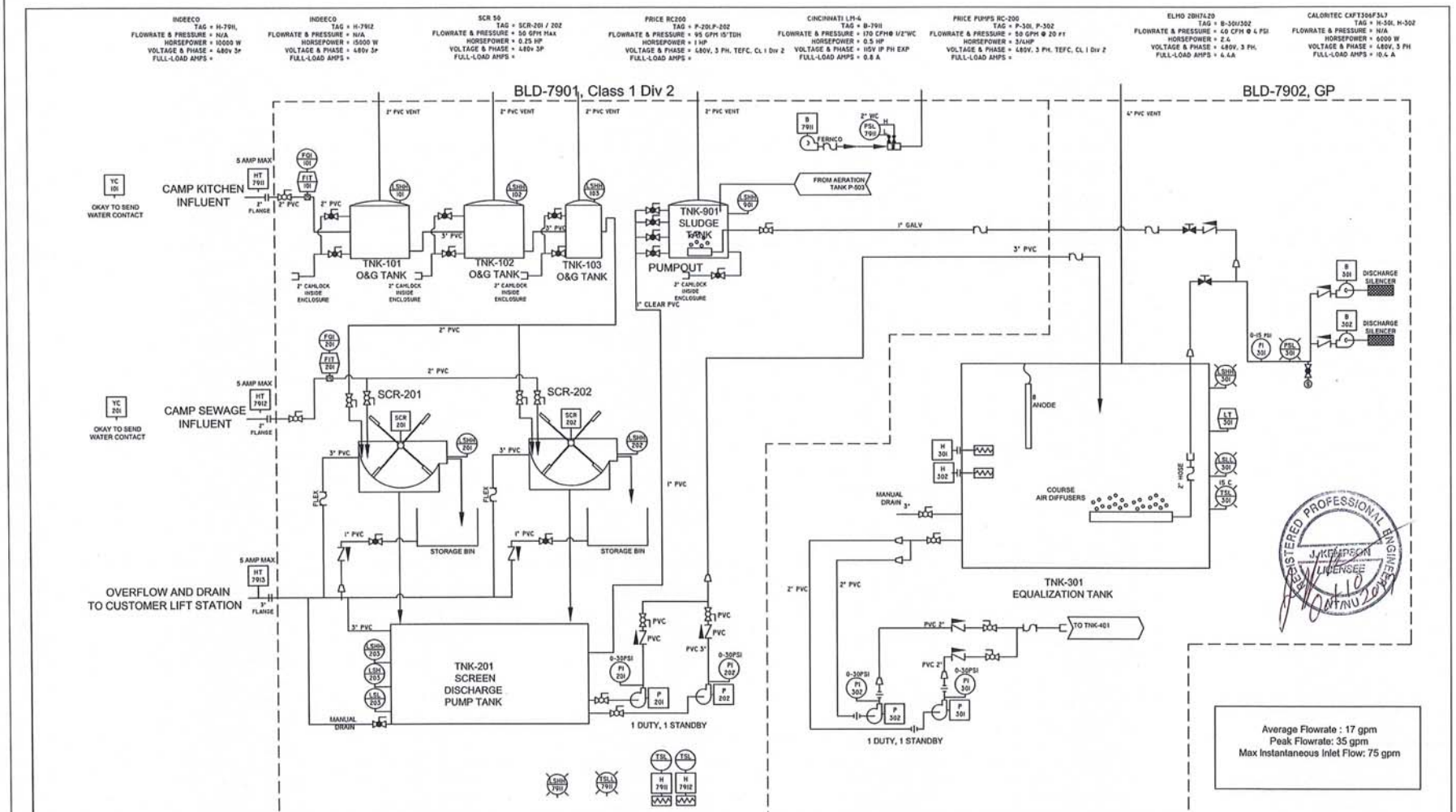
PROJECT NUMBER: 1704432

TITLE AND LOCATION: P&ID AMARUQ MINE

CUSTOMER: AGNICO EAGLE MINE

DRAWN BY: MH | DATE: | SHEET: 4 | SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra



REGISTERED PROFESSIONAL ENGINEER
J. KRAPEZON
LICENSEE
10
CONTINUED

NOTES

IS INPUT WIRING TO BE WIRED FOR OUTDOORS, ACCORDING CEC FOR HAZARDOUS LOCATIONS.

WIRING TO BE CLASS I DIVISION 2, AS PER THE CEC.

newterra

PHONE: (800) 420-4056

www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
D	T-401 MIX PIPE SIZE	10/10/17	JJK
C	AS-BUILT	13/09/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

PROJECT NUMBER: 1704432

TITLE AND LOCATION: P&ID AMARUQ MINE

CUSTOMER: AGNICO EAGLE MINE

DRAWN BY: MH | DATE: | SHEET: 1 | SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra

PRICE PUMPS RC-200
TAG = P-601,602
FLOWRATE & PRESSURE = 300 GPM @ 60 FT
HORSEPOWER = 5HP
VOLTAGE & PHASE = 480V, 3 PH, TEFC, CL 1 Div 2
FULL-LOAD AMPS =

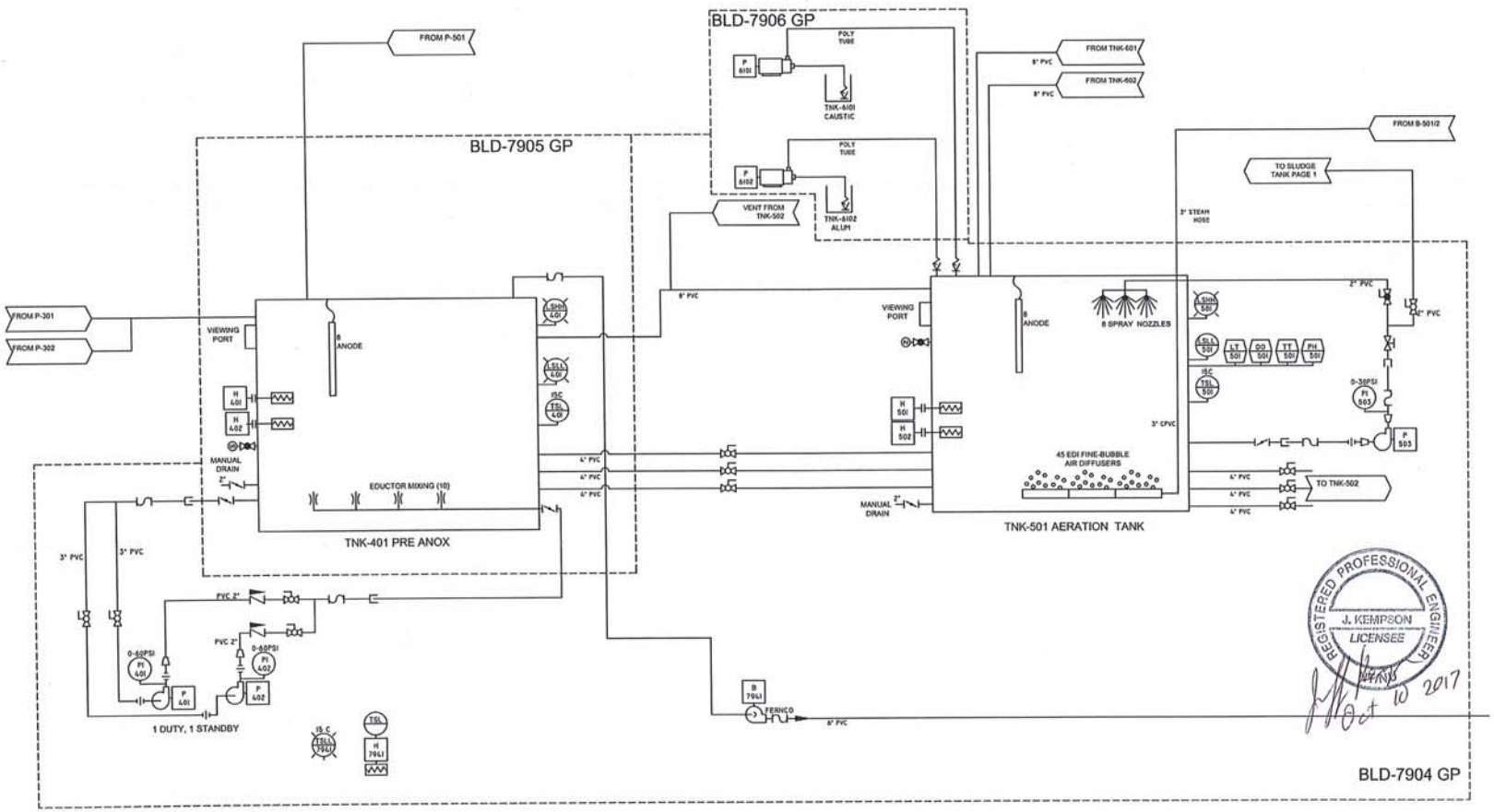
CALORITEC CXFT306F347H83
TAG = H-601,602,501,502
FLOWRATE & PRESSURE = N/A
HORSEPOWER = 6000 W
VOLTAGE & PHASE = 480V, 3 PH
FULL-LOAD AMPS = 10.4 A

CINCINNATI LM6
TAG = B-794I
FLOWRATE & PRESSURE = 700 CFM@ 2"WC
HORSEPOWER = 1.5 HP
VOLTAGE & PHASE = 480V 3P PH
FULL-LOAD AMPS =

OMELLET OAC649088L
TAG = H-794I
FLOWRATE & PRESSURE = N/A
HORSEPOWER = 4800 W
VOLTAGE & PHASE = 480 V, 1 PH
FULL-LOAD AMPS = 8.34

PRICE PUMPS RC-200
TAG = P-503
FLOWRATE & PRESSURE = 50 GPM @ 10 FT
HORSEPOWER = 1/4 HP
VOLTAGE & PHASE = 480V, 3 PH, TEFC, CL 1 Div 2
FULL-LOAD AMPS =

PROMINENT BETA 4
TAG = P-601, 602
FLOWRATE & PRESSURE = 3.2 GPH@58PSI
HORSEPOWER = N/A
VOLTAGE & PHASE = 120 V, 1 PH
FULL-LOAD AMPS = N/A



REGISTERED PROFESSIONAL ENGINEER
J. KEMPSON
LICENSEE
Oct 10 2017

NOTES

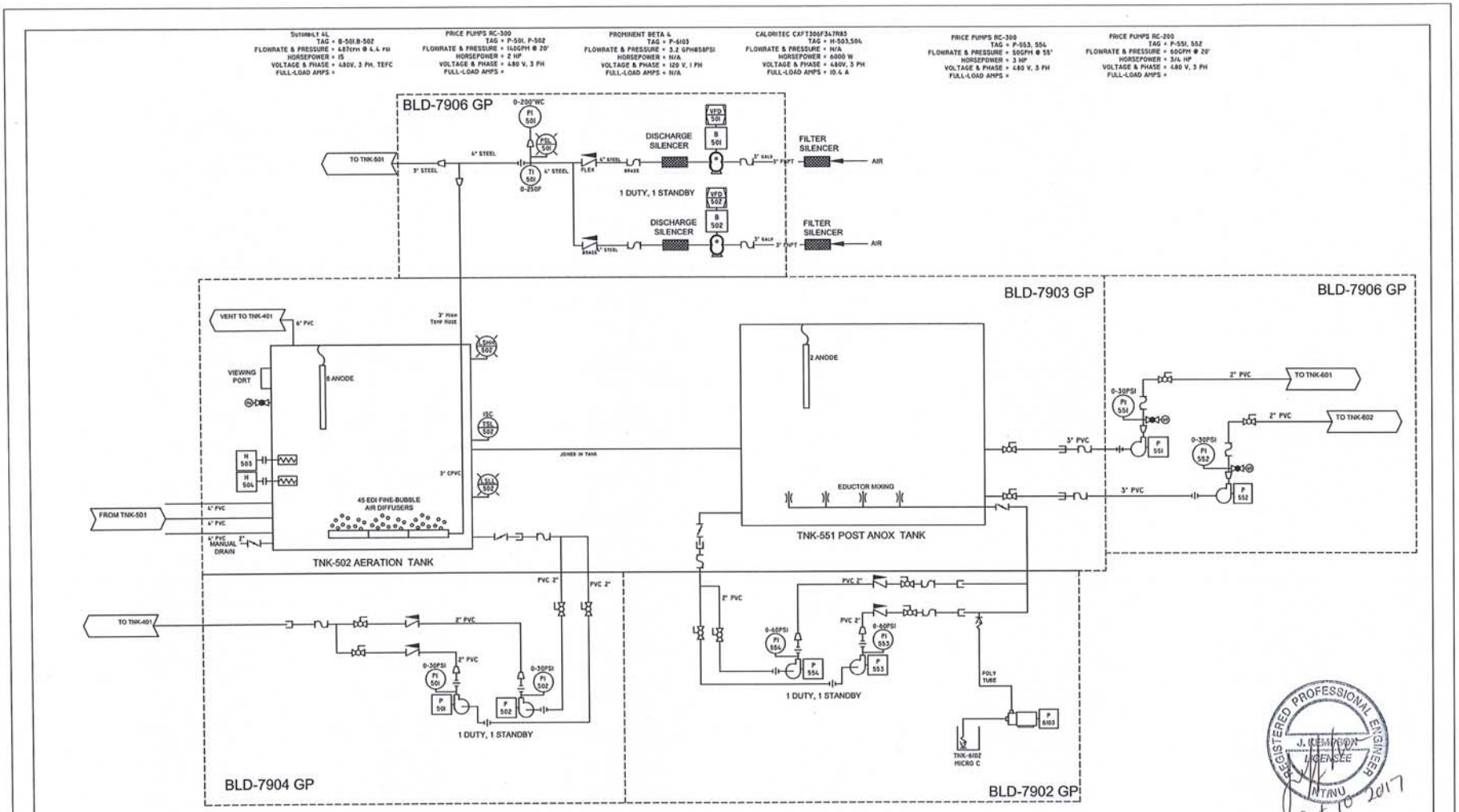
newterra

PHONE: (800) 420-4056
www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
D	T-401 MIX PIPE SIZE	10/10/17	JJK
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

PROJECT NUMBER: 1704432
TITLE AND LOCATION: P&ID AMARUQ MINE
CUSTOMER: AGNICO EAGLE MINE
DRAWN BY: MH
DATE:
SHEET: 2
SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra



REGISTERED PROFESSIONAL ENGINEER
J. KEMPTON
LICENSEE
NT/NU
Oct 10 2017

NOTES

newterra

PHONE: (800) 420-4056

www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
D	T-401 MIX PIPE SIZE	10/10/17	JJK
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

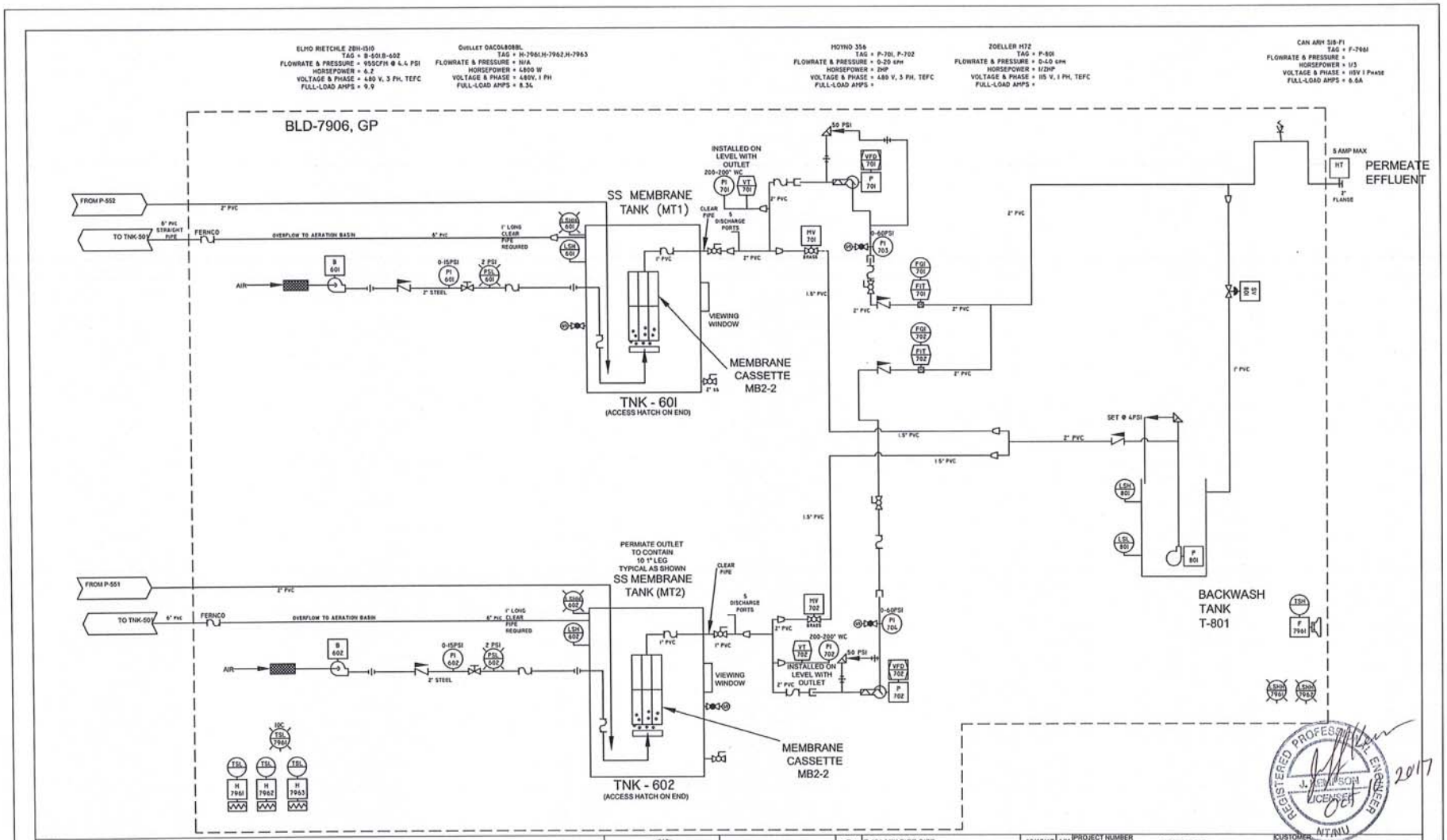
PROJECT NUMBER: 1704432

TITLE AND LOCATION: P&ID AMARUQ MINE

CUSTOMER: AGNICO EAGLE MINE

DRAWN BY: MH | DATE: | SHEET: 3 | SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra



NOTES

newterra
PHONE: (800) 420-4056
www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
D	T-401 MIX PIPE SIZE	10/10/17	JJK
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

PROJECT NUMBER: 1704432
TITLE AND LOCATION: P&ID AMARUQ MINE
CUSTOMER: AGNICO EAGLE MINE
DRAWN BY: MH
DATE:
SHEET: 4
SHEETS: 4

REGISTERED PROFESSIONAL ENGINEER J. KEVIN SON LICENSED 2017 NT/NU

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra

Appendix C: Newterra Operation and Maintenance Manual

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

newterra MBR Wastewater Treatment Plant

OPERATION AND MAINTENANCE MANUAL

System:	**newterra MBR WWTP**
Location:	**Amaruq mine, Kivalliq District of Nunavut**
Client:	**Agnico Eagle**
Project:	**1704432**
Rev.:	**1**
Date:	**August 2017**

All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

TABLE OF CONTENTS

1.0 INTRODUCTION 8

2.0 SAFETY 10
2.1 Introduction 10
2.2 Personal Protective Equipment (PPE) 11
2.2.1 Head protection 11
2.2.2 Eye and Face Protection 11
2.2.3 Foot Protection 12
2.2.4 Hand Protection 12
2.2.5 Body Protection 12
2.2.6 Hearing Protection 13
2.3 Bacterial Safety 13
2.4 Chemical Safety 13
2.5 Electrical Safety 14
2.5.1 Lockout Procedures 14
2.6 Confined Spaces 15
2.7 Fire Safety 16
2.8 Responsibility for Safety 16
2.8.1 Management 16
2.8.2 Worker 16
2.8.3 Plant Safety – Simple Rules to Follow 17
2.9 Hazard Warning Signs/Symbols 18
2.10 First aid 19
2.10.1 CPR Poster 20

3.0 WASTEWATER TREATMENT PLANT DESIGN BASIS 22
3.1 newterra MicroClear™ MBR Process Specification 22
3.2 MicroClear™ MB2-2 Membrane Module Characteristics 23
3.3 MicroClear™ MCXL Membrane Cassette Characteristics 23
3.4 Influent/Effluent Wastewater Characteristics 24
3.5 Estimated Chemical Consumption 24
3.6 Prohibited Items 25
3.7 Removal of Oily Materials 25
3.8 MicroClear™ Membrane Compatibility Chart 26

4.0 PLANT INSTALLATION, INSPECTION, AND TESTING 28
4.1 System Overview 28
4.2 Site Conditions Requirements 29
4.3 Inspection upon Delivery 29
4.4 Plant Initial Set up 30
4.4.1 Installation Checklist 30
4.4.1.1 Customer's Scope List 30
4.4.1.2 Civil Checklist 31
4.4.1.2 Electrical Checklist 31
4.4.1.3 Mechanical Checklist 32
4.4.2 System Electrical Specifications 32
4.5 Plant Initial Testing 33
4.5.1 Dry Test 33

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

4.5.2 Hydraulic Test 33
4.5.2.1 EQ, Anox and Aeration Tanks 34
4.5.2.2 Membrane Tank 34
4.5.2.3 O&G and 901 Tanks 35

5.0 OPERATION OF NEWTERRA MICROCLEAR™ MBR 36
5.1 Control System – Main SCADA Control, PLCs and HMIs 36
5.1.2 HMI Control Screen 36
5.1.3 HOA (Hand/Off/Auto) Screen 38
5.1.4 Process Screens 39
5.1.5 HMI Alarm Screen 41
5.2 WWTP Buildings/Utilities 43
5.2.1 Power Supply 43
5.2.2 E-Stop 43
5.2.3 Building Temperature Control 43
5.2.3.1 Logic 43
5.2.3.2 Alarms 44
5.2.4 Ventilation 44
5.2.4.1 Logic 44
5.2.4.2 Alarms 44
5.3 Process Narrative 45
5.4 Kitchen Inlet Module (TNK-101/2/3) Module 47
5.4.1 Function 47
5.4.2 Inputs 47
5.4.3 Setpoints 48
5.4.4 Logic 48
5.4.5 Alarms 48
5.5 Fine Screens (SCR-201/202) Module 49
5.5.1 Function 49
5.5.2 Inputs 49
5.5.3 Setpoints 50
5.5.4 Logic 50
5.5.5 Alarms 50
5.6 Equalization Tank (TNK-301) Module 51
5.6.1 Function 51
5.6.2 Inputs 51
5.6.3 Setpoints 52
5.6.4 Logic 52
5.6.5 Alarms 53
5.7 Pre-Anox Tank (TNK-401) Module 54
5.7.1 Function 54
5.7.2 Inputs 54
5.7.3 Setpoints 55
5.7.4 Logic 55
5.7.5 Alarms 55
5.8 Aeration Tanks (TNK-501/502) - Biological Treatment Module 56
5.8.1 Function 56
5.8.2 Inputs 57
5.8.3 Setpoints 57
5.8.4 Logic 58

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.8.5 Alarms 60
5.9 Post-Anox Tank (TNK-551) Module 61
5.9.1 Function 61
5.9.2 Inputs 61
5.9.3 Setpoints 61
5.9.4 Logic 62
5.9.5 Alarms 62
5.10 Membrane and Permeate Module 63
5.10.1 Function 63
5.10.2 Inputs 64
5.10.3 Setpoints 64
5.10.4 Logic 66
5.10.5 Alarms 68
5.10.6 Blower Control 69
5.10.7 CIP Cleaning 69
5.11 Sludge Holding Tank Module (TNK-901) 70
5.11.1 Function 70
5.11.2 Inputs 70
5.11.3 Setpoints 71
5.11.4 Logic 71
5.11.5 Alarms 71
5.12 Setpoints 72
5.12.1 PLC Date & Time 72
5.12.2 Factory Defaults 73
5.13 Statistics 73
5.14 PLC Status 74

6.0 PLANT START-UP, OPERATING GUIDELINES AND MONITORING 76
6.1 MBR Plant Start-Up 76
6.1.1 Mechanical & Electrical Start-up Procedure 76
6.1.2 Process Start-up 76
6.2 MBR System Operating Guidelines and Monitoring 81
6.2.1 Operating Guidelines 81
6.2.1.1 Membrane Filtration Operational Conditions 82
6.2.1.2 MBR – Recommended Biological Operational Conditions 83
6.2.2 Sampling 84
6.2.2.1 Filterability Test 85
6.2.3 Suggested Test Equipment for Monitoring 86
6.2.3.1 Filterability - Laboratory Glassware and Filter Paper 86
6.2.3.2 Turbidity, Phosphorus - Hach DR900 (and reagents) 87
6.2.3.3 DO and pH - Hach HQ40d with probe or Equivalent 87
6.2.3.4 Sludge Settling - Settleometer 88
6.2.3.5 TSS - Aysix model 3150 hand held TSS meter or Equivalent 88
6.2.3.6 Hach CEL Advanced Wastewater Laboratory 88
6.2.4 Record Keeping 89
6.2.5 Process Trending 89

7.0 SYSTEM MAINTENANCE 90
7.1 Plant Visual Checks 90
7.1.1 Air Scouring Patterns in Membrane Tanks 91

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.2 Schedule for Routine Operation and Maintenance Checkups 92
7.3 MBR Membrane Cleaning 97
7.3.1 Membrane In-situ Chemically Enhanced Backflush (CEB) 97
7.3.1.1 Procedure – Backwash Solution Preparation 98
7.3.1.2 Procedure – Organic Fouling Solution 99
7.3.1.3 Procedure – Organic Fouling Solution 100
7.3.1.4 Procedure 100
7.3.2 Membrane Recovery Cleaning 101
7.3.2.1 Step 1 - Preparation 102
7.3.2.2 Step 2 – Cleaning with High pH Solution 102
7.3.2.3 Step 3 - Cleaning with Sodium Hypochlorite (NaOCl) 103
7.3.2.4 Step 4 - Cleaning with Citric Acid 104
7.3.2.5 Step 5 - Resume normal operation 104
7.3.2.6 Step 6 - Checking Permeability 104
7.3.3 Membrane Physical Check 105
7.4 Sludge Decanting (TNK-901) 108
7.5 Trouble Shooting 109
7.5.1 MBR Membrane Fouling 109
7.5.1.1 Microbial/Biological Fouling 109
7.5.1.2 Particulate/colloid Fouling 109
7.5.1.3 Inorganic Fouling 110
7.5.1.4 Organic Fouling 110
7.5.1.5 Fouling Prevention 111
7.5.1.5 MBR WWTP Fouling Control & Troubleshooting Chart 112
7.5.1.5.1 Air Scouring 112
7.5.2 MBR Alarm Trouble Shooting 114
7.5.3 MBR Process Trouble Shooting 119
7.5.3.1 Biological System 119
7.5.3.2 Foaming 121
7.5.3.3 Permeate 122
7.5.3.4 Membrane air system 124
7.5.3.5 Membrane Cleaning 124
7.5.3.6 Mechanical / Electrical Issues 125
7.5.4 P-201/2, 301/2, 401/2, 501/2, 553/4, 551/2 - Trouble Shooting 126
7.5.5 P-701/702 Trouble Shooting 127
7.5.6 P-801 Trouble Shooting 128
7.5.7 B-501/502 - Trouble Shooting 128
7.5.8 B-301/302, B-601/602 - Trouble Shooting 129
7.5.9 LT-301/501 - Trouble Shooting 130
7.5.10 PH-501 - Trouble Shooting 135
7.5.11 MV-701/702 - Trouble Shooting 137

8.0 SHUT DOWN 139
8.1 MBR Temporary Shut Down 139
8.2 MBR Permanent Shut Down / Winterizing 139
8.2.1 Process Shut Down Procedure 139
8.2.2 Cleaning - General 139
8.2.3 Membranes 139
8.3 General Components 141
8.4 Blowers – B-501/502 143

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

8.4 Chemical Dosing Pumps – P-6101/6102/6103 144

9.0 SERVICE & SUPPORT 146
9.1 Commissioning and Start-up 146
9.1.1 Startup/Commissioning 146
9.1.2 Training 146
9.2 Post commissioning Services 147
9.2.1 Technical Support 147
9.2.2 Spare Parts 147
9.2.3 Assistance in telemetry control and monitoring 148
9.2.4 Site visits and system audits 149

10.0 WARRANTY 150

List of Appendices

Appendix A Drawings
Appendix B Packing Slips
Appendix C Commissioning Checklists
Appendix D Recommended Spare Parts List
Appendix E Technical Specs and Brochures for Parts and Equipment
Appendix F Material Safety Data Sheets
Appendix G Glossary & Terms
Appendix H Biological Treatment & Monitoring Parameters
Appendix I Process and Chemicals Dosage Calculations
Appendix J newterra MicroClear™ Membrane Cleaning Log Sheet
Appendix K Control Narrative

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

1.0 INTRODUCTION

The purpose of this manual is to provide necessary information for the Installation, Operation and Maintenance of the Wastewater Treatment Plant equipment.

ATTENTION	**The newterra MicroClear™ MBR wastewater treatment plant (WWTP) functions optimally if the operating procedures described in this manual are followed. If you have any questions after reading through this manual, please contact newterra ltd.**

- This O&M Manual must be kept on-site and available to employees at all time.
- It is IMPERATIVE that employees read the manual BEFORE working in the plant.
- Employees must read ***Section 2*** – Health and Safety.
- Technical Support Department contacts are provided in ***Section 9***.



WARNING: ***Failure to comply with the instructions provided in this manual can cause equipment & property damage or severe personal injury, and will render the warranty null and void.***

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

2.0 SAFETY

2.1 Introduction

This section provides general personal and environmental safety information for newterra MBR WWTP operators.

Always refer to local codes and regulations.

Specific equipment and parts safety information can be found in Appendix E. Material Safety Data Sheets (MSDSs) include detailed information regarding health & safety of chemicals used in wastewater treatment process and are presented in Appendix F. These are sample MSDS sheets and need to be replaced by the actual vendor MSDS sheets.
Information and guidelines outlined in this manual **must** be followed at all times prior to system installation and during operation and maintenance.

ESSENTIAL FOR SAFE OPERATION:

- Installation and operation of the newterra system must only be carried out by **trained and qualified** personnel.
- All necessary **safety precautions must** be carefully exercised, including but not limited to proper use of personal protective equipment considering given working environment and conditions.
- All **electrical installations and troubleshooting must** only be carried out by licensed electricians.
- All **plumbing work must** only be carried out by licensed plumbers or qualified personnel.
- Please keep in mind that trees and shrubs taller than two meters located in close proximity to the newterra system may become a safety concern at the time of installation or service.

DEFINITION OF SAFETY AND WARNING SIGNS USED IN THE MANUAL



ATTENTION SYMBOL

Special attention is required to ensure compliance with instructions concerning correct operating sequences to prevent damage to the plant or its function.

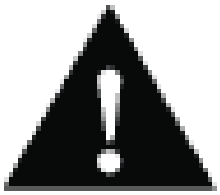


GENERAL WARNING SIGN

This symbol accompanies all important instructions or warnings associated with risks of injury as well as possible equipment damage.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com



WARNING

CRITICAL WARNING SIGN

Warns against an unsafe situation or practice associated with severe injury as well as major equipment damage.

2.2 Personal Protective Equipment (PPE)

Personal protective equipment (PPE) refers to protective clothing, gloves, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. ”Protective clothing" is applied to traditional categories of clothing, and "protective gear" applies to items such as pads, guards, shields, masks, and others.

The purpose of personal protective equipment is to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective to reduce these risks to acceptable levels. PPE is needed when there are hazards present. PPE has the serious limitation that it does not eliminate the hazard at source and may result in employees being exposed to the hazard if the equipment fails.
The following list includes the minimum scope of PPE that should be available to system operators:

2.2.1 Head protection

Hard hats, bump caps, or helmets are types of protection that should be considered if there is a hazard of head injury. Head injuries can occur under various circumstances including as the result of a slip or fall, working in confined areas or where there are low ceilings, where there may be falling objects. Hard hats should be worn at all times when overhead work is being conducted.

2.2.2 Eye and Face Protection

Eye protection with side shields should be used at all times while inside the newterra system as there may be a danger of flying objects, particles, liquids, sprays or other matter entering the eyes. Protection can take many forms including:

- safety glasses,
- goggles, or
- full face protection. This should be used if handling chemicals, waste product or working around pressurized lines (air of liquid).

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

2.2.3 Foot Protection

Foot protection should be used at all times within the newterra system. Foot protection is usually in the form of steel-toed work boots, with a steel shank to protect the bottom of the foot from puncture wounds. In wet environments, steel-toed boots that are waterproof and slip-resistant may be necessary.

2.2.4 Hand Protection

Hand protection should be worn within the newterra system. The workplace can create many hazards for hands, whether from chemicals, cuts or burns. No single glove can provide appropriate protection for every work situation, so it is important to assess the risk for each task and select a glove that provides specialized protection.

The following is a list of gloves and their suggested appropriate application:

- Coated fabric gloves: This type of glove can provide protection against some moderate concentrated chemicals. They can be used in laboratory work provided they are strong enough to protect against the specific chemical being handled.
- Rubber, plastic or synthetic gloves: These types of glove can be used when cleaning or working with oils, solvents and other chemicals.
- Leather gloves: These should be used when welding, as the leather can resist sparks and moderate heat. The risk of cuts and abrasions also can be minimized by wearing leather gloves.
- Kevlar gloves: These have a wide variety of industrial applications. They are cut- and abrasion-resistant and provide protection against both heat and cold.
- Chemical/liquid-resistant gloves: Several types of gloves help protect against specific chemicals:
    - Butyl rubber gloves: nitric acid, sulfuric acid, hydrochloric acid and peroxide
    - Natural latex/rubber gloves: water solutions or acids, alkalis, salts, and ketones
    - Neoprene gloves: hydraulic fluids, gasoline, alcohols and organic acids
    - Nitrile rubber gloves: chlorinated solvents

2.2.5 Body Protection

Body protection may be required in various situations including dusty environments or when spraying liquid pesticides or handling dangerous chemicals. The hazard to be controlled will determine the type of protection that is most appropriate, for example, an apron, coveralls or a full rain suit. As a minimum, the operator should be wearing work coveralls.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

2.2.6 Hearing Protection

Hearing protection should be worn in work environments where noise levels exceed 85 decibels – such as around blowers and air compressors. There are many types of hearing protection, including earplugs or muffs. Hearing protection that is suitable for the work environment and provides adequate noise reduction should be chosen. Disposable ear plugs or headset style are acceptable.

2.3 Bacterial Safety

The wastewater contains a mixture of viable bacteria and other biological organisms. A wastewater treatment plant poses a number of bacterial hazards and consequently potential health risk. Immunization protects operator against infection. The use of proper hygiene measures, protective equipment, good housekeeping and common sense prevent contact with pathogens.

These measures prevent infection!



Ensure that hands are washed with an antibacterial soap and warm water and dried by disposable towels on a regular basis, especially prior eating!
Do not expose cuts or open sores to wastewater!
Use personal protective equipment (PPE) at all times in wastewater treatment facility!
Any concern about possible infection should be brought to the attention of medical physician immediately!

2.4 Chemical Safety

The following chemicals are used in operation of newterra MBR WWTP:

- **Sodium Carbonate (Soda Ash)** is used for pH adjustment, in case there is a deficiency in alkalinity in influent sewage and pH drops. It is hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation (lung irritant).
- **Sodium hypochlorite (NaOCl)** and **Citric Acid ($C_6H_8O_7$)** are used for cleaning the membranes.
    - **Sodium hypochlorite (NaOCl)** is a common disinfectant, which can be an irritant or corrosive, depending on its concentration. It cannot be mixed with organics, ammonia compounds or acids. ***Contact with acids produces highly toxic chlorine gas***. ***It has to be mixed only with pure water.***
    - **Citric Acid ($C_6H_8O_7$)** is hazardous in case of skin contact (irritant, sensitizer), or ingestion, eye contact (irritant) and inhalation (lung irritant).

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

- **Aluminium Sulphate ($Al_2(SO_4)_3$)** is used for Phosphorus Removal. Mild to moderate irritation can occur from unprotected contact. Aluminum is very poorly absorbed through the skin and toxic effects would not be expected following short-term skin contact. Inhalation of mists can be irritating to the respiratory tract and lungs.

- **MicroC 2000** is used for nitrate removal.
  - Exposure to eyes may cause slight irritation
  - Exposure to Skin may cause slight irritation
  - Inhalation of high mist concentrations may cause irritation of respiratory tract.

When handling chemicals, it is important to wear proper personal protective equipment such as chemical goggles with combination full face shield, protective clothing with chemical splash apron and chemical-resistant rubber gloves.



The above descriptions are preliminary warnings only. The MSDSs for each of the chemicals should be consulted prior to using or handling any of the chemicals.
Sample MSDSs for chemicals used in the PWTP process can be found in Appendix F of this Manual.



WARNING

Mixing chemicals can result in dangerous reactions, including violent splashing, fires, explosions and release of toxic gases!
Chemicals should only be used for their intended uses!

2.5 Electrical Safety

Power may be supplied to control panels from various sources. Even if the disconnect is in the OFF position, certain electrical components inside the panel may be energized and servicing should not be conducted unless all incoming power is disconnected. Refer to the electrical drawings in Appendix A of this manual.

Ensure that the system is properly grounded before applying power to the system. Installation and servicing is only to be performed by **qualified authorized personnel**.

2.5.1 Lockout Procedures

Lockout procedures must be followed prior to performing mechanical or electrical maintenance to ensure that equipment has been de-energized. All relevant local guidelines and procedures must be applied. The person who locked out the device, should be the only person to remove the lockout.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

When equipment is to be locked out, employers, supervisors and workers should follow accepted lockout principles, including:

- Pre-planning for the lockout by identifying all energy sources, switches, etc.
- Where lockout is complex, a written sequence in checklist form should be prepared for equipment access, lockout/tagout, clearance, release and start-up.
- All workers affected by the lockout should be notified.
- Equipment should be shut down by normal means by turning of switches and closing valves etc.
- Equipment should be isolated from energy sources by disconnecting or blocking the sources of energy.
- Lockout and tag the energy isolating devices by padlock or some other locking device that the worker has control over as well as a tag indicating that the equipment has been shut down.
- Verify that all energy sources have been isolated by attempting to cycle the equipment prior to working on it.
- When work is completed, release equipment from lockout.
- Test equipment

2.6 Confined Spaces

"**confined space**" means a fully or partially enclosed space:

- that is not both designed and constructed for continuous human occupancy, and
- in which atmospheric hazards may occur because of its construction, location or contents or because of work that is done in it.

If you have a space that is fully or partially enclosed, the two conditions – (a) and (b) above – must both apply before the space can be considered a "confined space".

"**atmospheric hazards**" means:

- the accumulation of flammable, combustible or explosive agents,
- an oxygen content in the atmosphere that is less than 19.5 per cent or more than 23 per cent by volume, or
- the accumulation of atmospheric contaminants, including gases, vapours, fumes, dusts or mists, that could,
    - result in acute health effects that pose an immediate threat to life, or
    - interfere with a person's ability to escape unaided from a confined space.

Follow local laws and regulations with respect to entering a confined space.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

If a workplace includes a confined space that workers may enter to perform work, it is highly recommended that written program for the confined space is developed and maintained in accordance with this local regulations and policies before a worker enters the confined space. A confined space program is a written document that would include: a method for recognizing each confined space to which the program applies; a method for assessing the hazards to which workers may be exposed; a method for the development of confined space entry plans; a method for training workers; and, an entry permit system.

2.7 Fire Safety

Exposed hot surfaces can create potential burn/ignition hazards. Blowers and air compressors compress ambient air, causing heat to be generated. This heat can bring the temperature of the air compressor head and blower piping to a level that can cause burns to exposed flesh.
Follow local laws and regulations with respect to Fire Safety and regulations.

2.8 Responsibility for Safety

2.8.1 Management

Management is responsible for providing a safe working environment. This is accomplished partly by:

- Ensuring that all facilities and equipment are built and maintained in accordance with the appropriate safety standards
- Providing adequate funds for equipment and plant maintenance
- Establishing, promoting, and enforcing a ***safety policy***
- Establishing a safety training program
- Supplying easy accessible eyewash and first-aid stations and proper personal protective equipment (PPE) for personnel servicing wastewater treatment facility.

2.8.2 Worker

- To develop a positive and professional attitude towards safety.
- To avoid mistakes caused by indifference to safety, poor work habits, lack of attentiveness, rushing the job, failure to observe established safety procedures and poor physical condition.



***Remember the "ABC" of accident prevention*:**
ALWAYS BE CAREFUL!!!

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

In addition to ***"being careful"***, it is the responsibility of all workers to:

- Work in accordance with established safety procedures
- Follow the established safety rules
- Wear appropriate personal protective equipment (PPE)
- Report all accidents, no matter how minor
- Report potential safety hazards
- Participate in safety programs

2.8.3 Plant Safety – Simple Rules to Follow



Common sense plays a very important part in the safe operation of any type of plant!

- Wear the appropriate personal protective equipment at all times.
- Keep walkways clear of snow and ice, and loose objects such as pails, shovels, tools, etc.
- Clean up spills of oil, grease, chemicals, or other substances immediately.
- Keep all tools and similar equipment clean, in good condition, and properly stored when not in use.
- Replace all manhole covers, access trap doors, etc. as soon as possible. Erect a safety barrier if it is necessary to leave the opening uncovered.
- Wear a safety belt whenever there is the possibility of falling even a short distance, or when working over water.
- Lock out and tag electrical equipment before working on it or the associated equipment.
- Ensure that moving machinery is properly guarded. Wear ear protection in noisy environments.
- Ensure that fire-fighting equipment is in good working condition.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

2.9 Hazard Warning Signs/Symbols

Below is a sample of possible hazard warning signs/symbols that may be provided with the newterra system. It is recommended that the operator become familiar with the warning signs in the system.



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

2.10 First aid

First aid is emergency care given immediately to an injured person. The purpose of first aid is to minimize injury and future disability. In serious cases, first aid may be necessary to keep the victim alive.

It often consists of a one-time, short-term treatment and requires little technology or training to administer. First aid can include cleaning minor cuts, scrapes, or scratches; treating a minor burn; applying bandages and dressings; drinking fluids to relieve heat stress, etc.

Operators must know the location of emergency telephone number(s), First Aid Kits, emergency eye wash stations and first aid attendant(s).

In over 98% of locations in the United States and Canada, dialing "9-1-1" from any telephone will link the caller to an emergency dispatch office—called a Public-Safety Answering Point (PSAP) by the telecom industry—which can send emergency responders to the caller's location in an emergency. In approximately 96 percent of the U.S., the Enhanced 9-1-1 system automatically pairs caller numbers with a physical address.

Follow local laws and regulations with respect to First Aid procedures and reporting.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

2.10.1 CPR Poster

CPR for an Adult or Child

1

- Check the scene to ensure it is safe. If it is safe to do so, check the person and the person's ABCs (Airway, Breathing, Circulation).
- Call EMS/9-1-1 and get an AED or have someone else do this.



2

- Place the heel of one hand on the middle of the chest. Place the other hand on top.
- Do 30 compressions. Push hard, push fast.



3

- Open the airway by tilting the head back and lifting the chin. Pinch the nostrils closed and give 2 breaths.
- Repeat the cycle of 30 compressions and 2 breaths.
- Continue CPR until an AED arrives or more advanced care takes over.



The information on this poster does not replace formal First Aid & CPR training.

To find a Red Cross First Aid course in your area scan the QR code, or:
redcross.ca/firstaid | 1.877.356.3226

CANADIAN RED CROSS

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

3.0 WASTEWATER TREATMENT PLANT DESIGN BASIS

This section presents the design basis of the newterra MicroClear™ Membrane Bioreactor (MBR) Wastewater Treatment Plant (WWTP), including the influent constituent loading rates, hydraulic capacity and specifications for the membrane module and cassettes used. This section also includes a list of prohibited chemicals that should not be added to the influent wastewater and chemicals that should not come in contact with the membranes. The system is designed to meet effluent discharge criteria presented in this section below.

3.1 newterra MicroClear™ MBR Process Specification

Design loading	**SI Units**
Design Hydraulic Load	96 m^3/d
Organic Load	87.1 kgBOD/d
TKN Load	12.5 kgTKN/d
Phosphorus Load	1.15 kgTP/d
Process Tanks	**SI Units**
Three (3) Oil & Grease Tanks (TNK-101/TNK-102/TNK-103) with a total volume	12 m^3
One (1) Equalization Tank (TNK-301) with effective volume	40 m^3
One (1) Pre-Anoxic Tank (TNK-401) with effective volume	46 m^3
Two (2) Aeration Tanks (TNK-501/TNK-502) with total effective volume	76.5 m^3
One (1) Post-Anoxic Tank (TNK-401) with effective volume	8.6 m^3
Two (2) Membrane Tanks (TNK-601/TNK-602) each with effective volume	8.0 m^3
Two (2) Sludge Holding Tank (TNK-901) each with effective volume	7.0 m^3
Membrane Bioreactor (MBR) including anoxic tanks, aeration tanks and membrane tanks - total effective volume	**147.1 m^3**
Design Hydraulic Retention Time (HRT)	36.8 h
Sludge Age	26.5 d
Mixed Liquor Return Ratio - from Membrane Tank to Aerobic Tanks	5 x
Mixed Liquor Return Ratio - from Aerobic Tanks to Pre-Anoxic Tank	8 x
Design net flux (average)	13 LMH
Design Sludge Wasting Rate	5.36 m^3/d
Minimum design operating temp	**10 °C**

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

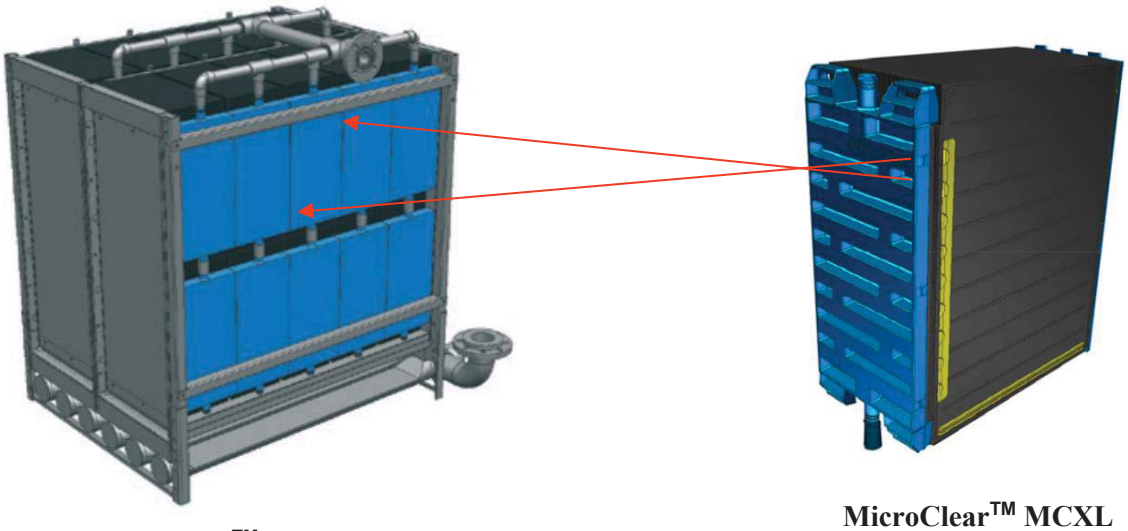
newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

3.2 MicroClear™ MB2-2 Membrane Module Characteristics

MicroClear™ MB2-2 membrane module	SI Units
MB2-2 modules in MBR	2
MCXL cassettes in MB2-2 module	20
Total Area of MB2-2 module	160 m^2
MB2-2 Module Dimensions (L x W x H)	1.302 m x 1.124 m x 1.379 m
Housing materials	Stainless steel

3.3 MicroClear™ MCXL Membrane Cassette Characteristics

MicroClear™ MCXL membrane cassette	
Membrane Material	Polyethersulfone (PES)
Individual Cassette Area	8 m^2
Pore Size	0.04 µm
Cut Off	150 kDalton
Filtration Pressure	0.1 – 0.25 bar
Backwash Pressure	0.07 – 0.1 bar
Cassette Dimension	0.416 m x 0.209 m x 0.490 m



MicroClear™ MB2-2 membrane module

MicroClear™ MCXL membrane cassette

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

3.4 Influent/Effluent Wastewater Characteristics

The newterra MBR shall treat wastewater from the mine camp with the following characteristics upon entering the newterra MBR.

Parameters	Unit	Influent*	Effluent
pH	s.u.	6 - 9	6.5 – 8.5
Fat, Oil, Grease (FOG)	mg/L	< 30	< 5
Biological Oxygen Demand (BOD)	mg/L	907.5	< 25
Total Suspended Solids (TSS)	mg/L	262.5	< 25
Total Kjeldahl Nitrogen (TKN)	mgN/L	130	-
Unionized Ammonia Nitrogen (NH_3-N)	mgN/L	-	< 1.25
Nitrate Nitrogen (NO_3-N)	mgN/L	-	< 5
Total Phosphorus (TP)	mgP/L	12	< 0.5
Fecal Coliform	CFU/100mL	-	< 200**
Total Residual Chlorine	mg/L	-	< 0.02
Alkalinity (assumed)	mg/L as $CaCO_3$	471	-
Total Dissolved Solids(TDS)	mg/L	< 1,200	-

3.5 Estimated Chemical Consumption

Consumable		Usage Rate			
Purpose	Name	Value	Unit	Value	Unit
Supplemental Alkalinity	**Dry Soda Ash**	6.28	kg/d	2292	kg/year
Phosphorus Removal	**Liquid Alum, 48%**	14.6	L/d	5346	L/year
Nitrate Removal	**MicroC 2000**	16.5	L/d	6025	L/year
Membrane Cleaning	**Sodium Hypochlorite, 12%**	-	L/d	150	L/year

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

3.6 Prohibited Items

The raw wastewater should not contain any of the following substances:

- Hydrocarbons – lubricants, gasoline, diesel, etc.;
- Paints, solvents, silica, silicones and polymers;
- Antibacterial solutions, and products with quaternary ammonia;
- Large quantities of chemicals such as water softener, disinfectants, strong acids & alkalis, pesticides or photographic chemicals;
- Silicone based defoamers;
- Non-biodegradable solid waste (plastic, rubber products, disposable diapers, etc.);
- High amount of metals, such as iron, magnesium, calcium, barium and strontium.



TOXIC MATERIALS SHOULD NOT BE THROWN INTO THE DRAIN!

3.7 Removal of Oily Materials

The wastewater must pass through a grease trap (or similar facility for grease/fat removal), if there is kitchen usage onsite. The large amount of oil and fat can harm treatment facility (e.g., clogging pumps and piping and cause foaming in the aeration tank). To avoid premature membrane fouling, maximum FOG concentrations should not exceed 30 mg/L.



Fats, oils and grease (FOG) must be removed prior to MBR. Removing of FOG significantly reduces membrane fouling, foaming potential and increases aeration efficiency.

The raw wastewater should also comply with the following compatibility chart. The lipophilic substances concentration must be lower than **50 mg/L.**

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

3.8 MicroClear™ Membrane Compatibility Chart

Group	Substances	Compatibility
Chlorinated solvents	Methylene Chloride, Chloroform, Carbon Tetrachloride, Chlorobezene, Trichloroethane (<1%)	**Not recommended**
Esters	Ethyl Acetate, Butyl Acetate, Butyl Acrylate (<1%)	**Not recommended**
Ethers	Ethyl Ether, Polyethylene Oxide (<1%)	**Not recommended**
H_2O_2	<2000 ppm	Very good
Inorganic acids	HF, HCl, H_2SO_4	pH 0 - 14
Ketones	Acetone, Methyl Ethyl Ketone	**Not recommended**
NaOCl	100,000 ppm x h	Very good
Organic acids	Sulfamic Acid, Formic Acid, Oleic Acid, Sulfonic Acid, Acetic Acid, Acrylic Acid, Lactic Acid	pH 0 - 14
Phenols		**Not recommended**
Silicones		**Not recommended**
Alcohols	Ethanol, Butanol, Isopropranol (<50%)	Good
Aldehydes	Formaldehyde (<1%)	Very good
Alkali		pH 0 - 14
	Dimethyl Formamide, Dimethyl, Acetamid Dioxane, N-Methyl, Pyrrolidone, Tetramethyl Acetamide	**Not recommended**
Aprotic Solvents	Benzene, Toluene, Xylene, Anthracene, Naphatalene, Gasoline	**Not recommended**
Aromatic hydrocarbon	Methoxyethanol, Ethoxyethanol, Buthoxyethanol	unknown

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

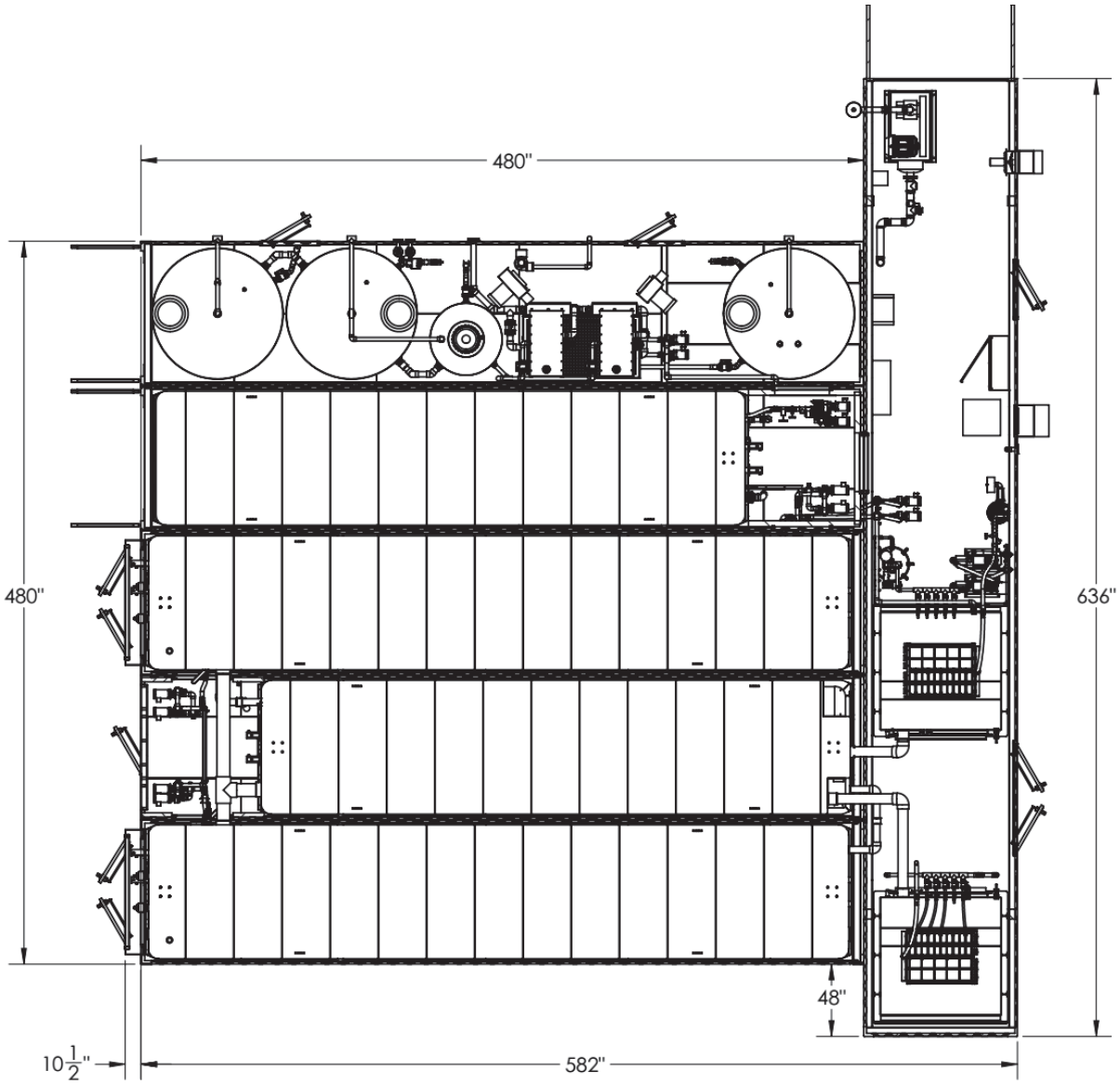
© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

4.0 PLANT INSTALLATION, INSPECTION, AND TESTING

4.1 System Overview

The **newterra** MicroClear™ MBR WWTP is 96m3/day MBR for for the Amaruq Mine located in Nunavut. The system consists of five (5) modified 40 foot High Cube ISO shipping containers and one (1) modified 53 foot High Cube ISO shipping container. See below. .



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

4.2 Site Conditions Requirements

- Installation site for the **newterra** MicroClear™ MBR WWTP should be close to the sewer drain and have a sufficient power source (refer to Electrical Drawings in Appendices B-F).
- Location must permit easy access for equipment capable of transporting, offloading, and handling of the designed loads.
- There should be adequate space around the containers for safe operation and maintenance.
- The firm base (foundation) must be built to support the full operating weight of the plant to prevent buildings from shifting and pipe/electrical conduit connection failure – pilings are recommended.



The firm base for the container must be level and must be capable of supporting the operating weight.

WARNING: ***Always check with the local utility companies for the location of water lines, electrical and telephone cables, or any additional hazards below grade, prior to excavation. Failure to do so could result in severe bodily injury or death.***

4.3 Inspection upon Delivery

The **newterra** MicroClear™ MBR WWTP is carefully manufactured, checked, and tested at the manufacturing plant. All equipment is pre-wired, pre-piped, mounted inside the enclosures and factory tested. Upon receiving the system, please perform the following:

- Place the container onto the prepared firm base to avoid sagging, equipment vibration, and shifting. When lifting the containers, ensure that lifting equipment is clear of overhead obstructions such as power lines, trees or rooftops. Be careful during this procedure!
- Be careful when offloading the containers to prevent damage to the internal pipe work.
- Check the containers for any signs of shipping damages.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

- Inspect the containers to ensure that no components or parts are missing (refer to the Packing List – see Appendix B). Also, inspect for visual damage of the tanks, pumps, blowers, piping, and control panel.

- If the containers, equipment inside and any parts shipped loose are free of damage, proceed with the installation.

For any damages or loss of equipment, **please notify newterra ltd. at (800) 420-4056 immediately.**

4.4 Plant Initial Set up

WARNING: ***The installer must ensure that the installation site is safe from hazards. These could include excavations left open overnight, debris left lying around, and tanks & equipment not properly blocked. Provisions must be made to eliminate the potential hazards by roping off and proper shoring around the excavations, cleaning up at the end of each workday, and proper storage of equipment. Failure to do so could result in severe injury or death.***

4.4.1 Installation Checklist

At Appendix C is the installation and commissioning checklist for the system. Below is a summary of installation activities.

4.4.1.1 Customer's Scope List

- Placement and anchoring (if required) of equipment
- Interconnecting piping supply and installation
- Interconnecting electrical and controls supply and installation including connection inside newterra's control panel
- Electrical power supply to our electrical panel, lightning, grounding, etc.
- Permitting
- Potable water supply to the plant site for plant hydraulic test during startup
- Seed sludge
- Wastewater testing
- Chemicals supply and storage
- Treated effluent and waste sludge disposal
- All site civil work including design

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

4.4.1.2 Civil Checklist

- Ensure that a potable water supply is available (used for hydraulic testing during start-up, membrane cleaning, washing hands and for performing onsite testing).
- Ensure availability of on-site emergency eyewash station and personal protection equipment.
- Remove hatch covers from the interconnecting ports.
- All doors are closing, latching and locking
- Weather stripping has been installed around each door
- Door sweeps have been installed on each door
- Louvers and hoods have been installed and sealed
- Install Liquid Rubber Container Seal as per drawing at Appendix C.

4.4.1.2 Electrical Checklist

- Connect electrical power to the Main Disconnect from available source ensuring correct phase rotation (See Electrical Drawings at Appendix A for power source specifications).
- Connect electrical power to the Control Panel (See System Layout drawing in Appendices A for locations)
- Ensure that proper electrical grounding and lightning protection is available.
- Switch Main Switch Panel's isolator to the ON position.
- Check all internal lighting and heating for correct operation.
- Install packed external lighting into brackets above the doorways.
- All internal electrical connections have been terminated
- Confirm Phase Monitor is not in alarm
- Site voltage measured:
    - L1/L2 - L2/L3 - L3/L1 - L1/GRD - L2/GRD - L3/GRD:
- Check field wiring and piping as per drawings
- Check panel for loose wiring, Correct as required
- Check voltage on AC transformer
- Check voltage on DC transformer
- Check I.S. barrier is grounded as per input drawing

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

4.4.1.3 Mechanical Checklist

- All hoses and mechanical connections have been hooked up
- Ensure all unions and fittings are tight, as some are loosened to prevent stress in shipping
- Check alignment of motors, Correct as required
- Check all motor belt tensions, Correct as required
- Check alignment of pulleys for all belt driven blowers
- Verify membrane modules are secure within the membrane tanks – i.e. verify wheel chocks are in the correct location and that there is no lateral movement (less than an inch) of the membrane modules on the wheel tracks in the tanks.
- Confirm Tank Diffusers and Educators have not moved during shipping
- Calibrate pH sensor

4.4.2 System Electrical Specifications

Verify site power per system design criteria. Additional detail is at Appendix A.

ELECTRICAL SPECIFICATIONS	
VOLTAGE	600V
PHASE	3Ø
FREQUENCY	60 Hz
FULL LOAD AMPS	172A
MAIN DISCONNECT SIZE	400A - FUSED @ 250A
SCCR SYMMETRICAL (kAMPS)	10
SYSTEM APPROVAL AND CLASSIFICATION	cMET - CL1Div2
PANEL APPROVAL AND CLASSIFICATION	cMETus to UL698A

Please refer to the as-built electrical drawings in Appendices A of this manual.

ATTENTION	**Only trained and certified electricians should make the electrical connections.**

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

4.5 Plant Initial Testing

The newterra MicroClear™ MBR WWTP (except the membrane modules) undergoes electrical and leakage tests in our manufacturing facility prior to shipment; however, fittings could shift during shipment, so it is our standard practice to perform initial testing on the plant after installation, including **dry and hydraulic tests.**

The following subsection is presented for one single process train; if multiple trains are provided, performing the dry test and hydraulic test for each train is identical.

4.5.1 Dry Test

The following tasks have to be performed **before** potable water is introduced into the system:

- Ensure that all tanks are clean and free of any dirt or debris (this is to prevent obstruction or damage to the piping, pumps, and membranes).
- Ensure that all connections have been provided and joints have been tightened.
- Check the placement of the air diffusers in the equalization tank(s) and the aeration tank(s) if incorrectly positioned, proper adjustment has to be performed.
- Ensure that a functional check of the electrical and control system has been performed (please refer to the newterra Commissioning Checklist presented in Appendix H).
- Confirm heater/fan and air conditioner operations

4.5.2 Hydraulic Test

The hydraulic test is performed using potable water to:

- Check for and fix any leakage;
- Check the setting of level switches/transmitters;
- Check the hydraulic flow through the plant;
- Check if all the ancillary equipment and controls of the plant function as per design;
- Recalibrate instruments (if applicable);
- Perform clean water test on membranes.
- Perform clean water test on the chemical distribution system.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

4.5.2.1 EQ, Anox and Aeration Tanks

- Fill the tanks in order - TNK-301, 401, 501, 502, 551, 601, 602 with potable water, run the pumps and check for any signs of leakage.
- Perform electrical and instrumentation (E&I) functional checks and adjustment of level switches.
- Turn on the air blower(s) for the blower(s) for aeration tank(s), and check for:
    - Buoyancy of air diffusers and if this occurs, empty the tank and fix;
    - Air leakages: if this occurs, tighten up the fittings;
- Manually check water temperature and DO (dissolved oxygen): with a hand-held DO meter and adjust air flow to keep it up to 0.5 – 1 mg/L for equalization tank(s) and 2 - 3 mg/L for aeration tank(s); check the DO readings on the touch screen.
- DO Control System: check automatic ON/OFF of Aeration Tank air blowers at low and high settings of DO without the return of aerated water from the membrane tanks to aeration tanks (i.e. turn off transfer pump(s) from aeration tank(s) to membrane tank(s) and turn of recirculation pump(s) from membrane tank(s) to aeration tank(s), if included), and record blower ON/OFF duration.

4.5.2.2 Membrane Tank

- Enable membrane operation using the HMI
- Start the transfer pump(s) from the aeration tank(s) to the membrane tank(s) and fill the membrane tank(s) with potable water.
- Start the air blowers for the membrane tank(s) and check for an even distribution of air across the membrane filter area and air bubble uniformity above the membrane module/cassette.
- Check hydraulic flow pattern through the membranes and between membrane module/ cassette and tank wall.
- Make a clean copy of the **Clean Water Testing Sheet** presented in **Appendix J** of this O&M Manual.
- Record all checked parameters in the **Clean Water Testing Sheet.**
- Start the permeate (vacuum) pumps.
- Record the vacuum (TMP) on the gauge(s) on the permeate line [for clean water could be 0.05 to 0.07 bar (20” to 29” WC)].
- Record water temperature and DO with a hand-held DO meter.
- Gradually increase the permeate flow while recording the vacuum (TMP) on the gauges up to the anticipated peak wastewater flow.

Forward a complete **Clean Water Testing Sheet** to **newterra** for analysis.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

4.5.2.3 O&G and 901 Tanks

- Fill the tanks in order - TNK-101, 102, 103 and 901 with potable water, run the pumps and check for any signs of leakage.
- Confirm diffuser operation in TNK-901. Adjust as necessary.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

5.0 OPERATION of newterra MicroClear™ MBR

MBR (Membrane Bioreactor) treatment technology is an effective combination of an activated sludge biological treatment process with MicroClear MBR membrane filtration technology.

This section provides a description of the treatment process and how it is controlled. For a more complete understanding, review the **Process & Instrumentation Diagram** and **System Layout** provided in **Appendix A** of this manual as well. The detailed Control Narrative with factory setpoints, alarms and logic, please see **Appendix K**.

Most of the equipment in the **newterra** WWTP can be operated in either manual or automatic mode. The system is designed to always run in auto mode. The manual option is provided mainly for maintenance purposes.

5.1 Control System – Main SCADA Control, PLCs and HMIs

The **newterra** MicroClear™ MBR is controlled by a PLC (Programmable Logic Controller). The system is programmed to:

- Receive analog and digital input signals from the switches and transmitters being controlled;
- Process the information using the structure and rules entered into the program;
- Generate outputs that control the equipment - turn equipment OFF or ON.
- Generate alarms if critical conditions are present
- Provide a HMI (Human Machine Interface) touch-screen for ease of operator process monitoring and control.

5.1.2 HMI Control Screen

An example of an HMI Control Screen is provided below:



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

System Operation

- (RUNNING/STOPPED) Indicates whether the system is currently in the **RUN** mode or turned off
- **START** button puts the system in **RUN** mode as long as there are no alarms preventing the start up of the system
- **STOP** button stops the system operation
- **RESET** button is used to clear alarms after they have been addressed
- Clarifier blowers, equalization tank blowers and the building fan if on, continue to run even after the **STOP** button has been pressed

The MBR will always remain in auto run mode, unless the kill switch is pressed or power is down.

The MBR will automatically restart after power failure.

A menu to navigate through the process and data information screens is provided at the bottom right corner of the HMI screen.

When the **MENU** button is pressed, it shows a list of individual screens with a scroll bar.

- To go to any of the listed screens, touch the icon.
- To go back to the main screen, touch the **X** button.



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.



Screen-shots presented in this manual are for example only and may not be representative of ideal operation.

5.1.3 HOA (Hand/Off/Auto) Screen

This screen displays all devices controlled by the PLC. Under normal operation (auto mode), all devices are set in the AUTO position.

- Each PLC controlled motor or valve in the system has a Hand/Off/Auto (HOA) Switch to control its operation.
- The HAND (H) position of a switch is used for testing and troubleshooting of the system. As a safety precaution to prevent damage to equipment, the equipment will operate for two minutes in hand mode and will then turn OFF and revert to the (O) position. Operators must be present when equipment is operated in the manual mode.



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

5.1.4 Process Screens

The main process screens are accessed from the main menu of the HMI control screen. These process screens are:

- Inlet
- EQ & Anox
- Aeration
- MBR

Note: In the following sections are the detailed descriptions of the main processes.



Switches are indicated on the HMI as follows:

- LSHH – level switch high high
- LSH – level switch high
- LSLL – level switch low low
- TSLL – temperature switch low low
- LSL – level switch low
- PSL – pressure switch low

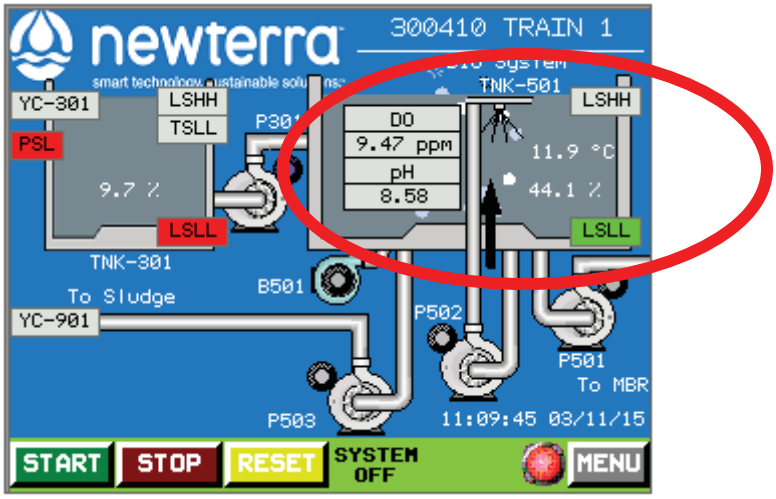
Status of the switches are indicated as follows:

Grey when **OFF**
Green when **ON**
RED when in Alarm

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Tank levels are indicated by level switch positions and percent full values where level transmitters are provided. For example, the following screen shows LSLL as green, LSHH as grey and the percent full as 44.1% in TNK-501. This indicates that the tank is 44.1% full, and the water level is above LSLL and below LSHH.



NOTE: Touching a device on the process screen will open an HOA popup for that device.

- The device status indicator color coding is as follows:

Indicator Color	Operational Status
Yellow	Manual operation
Orange	Interlock
Red	Failure
Green	ON / OK
Purple	Interlock / Communication failure
Pink	Unknown
Black	Faulty contactor
Grey	Off

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

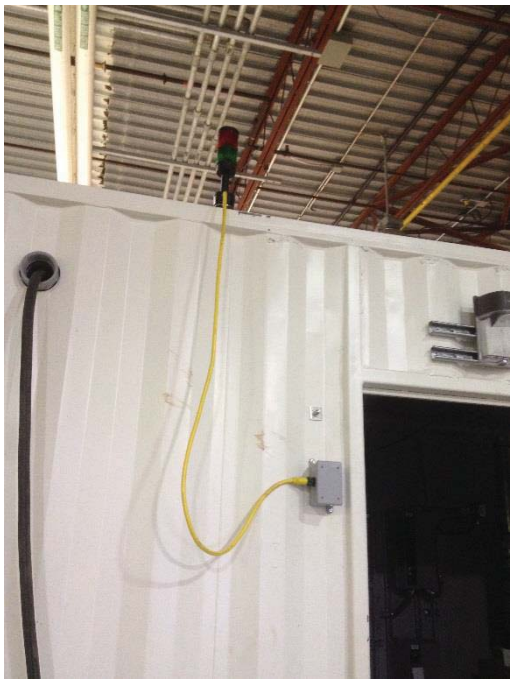
newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.1.5 HMI Alarm Screen

- When the **ALARMS** button is flashing red, it indicates an alarm is present in the system. Press the **ALARMS** button to be routed to the Active Alarms Screen.
- To clear alarms, first press the yellow **RESET** button then press the flashing **ALARMS** button to verify that the condition causing the alarm has been cleared.

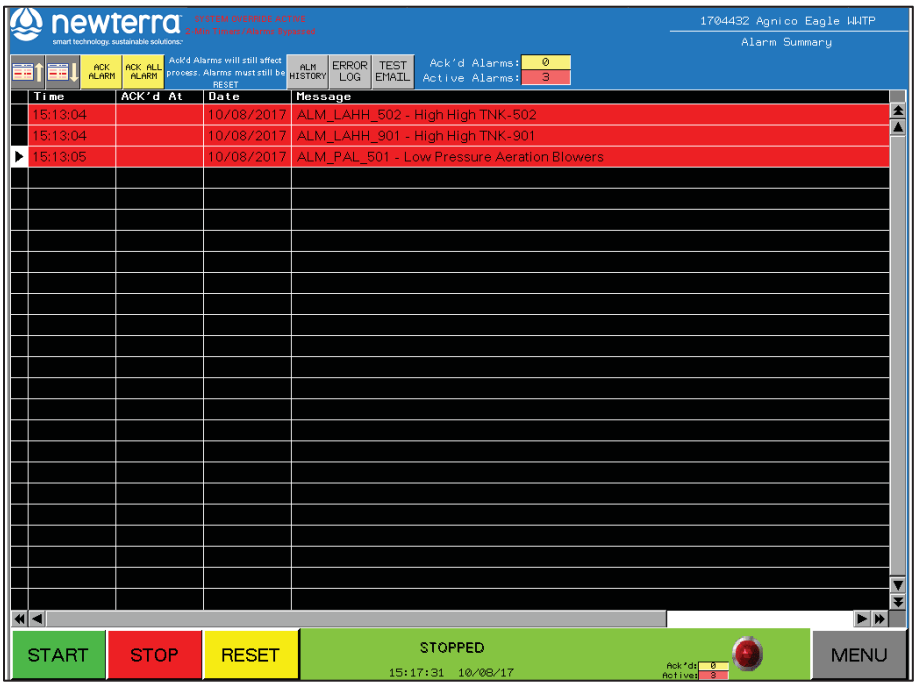
All alarms are visually indicated on a beacon stack on the roof of the exterior of the container and an alarm light on the system control panel:

- Green – System OK
- Red Solid – Warning Alarm
- Red Flashing – Critical Alarm
- No Light – Loss of Power



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com





NOTE: All high level alarms (identified as LSHH on P&ID and HMI) indicate a critical situation for imminent tank overflow and could result in pump(s) shutting off to avoid overflow situations.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.2 WWTP Buildings/Utilities

5.2.1 Power Supply

A power monitor has been installed in the main power distribution panel to ensure proper power and phase rotation is delivered to the system.

Alarms

Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)
ESA-8201	Emergency Stop Alarm	ESA-8201 = Active	Immediate	Y
PWR-FAIL	Power Failure		Immediate	Y
PLC FLT	PLC Fault Detected		Immediate	Y
PWR FLT	Phase Monitor Fault	JA-8201 = Active	Immediate	Y

5.2.2 E-Stop

Emergency stop buttons are located:



- On the Main Control Panel in each of the Screen Buildings
- On the Control Panel installed in each process train
- On the Main Control Panel in the Sludge Building
- Main Control Panel in each of the Receiving Stations
- There is an E-Stop PLC alarm if pressed.

5.2.3 Building Temperature Control

The electric heaters respond to the temperature set point set on the individual heater TSL temperature switches. If the building temperature falls below the temperature switch settings, electric heaters will turn on.

5.2.3.1 Logic

TAG	Description	Control Logic	Output Type
H-7911	Building Heater	Always on internally controlled	Direct (not PLC controled)
H-7912	Building Heater	Always on internally controlled	Direct (not PLC controled)
H-7941	Building Heater	Always on internally controlled	Direct (not PLC controled)
H-7961	Building Heater	Always on internally controlled	Direct (not PLC controled)
H-7962	Building Heater	Always on internally controlled	Direct (not PLC controled)
H-7963	Building Heater	Always on internally controlled	Direct (not PLC controled)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.2.3.2 Alarms

Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)
TALL-7911	Temperature Alarm Low Low	TSLL-7911 = Active	5s	Y
TALL-7941	Temperature Alarm Low Low	TSLL-7941 = Active	5s	Y
TALL-7961	Low Low Temp Aalrm	LSLL-7961 = Active		

5.2.4 Ventilation

A single fan (F-7963) located in the MBR Process container acts to exhaust the container during the warmer months. Temperature is monitored by the temperature sensor and a high setpoint turns the exhaust fan on. There are also exhaust blowers to de-rate classified areas.

5.2.4.1 Logic

Tag / Mode	Description	Control Logic	Output Type	HOA Control
B-7911	Ventilation Blower	The continuous ventilation blower will always be ON. This blower is used as means to de-rate the screen building to a Class 1 Division 2 area. Air exchanges must be a minimum of 12 per hour,	Direct (not PLC controled)	
B-7941	Aeration Exhaust Blower	On when B-501/502 is on OR B-601/602 is on	Discrete	Auto
F-7963	Building Fan	Always on controlled by Wall Mount Termostat	Direct (not PLC controled)	

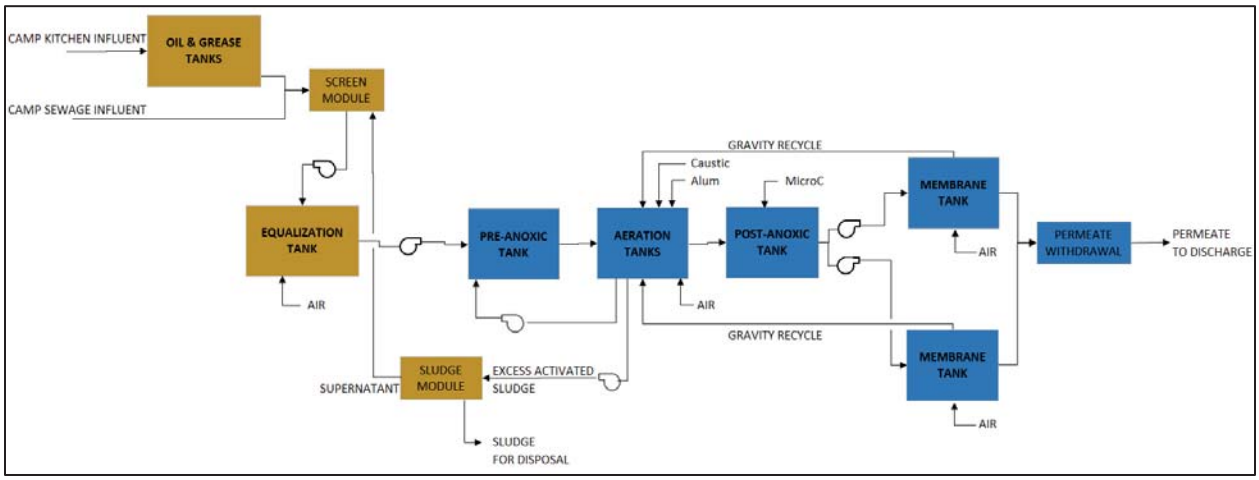
5.2.4.2 Alarms

Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)	Notes
PAL-7911	Pressure Alarm Low	PSL-7911 = InActive	5s	Y	Alarm indicates possible continuous ventilation failure, indicating risk that the room may become Class 1 Division 1 rated.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.3 Process Narrative



The wastewater treatment plant receives two streams of wastewater. The first source is domestic wastewater, which is fed directly to the fine to remove any fibers or debris that might damage the membranes. The second source is kitchen wastewater which is pre-treated in the oil and grease tanks to remove oil and grease prior to being fed into the fine screens. The combined screened wastewater is pumped to the equalization tank (TNK-301). The equalization tank buffers variability in the influent flow rate and concentrations of influent constituents, maintaining a consistent flow rate and wastewater strength through the MBR system. Wastewater is then pumped from the equalization tank to the pre-anoxic tank (TNK-401) for denitrification.

In the pre-anoxic tank screen wastewater containing organics is combined with recycled mixed liquor from the aeration tank containing nitrates. Bacteria use some of the organics to drive the denitrification process, converting nitrate into nitrogen gas. This process occurs in an anoxic environment where there is minimal oxygen. As such a pump and eductors are used to mix the tank to prevent addition of oxygen. The denitrification process is used to meet the effluent nitrate limit, reduce oxygen requirements and to recover alkalinity, thus reducing chemical consumption.

Mixed liquor from the anoxic tank flows by gravity to the first aerobic tank (TNK-501) followed by the second aeration tank (TNK-502) for aerobic biological degradation of the influent constituents (organics and ammonia). In the aerobic tanks the nitrification process converts ammonia to nitrate in order to meet the effluent ammonia limit. This process consumes alkalinity, so a caustic dosing pump is used to control the pH. Additionally, liquid alum is dosed into the anoxic zone to precipitate phosphorus in order to meet the effluent phosphorus limit. Mixed liquor flows by gravity from the second aeration tank to the post-anoxic tank (TNK-551) for final denitrification polishing. In the post-anoxic tank there are minimal dissolved influent organics to drive the denitrification process. As such, an external carbon source in the form of Micro C is dosed to supplement the organics and drive the denitrification process.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Mixed liquor is pumped from the post-anoxic tank to the membrane tanks (TNK-601 and TNK-602). The membrane tanks serve as additional volume for aerobic biological treatment to remove any excess MicroC (which would other cause BOD in the effluent) and house the membrane filters used for solid-liquid separation. Treated effluent is drawn through the membranes by vacuum pumps.

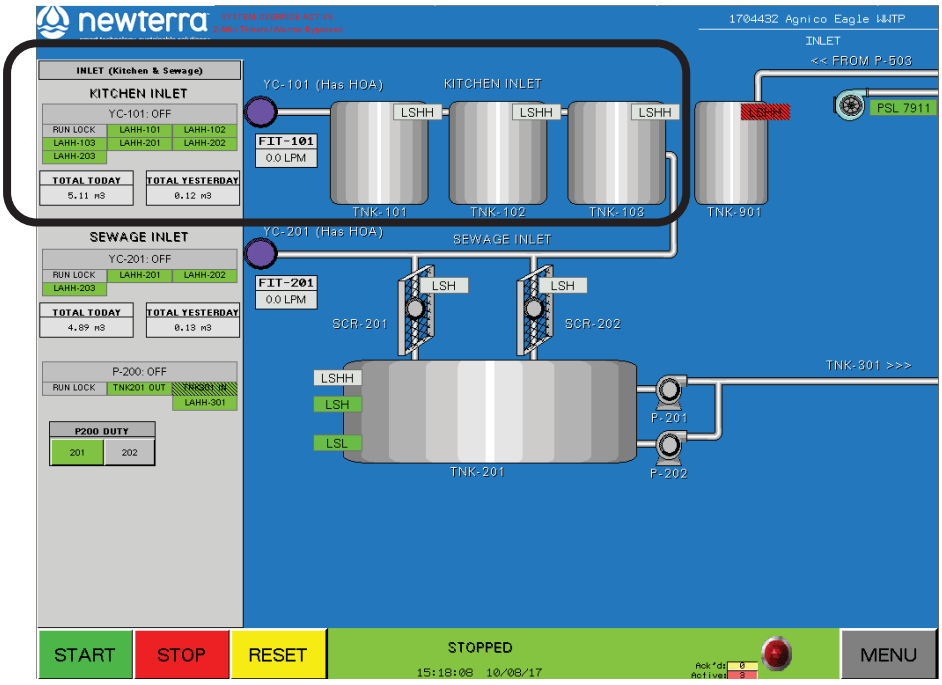
Since the solid-liquid separation process results in an accumulation of solids in the membrane tank, the mixed liquor (containing both solids and filtrate) is continuously recycled to the first aeration tank (TNK-501). This prevents excessive solids build-up in the membrane tank, and maintains sufficient biomass in the anoxic and aeration tanks. The solids that accumulate in the system consist of biomass that have grown from the influent organics and ammonia, as well as non-biodegradable solids from the influent wastewater. In order to maintain an optimal concentration of mixed liquor suspended solids (MLSS) (typically 10 g/L), a portion of the mixed liquor is periodically wasted by pumping from the Aeration Tank (TNK-501) to the sludge holding tank (TNK-901). Wasted sludge in the sludge holding tank is thickened by decanting supernatant back to the screen tank. Thickened sludge accumulates in the sludge holding tanks until it is eventually pumped out for disposal.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.4 Kitchen Inlet Module (TNK-101/2/3) Module

A schematic of the Kitchen Inlet Module is located on the INLET HMI screen and shown below.



5.4.1 Function

The Waste Water Treatment Plant accepts waste water from the local kitchen which contains kitchen oils and greases. These need to be removed prior to being fed into the fine screens. This is done by using TNK-101/2/3 as grease traps. The kitchen waste water enters TNK-101, the solid food particles sink to the bottom, while lighter grease and oil floats to the top. The relatively grease-free water is then fed into TNK-102 where the process is repeated to further separate the oils and greases from the waste water. The same applies to TNK-103. The waste water is then fed to the fine screens.

5.4.2 Inputs

TAG	Description	Input Type	HMI Display Units	Device Range and Units	Device Span/PLC Scale	Datalog (Y)	Trending (Y)
FIT-101	Flow Indicating Transmitter	Analog	GPM	0-760lpm	0-760lpm	Y	Y
FQI-101	Flow Totalizer	Discrete N.O.	Pulse/Gal	1 liter/ Pulse			
LSHH-101	Level Switch High High	Discrete N.C.					
LSHH-102	Level Switch High High	Discrete N.C.					
LSHH-103	Level Switch High High	Discrete N.C.					

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.4.3 Setpoints

Tag	Description	Factory Setpoint	Setpoint Range and Units	Setpoint Change Control	Alarm setpoint (Y/N)
FTAH-101-SP	Flow Transmitter Alarm High Setpoint	75	0-200 GPM	Open	Y

5.4.4 Logic

TAG	Description	Control Logic	Alarm Interactions	HOA Control
YC-101	Ready Contact	On when LSHH-101 / 102 / 103 and LSHH-201 / 202 and LSHH-203 are not ON	All LSHH's in the inlet area	HOA

5.4.5 Alarms

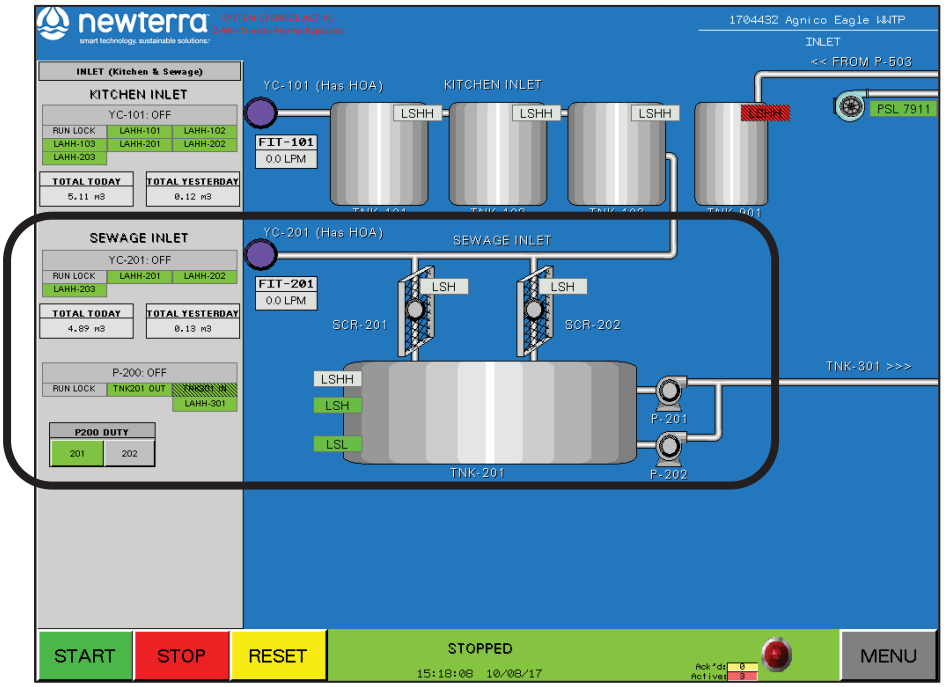
Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)
FTAH-101	Flow Transmitter Alarm High	FIT-101 > FTAH-101-SP	60s	
LAHH-101	Level Alarm High High	LSHH-101 = Active	5s	Y
LAHH-102	Level Alarm High High	LSHH-102 = Active	5s	Y
LAHH-103	Level Alarm High High	LSHH-103 = Active	5s	Y

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.5 Fine Screens (SCR-201/202) Module

A schematic of the Fine Screens are located on the INLET HMI screen and shown below.



5.5.1 Function

Camp domestic and kitchen wastewater is into the fine screens (SCR-201/202). The screening process is provided to remove hair, and fibrous materials from the supplied wastewater that might damage the membranes. The screening are collected in burlap bags that need to be removed daily. The waste water is then pumped to the EQ Tank.

5.5.2 Inputs

TAG	Description	Input Type	HMI Display Units	Device Range and Units	Device Span/PLC Scale	Datalog (Y)	Trending (Y)
FIT-201	Flow Indicating Transmitter	Analog	GPM	0-760lpm	0-760lpm	Y	Y
FQI-201	Flow Totalizer	Discrete N.O.	Pulse/Gal	1 liter/ Pulse			
LSHH-201	Level Switch High High	Discrete N.C.					
LSHH-202	Level Switch High High	Discrete N.C.					
LSHH-203	Level Switch High High	Discrete N.C.					
LSH-203	Level Switch High	Discrete N.C.					
LSL-203	Level Switch Low Low	Discrete N.O.					

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.5.3 Setpoints

TAG	Description	Factory Setpoint	Setpoint Range and Units	Setpoint Change Control	Alarm setpoint (Y/N)
FTAH-201-SP	Flow Transmitter Alarm High Setpoint	75	0-200 GPM	Open	Y

5.5.4 Logic

TAG	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter	HOA Control
YC-201	Ready Contact	On when LSH-201 / 202 and LSHH-203 are not ON				HOA
SCR-201	Inlet Screen	The inlet screen will be ON when influent flow is detected via flow transmitter FIT-201. The screen will run for 1 minute after influent flow has stopped via flow transmitter FIT-201. If the high high level switch LSHH-201 on the screen is ON then the inlet screen SCR-201 will be ON.		Discrete	Y	HOA
SCR-202	Inlet Screen	Same as SCR-201		Discrete	Y	HOA
P-201	Screen Transfer Pump	The pump will be ON when the LSH-203 turn on as long as LT-301 < LTH-301-sp setpoint the pump will turn off when the LSL-201 turns off	LAHH-301	Discrete	Y	HOA
P-202	Screen Transfer Pump	This pump runs duty standby with P-201 with a 5:1 rato	LAHH-301	Discrete	Y	HOA

5.5.5 Alarms

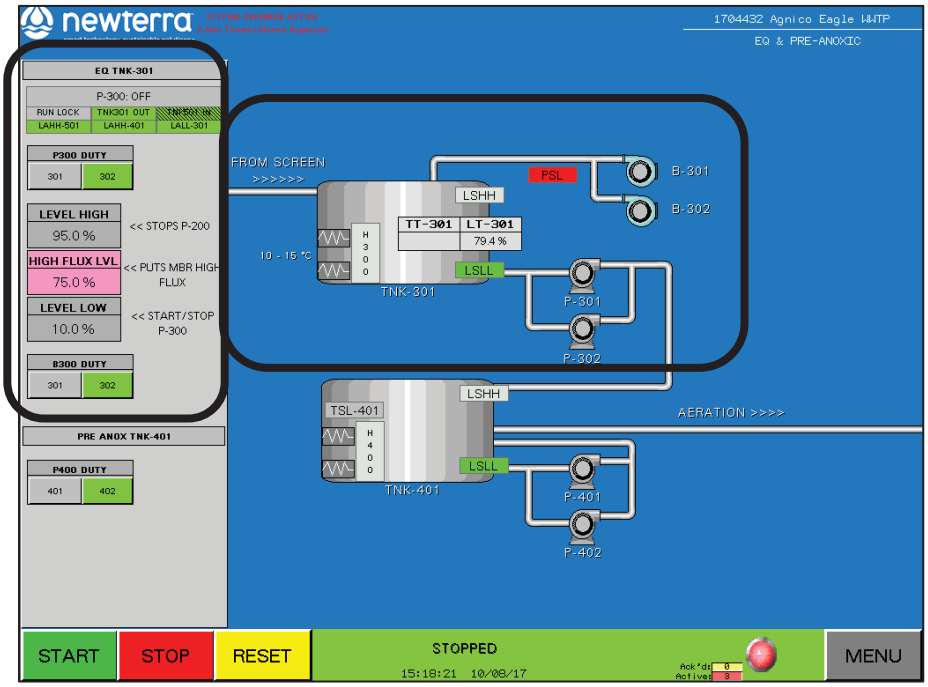
Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)
FTAH-201	Flow Transmitter Alarm High	FIT-201 > FTAL-201-SP	60s	
LAHH-201	Level Alarm High High	LSHH-201 = Active	5s	Y
LAHH-202	Level Alarm High High	LSHH-202 = Active	5s	Y
LAHH-203	Level Alarm High High	LSHH-203 = Active	5s	Y

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.6 Equalization Tank (TNK-301) Module

A schematic of the Equalization Tank (TNK-301) is located on the EQ & PRE-ANOXIC HMI screen and shown below.



5.6.1 Function

The EQ Tank (TNK-301) buffers variability in the influent flow rate to maintain a consistent flow rate through the membranes and to reduce concentration fluctuations of influent constituents (i.e. BOD, TSS etc.) through the MBR treatment system. Wastewater entering the newterra MBR will first have undergone pre-treatment by fine screens and grease traps (kitchen waste). The waste water is then pumped to the Pre-Anox Tank.

5.6.2 Inputs

Tag	Description	Input Type	HMI Display Units	Device Range and Units	Device Span/PLC Scale	Datalog (Y)	Trending (Y)	Notes
LSHH-301	Level Switch High High	Discrete N.C.						
LT-301	Level Transmitter	Analog	%	0-10 ftWC	0-10 ftWC	Y	Y	
TT-301	Temperature Transmitter	Analog	°C	0-100c	0-100c	n	n	Added to System
LSLL-301	Level Switch Low Low	Discrete N.O.						Must be above all immersion heaters in Tank
PSL-301	Pressure Switch Low	Discrete N.C.		9-85"WC				

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.6.3 Setpoints

Tag	Description	Factory Setpoint	Setpoint Range and Units	Setpoint Change Control	Alarm setpoint (Y/N)	Notes
LTL-301-SP	Level Transmitter Low Setpoint	10%	0-100%	Open		
LTHFLUX-301-SP	High Flux Level Setting	50%	0-100%			Puts the MBR Permeate pumps into High Flux Mode
LTH-301-SP	Level Transmitter High Setpoint	80%	50-100%	Open		

5.6.4 Logic

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter	HOA Control
H-301	Tank Heater	On when TT-301 < 10C Off when TT-301 >15C	LALL-301	Discrete		
H-302	Tank Heater	Same as H-301	LALL-301	Discrete		
P-301	EQ Transfer Pump	The EQ pump will be ON when the EQ level transmitter LT-301 > LTL-301-SP and the aeration tank level transmitter LT-501 < LTH-501-SP The EQ pump will be OFF when the EQ level transmitter LT-301 < LTL-301-SP OR LSLL-301 = InActive OR the aeration tank level transmitter LT-501 > LTH-501-SP OR LSHH-401 is active Runs Duty with P-302 as Standby	Turns OFF LAHH-501 LAHH-401 LALL-301	Discrete	Y	HOA
P-302	EQ Transfer Pump	This pump runs duty standby with P-201 with a 5:1 rato		Discrete	Y	HOA
B-301	EQ Blower	The EQ blower will be ON when the System is in Run & LSLL-301 is active.		Discrete	Y	HOA
B-302	EQ Blower	Runs Duty standby with B-301 switching every 120 hours		Discrete	Y	HOA

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.6.5 Alarms

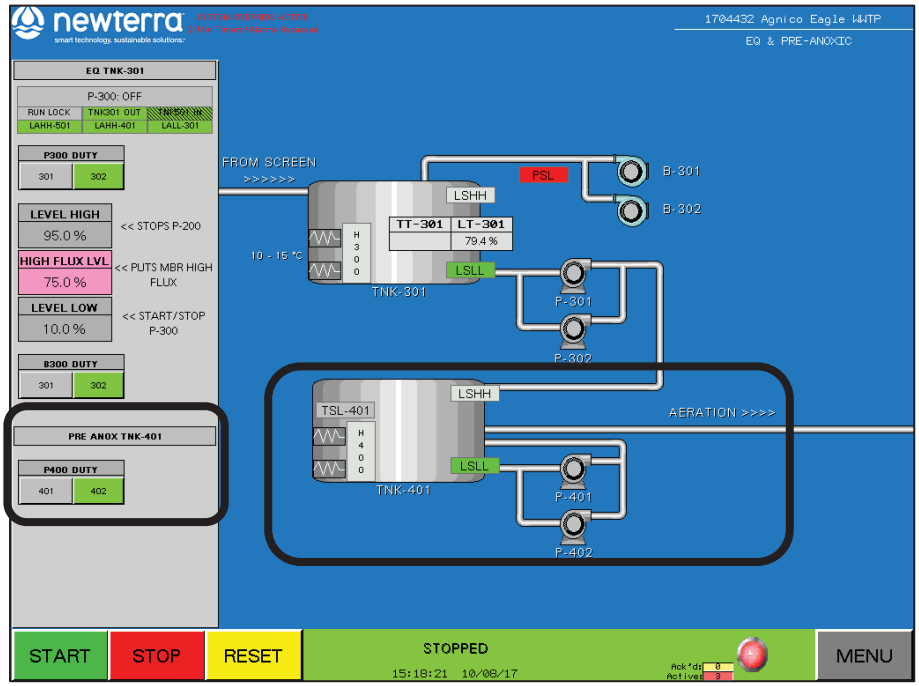
Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)
LAHH-301	Level Alarm High High	LSHH-301 = Active	5s	Y
LALL-301	Level Alarm Low Low	LSLL-301 = Off	5s	Y

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.7 Pre-Anox Tank (TNK-401) Module

A schematic of the Pre-Anox Tank (TNK-401) is located on the EQ & PRE-ANOXIC HMI screen and shown below.



5.7.1 Function

In the pre-anoxic tank (TNK-401), the wastewater containing organics is combined with recycled mixed liquor from the aeration tank containing nitrates. Bacteria use some of the organics to drive the denitrification process, converting nitrate into nitrogen gas. This process occurs in an anoxic environment where there is minimal oxygen. As such, a pump and eductors are used to mix the tank to prevent addition of oxygen. The denitrification process is used to meet the effluent nitrate limit, reduce oxygen requirements and to recover alkalinity, thus reducing chemical consumption.

5.7.2 Inputs

Tag	Description	Input Type
LSHH-401	Level Switch High High	Discrete N.C.
TSL-401	Temperature Switch Low	Discrete N.C.
LSLL-401	Level Switch Low Low	Discrete N.O.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.7.3 Setpoints

None

5.7.4 Logic

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter	HOA Control
P-401	Pre-Anox Mixing Pump	The pump will be ON when the System is in Run & LSLL-401 is active.	LALL-401 PUMP IS OFF	Discrete	Y	HOA
P-402	Pre-Anox Mixing Pump	Runs Duty standby with P-401 switching every 120 hours		Discrete	Y	HOA
H-401	Tank Heater	On when TSL-401 is OFF	LALL-401	Discrete		
H-402	Tank Heater	On when TSL-401 is OFF	LALL-401	Discrete		

5.7.5 Alarms

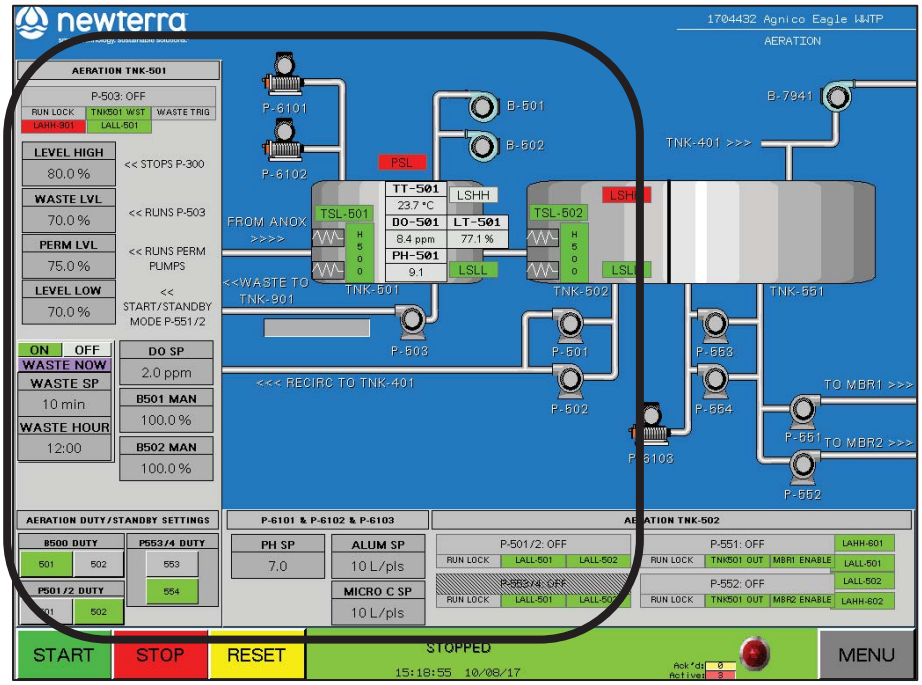
Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)
LAHH-401	Level Alarm High High	LSHH-401 = Active	5s	Y
LALL-401	Level Alarm Low Low	LSLL-401 = OFF	5s	Y

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.8 Aeration Tanks (TNK-501/502) - Biological Treatment Module

The schematic of the Aeration Tanks (TNK-501/502) is located on the AERATION HMI screen and shown below.



5.8.1 Function

Mixed liquor from the anoxic tank (TNK-401) flows by gravity to the first aerobic tank (TNK-501) followed by the second aeration tank (TNK-502) for aerobic biological degradation of the influent constituents (organics and ammonia). In the aerobic tanks (TNK-501/502), the nitrification process converts ammonia to nitrate in order to meet the effluent ammonia limit. This process consumes alkalinity, so caustic is dosed into TNK-501 (by pump P-6101) to control the pH. Additionally, liquid alum is dosed (by pump P-6102) into the anoxic zone to precipitate phosphorus in order to meet the effluent phosphorus limit.

pH measured by a pH probe (PH-501) in TNK-501.

Blowers (B-501/502) supply air to the submerged fine-bubble diffusers to ensure sufficient dissolved oxygen (DO) is available for biological oxidation and to keep solids in the water suspended. Dissolved Oxygen (DO) is measured by a DO Probe (DO-501) in TNK-501.

In order to maintain an optimal concentration of mixed liquor suspended solids (MLSS) (typically 10 g/L), a portion of the mixed liquor is periodically wasted by pumping from the Aeration Tank (TNK-501) to the sludge holding tank (TNK-901) by P-503.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.8.2 Inputs

Tag	Description	Input Type	HMI Display Units	Device Range and Units	Datalog (Y)	Trending (Y)
LSHH-501	Level Switch High High	Discrete N.C.				
LSLL-501	Level Switch Low Low	Discrete N.O.				
PH-501	pH Transmitter	Analog		0-14 pH	Y	Y
DO-501	Dissolved Oxygen Transmitter	Modbus	ppm	0-10	Y	Y
TT-501	Temperature Transmitter	Modbus	°C	0-100		
LT-501	Level Transmitter	Analog	%	0-10 ft	Y	Y
PSL-501	Pressure Switch Low	Discrete N.C.		9-85"WC		
LSHH-502	Level Switch High High	Discrete N.C.				
LSLL-502	Level Switch Low Low	Discrete N.O.				
TSL-502	Temperature Switch Low	Discrete N.C.				

5.8.3 Setpoints

Tag	Description	Factory Setpoint	Setpoint Range and Units	Setpoint Change Control	Alarm setpoint (Y/N)
LTL-501-SP	Level Transmitter Low Setpoint	70%	0-100%	Open	
LTH-501-SP	Level Transmitter High Setpoint	80%	0-100%	Open	
LT501-SLUDGE-SP	Waste Level for P-503	75%	0-100%	Open	
LT501-PERM-SP	Level Control for Permeate Pumps	75%	0-100%	Open	
P503 WASTE HOUR	When P-503 will waste	12pm	0-23		
P503 WASTE SP	Time that P-503 wastes for	10min	0-99		
PH-501-SP	pH Normal Setpoint	7 pH	6-8pH	Open	
PHAH-501-SP	pH Alarm High Setpoint	8 pH	7 - 14 pH	Open	Y

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Tag	Description	Factory Setpoint	Setpoint Range and Units	Setpoint Change Control	Alarm setpoint (Y/N)
PHAL-501-SP	pH Alarm Low Setpoint	6 pH	0-7 pH	Open	Y
DO-501-SP	Dissolved Oxygen Normal Setpoint	2 ppm	0-6 ppm	Open	
B500 I SP	Integral Gain setting DO PID Loop	10s	0-99		
B500 P SP	Proportional Gain setting DO PID Loop	100%	0-99		
B501 MAN SP	Manual Speed B-501	50%	0-100		
B502 MAN SP	Manual Speed B-502	50%	0-100		
DOAL-501-SP	Dissolved Oxygen Alarm Low Setpoint	0.5 ppm	0-6 ppm	Open	Y
ALUM DOSE	Alum Dose setting (xGal per Pulse)	10 Gallons	0-99 Gallons	Open	
MICROC DOSE	Micro C Dose setting (xGal per Pulse)	10 Gallons	0-99 Gallons	Open	
TALL-501-SP	Temperature Alarm Low Low	10 deg C	5 - 25 deg C	Password	Y
TTL-501-SP	Temperature Transmitter Low Setpoint	15 deg C	5-25 deg C	Open	
PAL-501-SP	Pressure Alarm Low Setpoint	28"WC (1PSIG)		On Device	Y
TALL-502-SP	Temperature Alarm Low Low	10 deg C	5 - 25 deg C	Password	Y

5.8.4 Logic

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter	HOA Control
P-6102	Alum Dosing Pump	Alum Dosing Pump P-6102 be ON when FIT-701 has reached a user adjustable volume of permeate via FT-701-DOSE setpoint. P-6102 will be ON for one pulse.		Discrete		HOA
P-6101	Caustic Dosing Pump	Caustic Dosing Pump P-6101 will be ON when PH-501 < PH-501-SP. The pump will be ON for 30s and OFF for 30s and will operate in pause mode		Discrete		HOA
H-501	Tank Heater	On when TSL-501 is OFF	LALL-501	Discrete		

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter	HOA Control
H-502	Tank Heater	On when TSL-501 is OFF	LALL-501	Discrete		
P-503	Waste Activated Sludge Pump	The waste activated sludge pump will be ON at time of day setting SLUDGE-WASTE-TOD IF level switch LT501-SLUDGE-SP	LAHH-901: Pump will be OFF	Discrete		HOA
H-503	Tank Heater	On when TSL-502 is OFF	LALL-502	Discrete		
H-504	Tank Heater	On when TSL-502 is OFF	LALL-502	Discrete		
P-501	Aeration Recirc Pump	The pump will run as long as LSLL-501 is Active	LALL-502: Pump will be OFF	Discrete	Y	HOA
P-502	Aeration Recirc Pump	Runs Duty standby with p-501 switching every 120 hours		Discrete	Y	HOA
B-501	Aeration Tank Aeration Blower	ON - AlwaysRuns via PID loop to maintain DO-501-SPRuns Duty/Standby 120 hours with B-502.		Direct	Y	HOA
B-502	Aeration Tank Aeration Blower	Runs via same logic as B-501. Runs Duty/Standby every 120 hours with B-501.		Direct	Y	HOA

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

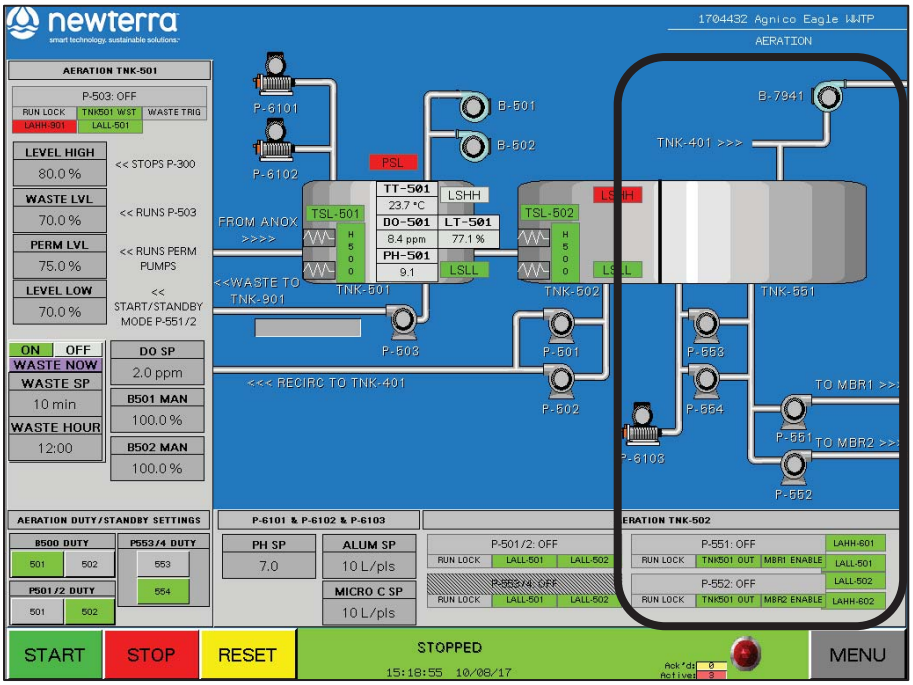
5.8.5 Alarms

Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)
LAHH-501	Level Alarm High High	LSHH-501 = Active	5s	Y
LAHH-502	Level Alarm High High	LSHH-501 = Active	5s	Y
PHAH-501	pH Alarm High	pH-501 > PHAH-501-SP	60s	
PHAL-501	pH Alarm Low	pH-501 < PHAL-501-SP	60s	
DOAL-501	Dissolved Oxygen Alarm Low	DO-501 < DOAL-501-SP	15m	
DOALL-501	Dissolved Oxygen Alarm Low Low	DO-501 < DOAL-501-SP	4hrs	
TTAL-501	Low Temp TNK-501	TT-501<TTAL-501-SP		
PAL-501	Pressure Alarm Low	PSL-501 = InActive	5s	Y
VFDA-501	VFD Fault			
VFDA-502	VFD Fault			
LALL-501	Low Low Level TNK-501	LSLL-501 = OFF		
LALL-502	Low Low Level TNK-502	LSLL-502 = OFF		

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

5.9 Post-Anox Tank (TNK-551) Module

The schematic of the Post-Anox Tank (TNK-551) is located on the AERATION HMI screen and shown below.



5.9.1 Function

Mixed liquor flows by gravity from the second aeration tank (TNK-502) to the post-anoxic tank (TNK-551) for final denitrification polishing. In the post-anoxic tank, there are minimal dissolved influent organics to drive the denitrification process. As such, an external carbon source in the form of Micro C is dosed (by P-6103) to supplement the organics and drive the denitrification process.

5.9.2 Inputs

None

5.9.3 Setpoints

None

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.9.4 Logic

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter	HOA Control
P-553	Post Anox Mix Pump	The pump will run as long as LSLL-501 is Active	LALL-501: Pump will be OFF	Discrete	Y	HOA
P-554	Post Anox Mix Pump	Runs Duty standby with p-501 switching every 120 hours		Discrete	Y	HOA
P-6103	Micro C Dosing Pump	Dosing Pump will be ON when FIT-701 or FT-702 has reached a user adjustable volume of permeate via DOSE setpoint.		Discrete		HOA
P-551	Aeration Transfer Pump Feed to MBR-1	The aeration pump will feed MBR tank T-601. The pump will be ON when level transmitter LT-501 > LTL-501-SP and LSLL-501 = Active and LSLL-502 = Active and MBR-1 is Enabled. The aeration pump will be cycle ON/OFF when LT-501 < LTL-501-SP and be OFF if LSLL-501 = InActive OR LSLL-502 = InActive	LAHH-601: Pump will be OFF MBR-1 Disabled	Discrete	Y	HOA
P-552	Aeration Transfer Pump Feed to MBR-2	The aeration pump will feed MBR tank T-602. The pump will be ON when level transmitter LT-501 > LTL-501-SP and LSLL-501 = Active and LSLL-502 = Active and MBR-2 is Enabled. The aeration pump will cycle ON/OFF when LT-501 < LTL-501-SP and be OFF if LSLL-501 = InActive OR LSLL-502 = InActive	LAHH-602: Pump will be OFF MBR-2 Disabled	Discrete	Y	HOA

5.9.5 Alarms

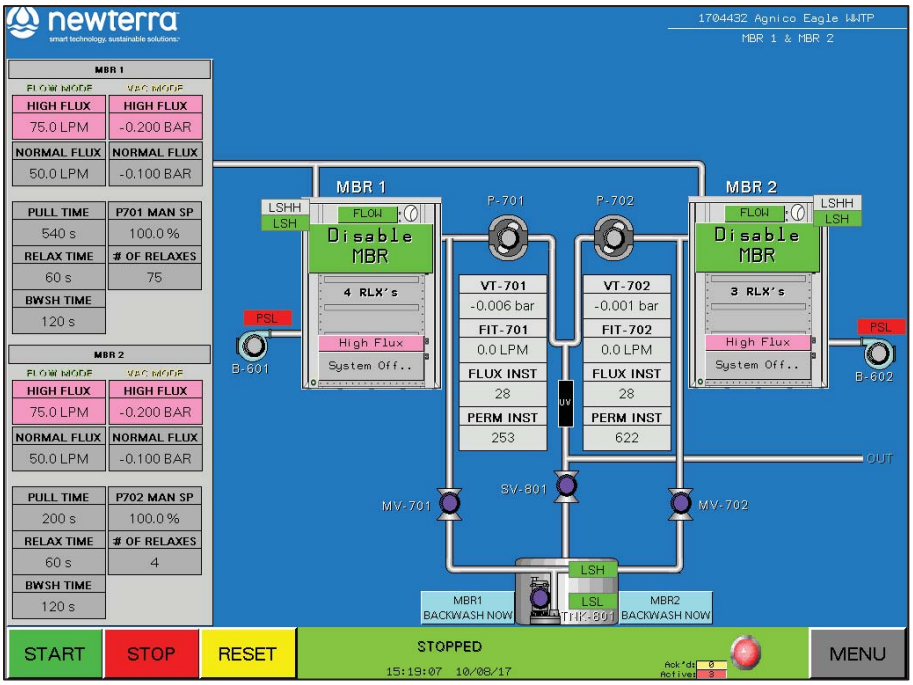
None

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.10 Membrane and Permeate Module

The schematic of the Membrane (TNK-601/602) and Permeate (P-701/702) Module is located on the MBR 1 & MBR 2 HMI screen and shown below.



5.10.1 Function

Mixed liquor filtration and supplemental biological oxidation.

Since the solid-liquid separation process results in an accumulation of solids in the membrane tank, the mixed liquor (containing both solids and filtrate) is continuously recycled to the first aeration tank (TNK-501). This prevents excessive solids build-up in the membrane tank, and maintains sufficient biomass in the anoxic and aeration tanks. The solids that accumulate in the system consist of biomass that have grown from the influent organics and ammonia, as well as non-biodegradable solids from the influent wastewater.

Vacuum pumps (P-701 and P-702) draw the water through the membranes under a low vacuum of 0.07 to 0.25 bar.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.10.2 Inputs

Tag	Description	Input Type	HMI Display Units	Device Range and Units	Datalog (Y)	Trending (Y)
LSHH-601	Level Switch High High	Discrete N.C.				
LSH-601	Level Switch High	Discrete N.O.				
LSHH-602	Level Switch High High	Discrete N.C.				
LSH-602	Level Switch High	Discrete N.O.				
PSL-601	Pressure Switch Low	Discrete N.C.		9-85"WC		
PSL-602	Pressure Switch Low	Discrete N.C.		9-85"WC		
VT-701	Vacuum Transmitter	Analog	Bar	-1.0 - 1.0 Bar	Y	Y
VT-702	Vacuum Transmitter	Analog	Bar	-1.0 - 1.0 Bar	Y	Y
VFD-701	VFD Status	Communcation				
VFD-702	VFD Status	Communcation				
FIT-701	Flow Indicating Transmitter	Analog	GPM	0-300lpm	Y	Y
FQI-701	Flow Totalizer	Discrete N.O.	Pulse/Gal	1liter / Pulse		
FIT-702	Flow Indicating Transmitter	Analog	GPM	0-300lpm	Y	Y
FQI-702	Flow Totalizer	Discrete N.O.	Pulse/Gal	1liter / Pulse		
LSH-801	Level Switch High	Discrete N.C.				
LSL-801	Level Switch Low Low	Discrete N.O.				

5.10.3 Setpoints

Tag	Description	Factory Setpoint	Setpoint Range and Units	Setpoint Change Control	Alarm setpoint (Y/N)	Notes
VT-701-SP	MBR-1 Vac Mode Permeate Setpoint	-0.1 bar	-0.2 - 0 bar	Open		
VT-701-HFSP	MBR-1 Vac Mode Permeate High Flux Setpoint	-0.15 bar	-0.2 - 0 bar	Open		
VTAH-701-SP	MBR-1 Vacuum Transmitter Alarm High	-0.3 bar	-0.3 - 0 bar	Open	Y	
VT-702-SP	MBR-2 Vac Mode Permeate Setpoint	-0.1 bar	-0.2 - 0 bar	Open		
VT-702-HFSP	MBR-2 Vac Mode Permeate High Flux Setpoint	-0.15 bar	-0.2 - 0 bar	Open		

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Tag	Description	Factory Setpoint	Setpoint Range and Units	Setpoint Change Control	Alarm setpoint (Y/N)	Notes
VTAH-702-SP	MBR-2 Vacuum Transmitter Alarm High	-0.3 bar	-0.3 - 0 bar	Open	Y	
FT-701-SP	MBR-1 Flow Mode Permeate Setpoint	60 GPM	0-200	Open		
FT-701-HFSP	MBR-1 Flow Mode Permeate High Flux Setpoint	75%	0-200	Open		
FTAH-701-SP	MBR-1 Flow Transmitter Alarm High Setpoint	100	0-200	Open	Y	
FTAL-701-SP	MBR-1 Flow Transmitter Alarm Low Setpoint	10	0-200	Open	Y	
FT-702-SP	MBR-2 Flow Mode Permeate Setpoint	60 GPM	0-200	Open		
FT-702-HFSP	MBR-2 Flow Mode Permeate High Flux Setpoint	75GPM	0-200	Open		
FTAH-702-SP	MBR-2 Flow Transmitter Alarm High Setpoint	100	0-200	Open	Y	
FTAL-702-SP	MBR-2 Flow Transmitter Alarm Low Setpoint	10	0-200	Open	Y	
BKWSH-TIME-SP	Backwash Time Setpoint	120s	0-999 s	Open		
RELAX-SP	Number of Relaxes Before Backwash	6	0-999	Open		
PERM-PULL-TIME	Permeate Pull Time	9m	0-30m	Open		
RELAX-TIME	Membrane Relax Time	60s	0-999 s	Open		
FLUX-SP	High Flux Setpoint	75%	50-100%	Open		Reading based on LT-301
SLUDGE-WASTE-TOD	Time of Day to Start Sludge Wasting	23hr	0-23 hr	Open		
SLUDGE-WASTE-TIME	Duration of Sludge Wasting	60m	0-1000m	Open		

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.10.4 Logic

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter
B-601	MBR Tank Blower	The membrane tank blower will be ON when the System is in Run. And the MBR 1 is enabled	MBR-1 Disabled	Discrete	Y
B-602	MBR Tank Blower	The membrane tank blower will be ON when the System is in Run. And the MBR 2 is enabled	MBR-2 Disabled	Discrete	Y
P-701	Permeate Transfer Pump	The permeate pump will be ON when MBR-1 is Enabled & level switch LSH-601 = Active & LT-501 > LT501-PERM-SP The Pump will perform a PULL/RELAX Cycle. The pump will be ON for the duration specified by the PERM-PULL-TIME setpoint and then be OFF for the duration of the RELAX-TIME setpoint. This will generate one PULL/RELAX Cycle. The VFD Speed of the pump will operate based on the following: In FLOW MODE: The VFD Speed will operate based on a PID loop to maintain the flowrate setpoint FT-701-SP. IF the vacuum transmitter VT-701 > -0.25 bar then the pump will switch to VAC MODE. IF the level transmitter LT-301 > FLUX-SP, the pump will run via PID loop to maintain a high flow setpoint FT-701-HFSP In VAC MODE: The VFD Speed will operate based on a PID loop to maintain the vacuum setpoint VT-701-SP. IF the level transmitter LT-301 > FLUX-SP, the pump will run via PID loop to maintain a high flow setpoint VT-701-HFSP P-701 will be OFF if P-501 is OFF.	VFDA-701: Pump Will be Off	Communication	Y

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter
P-702	Permeate Transfer Pump	The permeate pump will be ON when MBR-2 is Enabled & level switch LSH-602 = Active & & LT-501 > LT501-PERM-SP The Pump will perform a PULL/RELAX Cycle. The pump will be ON for the duration specified by the PERM-PULL-TIME setpoint and then be OFF for the duration of the RELAX-TIME setpoint. This will generate one PULL/RELAX Cycle. The VFD Speed of the pump will operate based on the following: In FLOW MODE: The VFD Speed will operate based on a PID loop to maintain the flowrate setpoint FT-702-SP. IF the vacuum transmitter VT-702 > -0.25 bar then the pump will switch to VAC MODE. IF the level transmitter LT-301 > FLUX-SP, the pump will run via PID loop to maintain a high flow setpoint FT-702-HFSP In VAC MODE: The VFD Speed will operate based on a PID loop to maintain the vacuum setpoint VT-702-SP. IF the level transmitter LT-301 > FLUX-SP, the pump will run via PID loop to maintain a high flow setpoint VT-702-HFSP P-702 will be OFF if P-502 is OFF.	VFDA-703: Pump Will be Off	Communication	Y
SV-801	Clean In Place Tank Fill Solenoid Valve	The Solenoid Valve SV-801 will be Open (Energized) when level switch LSH-801 is InActive and MBR-1 OR MBR-2 are not in Backwash. The Solenoid Valve SV-801will be Closed (De-Engergized) when LSH-801 is Active or IF MBR-1 OR MBR-2 are in Backwash.		Discrete	
MV-701	Backwash Actuated Valve	A Backwash is enabled once the permeate pumps for MBR-1 reach the number of PULL/RELAX cycles designated by the RELAX-SP on the HMI.the The actuated valve will be OPEN when MBR-1 is in Backwash and level switch LSH-801 is Active. If MBR-2 is already in backwash, MBR-1 will complete 1 additional PULL/RELAX Cycle before starting a Backwash Cycle.		Discrete	
MV-702	Backwash Actuated Valve	A Backwash is enabled once the permeate pumps for MBR-2 reach the number of PULL/RELAX cycles designated by the RELAX-SP on the HMI. the The actuated valve will be OPEN when MBR-2 is in Backwash and level switch LSH-801 is Active. If MBR-2 is already in backwash, MBR-1 will complete 1 additional PULL/RELAX Cycle before starting a Backwash Cycle.		Discrete	

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter
P-801	Backwash Transfer Pump	The backwash transfer pump will be ON when MBR-1 OR MBR-2 are in Backwash and level switch LSH-801 is Active The backwash transfer pump will be OFF after the duration of BKWSH-TIME-SP OR level switch LSL-801 becomes InActive.		Discrete	

5.10.5 Alarms

Alarm	Alarm Description	Actuation Control	Delay	Email Notification (Y)	Self Resetting (Y)
LAHH-601	Level Alarm High High	LSHH-601 = Active	5s		Y
LAHH-602	Level Alarm High High	LSHH-602 = Active	5s		Y
PAL-601	Pressure Alarm Low	PSL-601 = InActive	5s		Y
PAL-602	Pressure Alarm Low	PSL-602 = InActive	5s		Y
VTAH-701	Vacuum Transmitter Alarm High	VT-701 < VTAH-701-SP	5s		Y
VTAH-702	Vacuum Transmitter Alarm High	VT-702 < VTAH-702-SP	5s		Y
VFDA-701	VFD Fault				
VFDA-702	VFD Fault				
FTAH-701	Flow Transmitter Alarm High	FIT-701 > FTAH-701-SP	60s		
FTAL-701	Flow Transmitter Alarm Low	FIT-701 < FTAL-701-SP	60s		
FTAH-702	Flow Transmitter Alarm High	FIT-702 > FTAH-702-SP	60s		
FTAL-702	Flow Transmitter Alarm Low	FIT-702 < FTAL-702-SP	60s		

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.10.6 Blower Control

	**Blower for scouring air must be on 24/7, as failure of air supply can lead to clogging of the air diffusers and membranes.**

5.10.7 CIP Cleaning

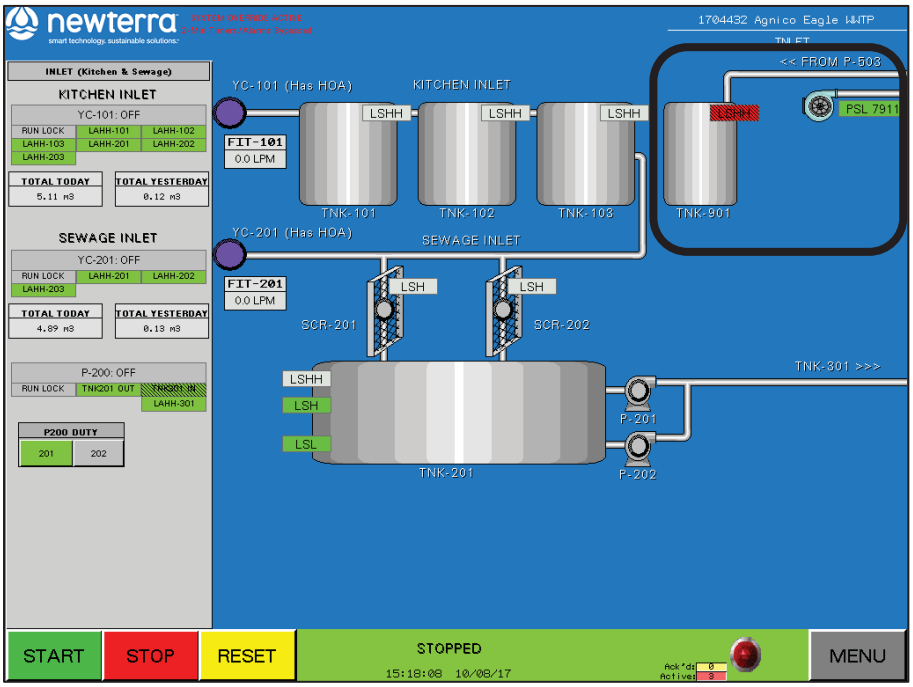
Note: At design flow when the membrane discharge vacuum exceeds 0.2 bar (80" WC), as transmitted by VT-701, VT-702 and indicated locally at PI-701, PI-702, it is necessary to take the membrane tank offline for CIP cleaning. See **Section 7** for instructions on CIP cleaning.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.11 Sludge Holding Tank Module (TNK-901)

A schematic of the Sludge Holding Tanks is located on the INLET HMI screen is shown below.



5.11.1 Function

To store and thicken waste activated sludge for later disposal off site.

In order to maintain an optimal concentration of mixed liquor suspended solids (MLSS) (typically 10 g/L), a portion of the mixed liquor is periodically wasted by pumping from the Aeration Tank (TNK-501) to the sludge holding tank (TNK-901). Wasted sludge in the sludge holding tank is thickened by decanting supernatant back to the screen tank. Thickened sludge accumulates in the sludge holding tanks until it is eventually pumped out for disposal.

5.11.2 Inputs

Tag	Description	Input Type
LSHH-901	Level Switch High High	Discrete N.C.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.11.3 Setpoints

Tag	Description	Factory Setpoint	Setpoint Range and Units	Setpoint Change Control	Alarm setpoint (Y/N)
P503 WASTE HOUR	When P-503 will waste	12pm	0-23		
P503 WASTE SP	Time that P-503 wastes for	10min	0-99		

5.11.4 Logic

Tag	Description	Control Logic	Alarm Interactions	Output Type	Hour Meter	HOA Control
P-503	Waste Activated Sludge Pump	The waste activated sludge pump will be ON at time of day setting SLUDGE-WASTE-TOD IF level switch LT501-SLUDGE-SP	LAHH-901: Pump will be OFF	Discrete		HOA

5.11.5 Alarms

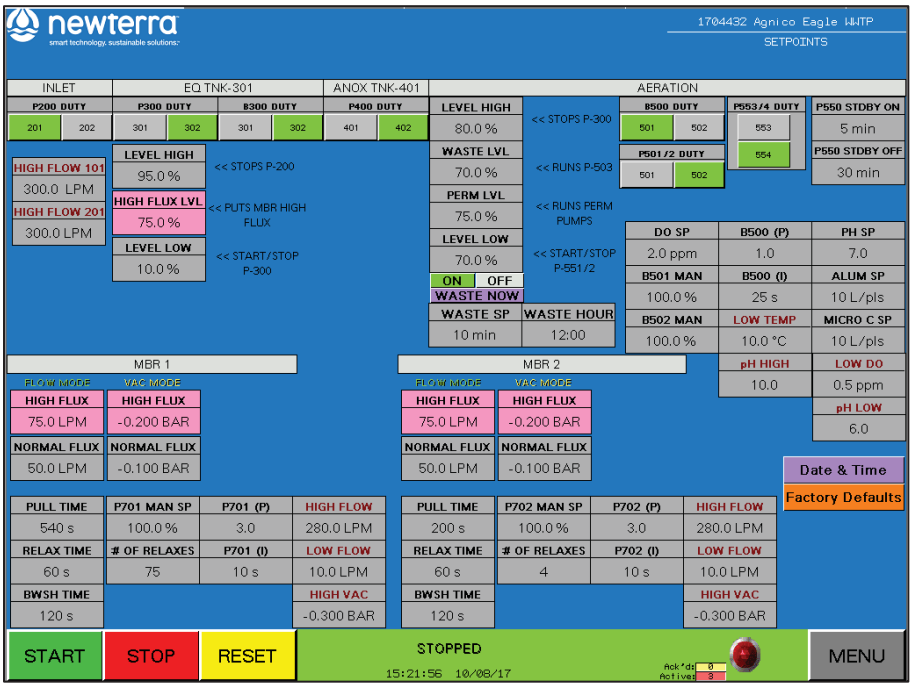
Alarm	Alarm Description	Actuation Control	Delay	Self Resetting (Y)
LAHH-901	Level Alarm High High	LSHH-901 = Active	5s	Y

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

5.12 Setpoints

The system Setpoints can be accessed from the SETPOINTS menu option.



5.12.1 PLC Date & Time

The PLC Time and Date can be adjusted from the SETPOINTS HMI screen. Below is an example of the screen that will appear for the operator.



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

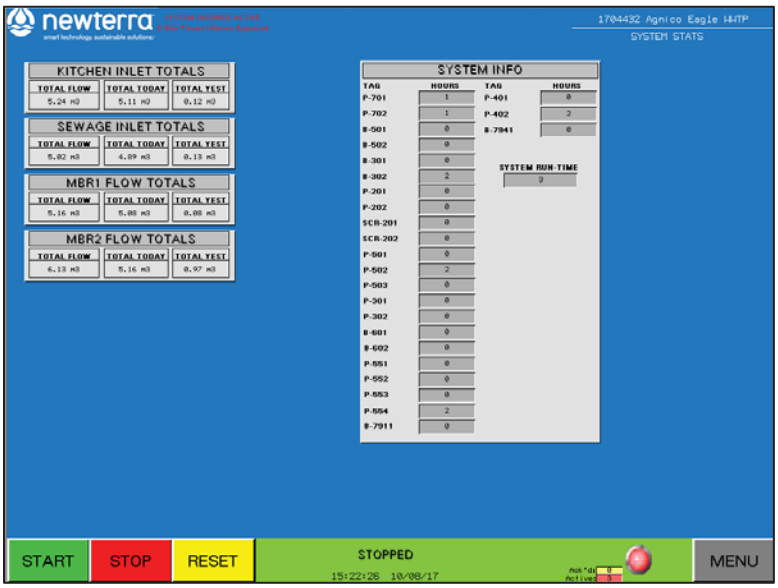
5.12.2 Factory Defaults

The Factory Defaults (setpoints) can be restored to the WWTP by pressing the Factory Default button from the SETPOINTS HMI screen. A confirmation screen will appear to the operator. See below. A listing of WWTP Factory Default values (setpoints) are at Appendix K.



5.13 Statistics

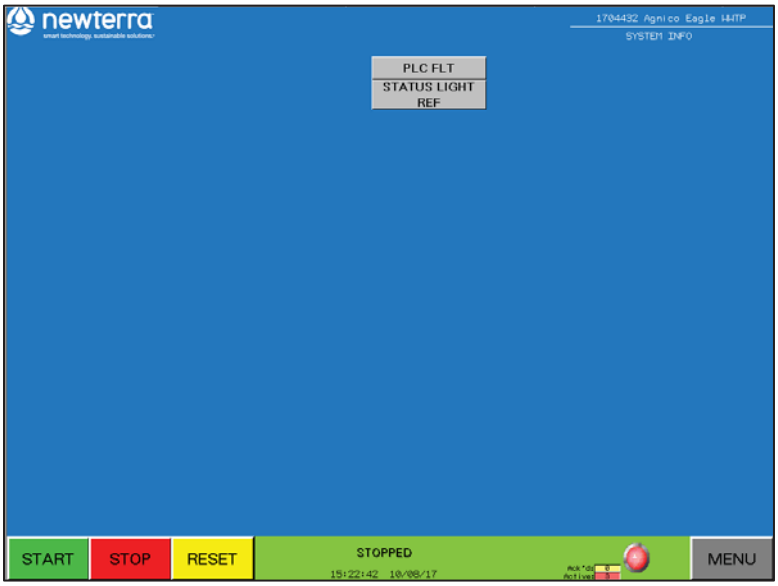
The system statistics can be accessed from the STATS menu option. Influent and Process Flow totals as well as motor run times are provided at this screen.



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

5.14 PLC Status

The system PLC status can be accessed from the SYSTEM INFO menu option.



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

6.0 PLANT START-UP, OPERATING GUIDELINES AND MONITORING

6.1 MBR Plant Start-Up

6.1.1 Mechanical & Electrical Start-up Procedure

- If the system is being started for the first time, work your way through the **newterra Commissioning Checklist** presented in **Appendix C** of this O&M Manual.
- If the kill switch on the panel (red mushroom shaped button) is pulled out, then push it in to confirm that the MBR system is off.
- Push the reset button on the operator interface to reset all alarms.
- Make sure there are no obstructions over any moving parts, for example a jacket laying on a belt drive.
- Put all HAND/OFF/AUTO switches to AUTO **(A)** mode.
- Pull the kill Button (red button on panel) out to start the process.
- Push the start button on the Operator Interface.

6.1.2 Process Start-up

NOTE: Sludge from a nearby wastewater treatment plant can be used to start up another system if the treatment process is similar (i.e. nitrification, de-nitrification etc.).

1. Introduce the seed bacteria and fill the aeration tank according to one of the following two methods specific to the type of seed used:

Sludge Seed

a. Calculate the volume of seed sludge required to ensure that there is a minimum of 3,000 mg/L MLSS in the MBR system. The volume of seed sludge required can be calculated with the following formula.

$$V_s = \frac{3000 \times V_t}{MLSS_s}$$

Vs: Total volume of seed sludge for MBR system (m3)
Vt: Total effective volume of process tanks in MBR system (see section 3 of the manual) (m3)
MLSSs: MLSS concentration of seed sludge from a treatment system with similar processes (nitrification, de-nitrification etc.) (mg/L)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Arrange for delivery of fresh seed sludge from an activated sludge system employing a suspended growth type process. If it is possible, obtain seed sludge from a facility treating similar wastewater and operated with similar processes (nitrification etc).

b. If possible drain the water used for clean water testing from the aeration tank. This will minimize dilution of the seed bacteria.

c. Pump seed sludge through the screen module to remove any debris that might damage the membranes. This can usually be done by slowly dumping the seed into the closest lift station. Ensure screen process and feed pumps to aeration tank are in “AUTO” mode.

d. If a primary clarifier is included and there is a screen between the aeration tank and membrane tank: Add seed sludge directly to the aeration tank.

e. Once aeration tank liquid level has filled above 30% with seed sludge, turn aeration tank blowers to “AUTO” mode.

f. Continue adding remaining seed sludge.

g. Once all seed sludge has been pumped into the aeration tank take note of the liquid level. If the aeration tank is full then continue to Step 2. If the aeration tank is not full then continue to fill the aeration tank 15% of its total volume per day using raw wastewater. This is to avoid shocking the bacteria with excess BOD, reducing the risk of forming foam causing bacteria and reducing the impact of un-metabolized BOD on the membranes.

Dry Seed

a. If possible drain the water in the aeration tank used for clean water test. This will minimize dilution of the seed bacteria.

b. Turn screen module and feed pump(s) to aeration tank to “AUTO”.

c. Allow aeration tank to fill to 30% with raw wastewater, and then turn off screen module and feed pump(s).
d. Remove the access cover from the aeration tank.

e. Adjust the DO probe and pH probe positioning in the aeration tank until both probes are submerged in the wastewater.

f. Turn aeration tank blowers to “HAND” to ensure vigorous mixing when adding dry seed bacteria. Note: When set to “HAND” the blowers will only run for 2 minutes. If this time runs out before all the dry bacteria have been added, then the blowers must be set to “OFF” and then back to “HAND”.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

g. Slowly add 25% of the supplied heterotrophic dry seed bacteria through the view port). The following quantities in Table 1 are typically shipped with standard camp systems, if the current system is not on this list please consult with a Process Engineer:

Table 1 - Seed bacteria quantities per standard camp model

Standard Camp Model	Dry Bacteria (Bioremove 5190) (lbs)	Nitrifying Bacteria (Bioremove 5895) (lbs)
50 Man	50	10
100 Man	50	10
300 Man	75	20
600 Man	75	20
1000 Man	100	30

h. Turn aeration tank blowers to “AUTO”.

i. Continue adding raw wastewater and dry seed bacteria according to the schedule outlined in Table 2 below:

Table 2 - Dry seed and wastewater dosing schedule

Day	Daily Wastewater Flowrate (% of Aeration Tank Volume)	Aeration Tank Fill Level (%)	Dry (heterotrophic) Seed to be Added (% of Total Supplied)
1	30%	30%	25%
2	10%	40%	20%
3	10%	50%	15%
4	15%	65%	10%
5	15%	80%	10%
6	15%	95%	10%
7	5%	100%	10%

j. As the aeration tank fills, continue to adjust the positioning of the DO and pH probes accordingly.

2. Once the aeration tank is full (liquid level >80%) the remaining equipment in the system can be started. Turn all equipment (except sludge wasting/processing equipment) to “AUTO”. Set the permeate flow rate at a value to achieve a flux of 6.5 lmh initially.

   Convert flux (lmh) to flow rate (lpm) as follows:

$$Flow\ rate\ (lpm) = \frac{Flux\ (lmh) * membrane\ surface\ area\ (m^2)}{60\ \left(\frac{min}{h}\right)}$$

   **** Verify the membrane cassette model – MCXL2 = 8 m^2 of surface area

3. Continue increasing the flux rate everyday according to the schedule in below.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

NOTE: Day 1 refers to the day that the aeration tank is full. If dry seed was used this will be day 7. If nitrifying bacteria were provided begin dosing into the aeration tank according to the schedule in below.

Flux and nitrifying bacteria dosing schedule

Day	Flux (lmh)	Nitrifying Bacteria to be Added (% of Total Provided) [If Provided]
1	6.5	20%
2	6.9	20%
3	7.4	20%
4	7.9	20%
5	8.4	20%
6	9.0	-
7	9.6	-
8	10.2	-
9	10.9	-
10	11.6	-
11	12.4	-
12	13.2	-
13	14.1	-
14	15.1	-
15	16.1	-
16	17.1	-
17	18.0	-
18	18.0	-
19	18.0	-
20	18.0	-
21	18.0	-
22	18.0	-
23	18.0	-

4. Foaming may occur during start-up, which is normal. Foaming can be caused by a number of factors. Typically during start-up foaming is a result of a high food (BOD) to microorganism (F/M) ratio. This promotes the growth of long chained filamentous bacteria that increases the surface tension resulting in strong, long lasting foam. As the quantity of biomass builds, and the sludge age increases the normal non-filamentous bacteria will dominate, and the foam should subside. In the meantime foaming can be addressed by spraying water, food based defoamer (silicone based defoamer is strictly prohibited) addition, or aeration minimization in the aeration tank. Check for signs of toxicity and excessive fat, oil and grease.

5. If a defoamer is required, consult with a process engineer for recommendation of an acceptable antifoaming agent and dosing quantities.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

6. Monitor the pH throughout the start-up process. An observed decline in pH is an indication that the nitrifying bacteria are beginning to remove ammonia. It is important, however, that the pH does not drop too low, as this can cause biological activity to be inhibited, which can then result in severe membrane fouling. During start-up it is beneficial to operate at a pH between 7.0 and 7.5 to ensure optimal performance and growth of bacteria.

   The pH should be maintained between 6.5 and 8.0 during normal operation.

ATTENTION	**It is advisable to start the MBR system with a minimum MLSS concentration of 3,000 mg/L to minimize foaming. The seed sludge should come from a plant which has a screen of 2 mm. It is critical to screen the seed sludge with 2 mm perforated screen prior to seeding for membrane protection.**

ATTENTION	**No untreated wastewater should enter the membrane tank. Make sure wastewater is completely biologically treated before it gets to the membrane tank**

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

6.2 MBR System Operating Guidelines and Monitoring

6.2.1 Operating Guidelines

This section outlines the operating conditions that are required for proper wastewater treatment, and longevity of the membranes. For instructions on how to control the system using the touch screen HMI, see **Section 5**. The operators are expected to run the MBR system at all times in accordance with the maintenance, operational procedures and details specified in this manual. The following two tables provide operating parameters that can be easily maintained, and define the range of operating values.

There may be situations where the system needs to operate outside of the conditions covered in this manual. If these conditions develop, please consult newterra ltd. to discuss operation and methods to optimize performance.

Generally, the following points can be used to operate the MBR system properly:

- The MBR system is designed to treat wastewater with specified influent characteristics.
- Never operate the MBR tank below the minimum membrane submerged level. It is necessary to maintain a minimum of 250 mm liquid level above the membrane modules to ensure they are wet at all times and to allow for proper filtration.
- Always supply the required amount of air for scouring to the membrane module.
- Always filter wastewater at or below design flow rate.
- Periodically, relax the membranes by ending filtration while allowing the membrane aeration scour to operate continuously and initiate backwash operation during membrane relaxation (default relaxation mode preset in PLC - permeation continues for 9 min and stops for 1 min).
- Always operate the MBR in accordance with the parameters listed in the following tables.
- Clean the membranes in-place with a dilute chemical in accordance with **Section 7** of the O&M Manual.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

6.2.1.1 Membrane Filtration Operational Conditions

Parameter	Recommended Value	Notes
Diffuser Relaxation	10 minutes/day	Effluent filtration must be turned off, blower shuts down for 10 mins/day
Relax Time	1 min/10 min	Filtration must be off and blower are operating continuously
Backwashing	48 cycles	Built-in backwash mode during relaxation mode
In-situ Chemically Enhanced Backwash (CEB)	500 ppm as NaOCl	Requires 3 L to fully backwash one MCXL cassette. Frequency of CEB may vary. Refer to Membrane Cleaning Section 7.3 for cleaning procedure.
TMP	< 0.2 bar (2.9 psi)	Membranes to be cleaned once the TMP exceeds 0.2 bar (2.9 psi)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

6.2.1.2 MBR – Recommended Biological Operational Conditions

Parameter	Recommended	Range	Notes
MLSS (mg/L)	10,000	8,000 – 15,000	Never operate the membranes if MLSS < 3,000 mg/l. Sludge wasting should be undertaken as required to maintain target MLSS
Temperature (°C)	15 - 35	10 – 35	Avoid sudden changes in temperature. Minimum operating temperature is 15 °C
pH (s.u.)	6.8 - 8.5	6.0 – 9.0	Membrane module can handle a change in pH, however it is recommended to keep pH between 6.8 - 8.5
Aeration Tank, DO (mg/L)	≥ 2.0	1.0 – 8.0	This can be maintained by adjusting the volume of air supplied to the aeration tank
Viscosity (mPa-s)	Not applicable	0 – 300	–
Aeration Tank to Anoxic Tank Recirculation	400%	200 – 500%*	Only applies if an anoxic tank is included. *The recycle ratio is a function of effluent NO_3-N/TN limit
Membrane Tank to Aeration Tank Recirculation	400%	200 – 600%	–
F:M (kg BOD/kg MLSS/d)	0.1	0.03 – 0.2	F:M = [Flow (m^3/d) x BOD conc (mg/l)] / [Process volume (m^3) x MLSS conc (mg/l)]
F:M (kg COD/kg MLSS/d)	0.15	0.05 – 0.3	F:M = [Flow (m^3/d) x BOD conc (mg/l)] / [Process volume (m^3) x MLSS conc (mg/l)]
SRT	> 15	12 – 50	

Process Troubleshooting Guide is presented in Section 7 of this O&M Manual.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

6.2.2 Sampling

To ensure accurate system monitoring and the validity of laboratory test data, samples must be collected as outlined below. These are only recommended guidelines. It is imperative that scheduled testing protocols are performed in compliance with local regulatory agency requirements. Composite samples of the MBR systems may need to be sent out to a certified laboratory for testing, based on the local regulatory requirements.

Monitoring and Testing Requirements

Parameter***	Influent	Aeration Tank	Membrane Tank	MBR Effluent
Flow rate	D (PLC)			D (PLC)
Fat, Oil and Grease (FOG)	AR			AR
Alkalinity	AR			
Biological Oxygen Demand (BOD)	W			W
Total Suspended Solids (TSS)	W			W
Total Kjeldahl Nitrogen / Total Nitrogen (TKN / TN)	M			AR
Ammonia Nitrogen(NH_4-N)				AR
Nitrate Nitrogen (NO_3-N)				AR
Total Phosphorus (TP)	W			W
Mixed Liquor Suspended Solids (MLSS)			W	
Mixed Liquor Volatile Suspended Solids (MLVSS)			AR*	
Temperature		D (PLC)		
pH	AR	D (PLC)		W
Dissolved Oxygen (DO)		D (PLC)		
Filterability			TW	
Turbidity				AR**
Fecal Coliform / *E-Coli*				W

Legend: D = daily; W = weekly; TW = three times weekly; M = monthly; AR = as required.
* If MLVSS /MLSS ratio of a minimum of 0.7 is detected, MLVSS testing can be done periodically, on an “as required” basis.

**The effluent should be routinely checked for any signs of problem. Normally, the effluent is reasonably clear, colourless, and odourless. If the effluent becomes turbid, testing should be carried out required.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

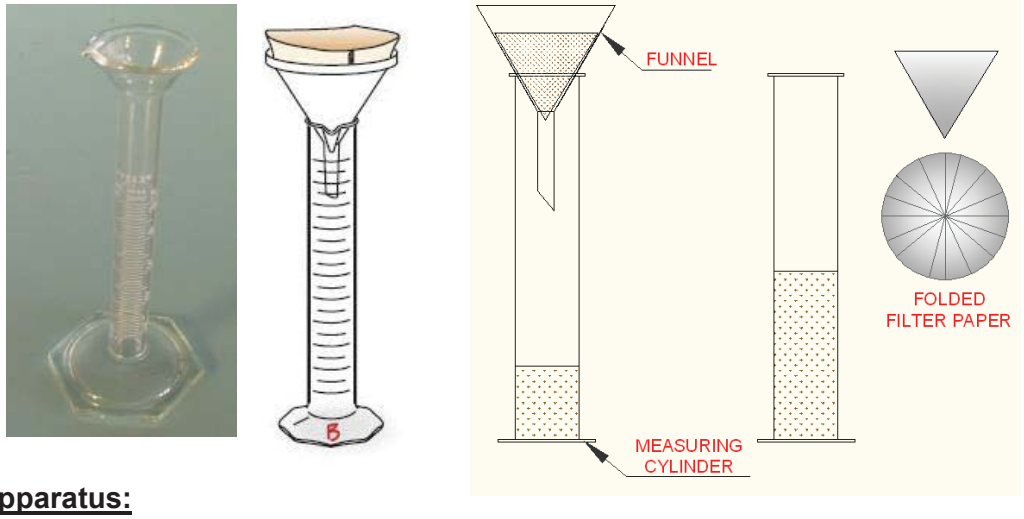
newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

*** Explanation and definition of abbreviations, acronyms and terms used in the manual are presented in **Appendix G – Glossary & Terms and Appendix H – Biological Treatment & Monitoring Parameters.**

6.2.2.1 Filterability Test

The objective of the filterability test is to evaluate the condition of the working biomass. This is assessed by measuring the volume of filtrate passing through the filter paper. If filtrate is greater than 10 mL/10 min, then biomass filterability is acceptable; however, if it is less than 10 mL/10 min, modifications to the plant operating condition are required to prevent premature membrane fouling. See the Membrane Fouling Troubleshooting Guidelines table in Section 7.6.1 to determine the cause of the low filterability and how to correct operation to improve the filterability.

Laboratory Glassware and Filter Paper



Apparatus:

Filterability Kit is distributed by **newterra ltd (Part # 24146).**

Measurement Procedure:

1. Pleat filter paper by folding in half, quarters etc.
2. Line the funnel with pleated filter paper and place the funnel in the graduated cylinder.
3. Collect 50 mL of activated sludge sample in a beaker and stir.
4. Pour the 50 mL sample into the funnel.
5. Start timer when the first drop of water filtered through the filter paper.
6. After 10 minutes of filtration, record the level of filtrate in the graduated cylinder.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

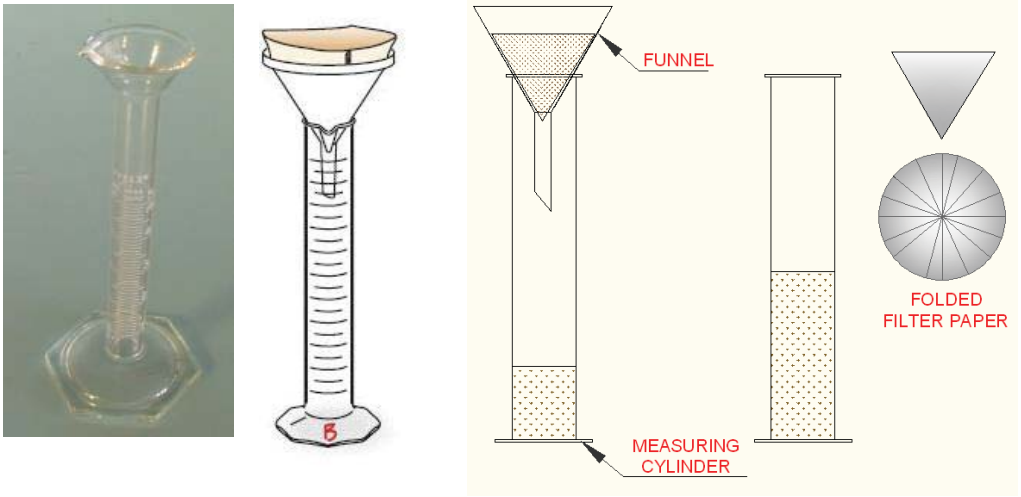
newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Filterability (FT)	Action	State of urgency
> 10 ml	Excellent, no action req'	
5 - 10 ml	Tweak process operation	
< 5 ml	Process adjustment req	**Contact newterra ltd.**

6.2.3 Suggested Test Equipment for Monitoring

The following test equipment's will assist in the monitoring of the MWWTP but are not provided with the system.

6.2.3.1 Filterability - Laboratory Glassware and Filter Paper



Apparatus:

- Filter paper - AMD Manufacturing, Part Number NO5C 18.5CM or equivalent;
- Funnel (75 mm diameter recommended);
- 50 mL graduated cylinder - Cole-Parmer Graduated Cylinder, Part Number RK-06134-67 or equivalent;
- Beaker (min 100 ml size) and stir rod
- Watch with seconds display or equivalent

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

6.2.3.2 Turbidity, Phosphorus - Hach DR900 (and reagents)



The hand-held DR 900 allows quick and easy access to most-used testing methods. This colorimeter is waterproof, dustproof and field durable. With an intuitive user interface, easy data transfer abilities, and the ability to test up to 90 of the most commonly tested water methods.

6.2.3.3 DO and pH - Hach HQ40d with probe or Equivalent



Designed for water applications, the Hach HQ40d portable meter is an advanced meter. HQd™ meters connect with smart probes that automatically recognize the testing parameter, calibration history, and method settings to minimize errors and setup time.
Portable meter measures critical water quality parameters - without the need for multiple instruments.
Intuitive user interface for simple operation and accurate results.
Meter kit includes field case, 4 AA batteries, protective meter glove, power adapter, USB/DC power adapter for data transfer, quick-start guide, user manual, and documentation CD.
DO and pH probes required.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

6.2.3.4 Sludge Settling - Settleometer



The ability to observe and measure the rate and characteristics of solids separation is essential to control biological treatment processes that produce sludge.

6.2.3.5 TSS - Aysix model 3150 hand held TSS meter or Equivalent



Portable Suspended Solids Analyser

6.2.3.6 Hach CEL Advanced Wastewater Laboratory



Includes the DR 900 Colorimeter, HQd multi-meter with pH probe, reagent sets, apparatus, illustrated instrument and procedures manuals, and a rugged carrying case

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

6.2.4 Record Keeping

An essential component of quality control in any facility is sound record keeping. A log book covering the entire treatment system performance should be maintained, updated, and readily accessible to all operators. The log book should be used to record observations, set point alterations, and unusual conditions.

For each wet chemistry parameter analysis, a separate work-sheet has to be prepared. Work-sheet data for at least the previous year should be kept for possible consultation.

The second step in quality control is to train all operators to follow an established procedure for each test. Identical samples should be periodically tested for any parameter by different operators, and the variability among results should be compared. Consistent variability in results may lead to the technique improvement of operators.

Duplicate analysis of a sample should also regularly be done. And, split samples should regularly be sent to an outside accredited laboratory and analysis results should be compared with those done in-house.

In addition to summary sheets, it is highly recommended that data should be entered into prepared Excel spread-sheets. Spread-sheets greatly aid in the data presentation and manipulation, and would be of immeasurable value when report writing is required.

6.2.5 Process Trending

Other than pre-planned process changes or major upsets, process modifications should be based on trends shown in the process data. A trend is nothing more than an indication of real change in a process parameter over time. A trend chart is simply a graph of data being trended.

As the graph changes, upward or downward trends are detectable. Smoothing trends by graphing the 3-, 7-, or 30-day average of the data allows the trend to be shown more clearly. Because the individual data point may be questionable, the actual value of data point are less important compared with the trend regarding the process monitoring.

Trend graphs are a part of the Excel data spread-sheet; the operator can trend and analyse many parameters in just a few minutes in order to assess process performance.
When a trend is identified, its indication to the process can be evaluated, and corrective action may be carried out, if needed. Statistically, the more data points there are in a trend chart, the more reliable the trend.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

7.0 SYSTEM MAINTENANCE

	**ATTENTION: MAINTENANCE SHOULD BE PERFORMED ONLY BY TRAINED PERSONNEL!** **When providing maintenance or cleaning the plant, avoid direct contact with wastewater, organic materials, etc.** **Always wear protective clothing, e.g. waterproof, protective gear, boots, and gloves to keep these materials from body. Wear face and eye protection as required by health & safety protocols and standards, especially when handling chemicals.**

CAUTION: Shut off all electrical power before working on the mechanical or electrical equipment.

The system should be routinely checked for any signs of operational problems. Such problems could include, but are not necessarily limited to, abnormally high peak flows, unpleasant odour, and diffuser clogging, and so on.

7.1 Plant Visual Checks

Noise	During normal operation, there is a uniform humming sound at the plant. In case of an unusual noise, it could be an indication that the blower needs maintenance or repairs.
Smell	The MicroClear™ MBR is an aerobic system. During normal operation, the system has an earthy smell similar to that of a well-maintained compost pile. If other odours are noticed, the aeration process may not be operating or the system has been overloaded. Check the DO manually and the blower to verify proper operation.
Sight	Normally, the effluent is reasonably clear, colourless, and odourless. If the effluent becomes turbid, there is a pin hole in the membrane or a leakage in the piping. Take the unit out of operation and investigate. **Check uniformity of membrane air distribution periodically to ensure air scouring is effective across all membrane plates.**

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.1.1 Air Scouring Patterns in Membrane Tanks

Membrane air scouring check is an essential routine maintenance procedure for **newterra** MBR WWTP to ensure membranes are receiving effective physical cleaning. Air scouring has to be observed for uniformity of bubbling action all across the membrane module/cassette on regular basis.

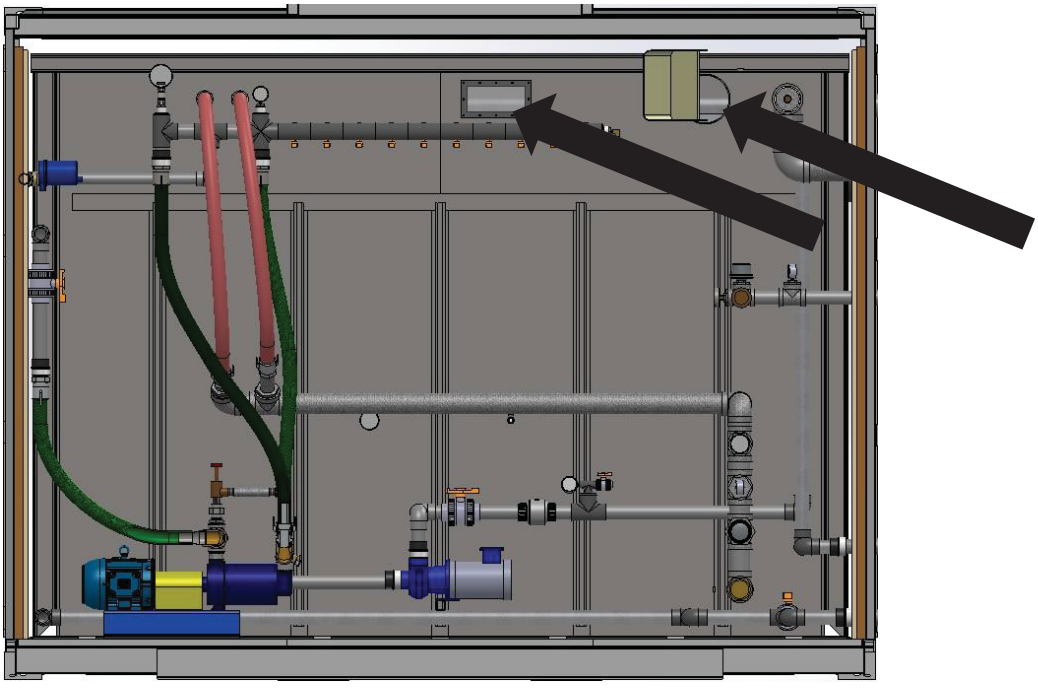
A visual inspection of the aeration patterns should be performed with the liquid level 2-3" (5 – 7.5 cm) above the top row of membranes and looking thru the tank viewport or inspection opening (see below).



Proper air scouring in membrane tank



Uneven aeration in membrane tank



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

It is easy to observe aeration patterns through the clear window in the membrane tank(s). Operator should note any unusual patterns of air distribution. The visual inspection should also be performed before any membrane cassettes are removed from the membrane tank(s). Operator has to check for:

- damage of air diffusers - if this occurs, empty the tank and fix the diffuser;
- air leakages - if this occurs, tighten up the fittings.

If there is insufficient air scouring, localized dewatering (**clogging, sludging, caking and plugging**) may occur and may in turn lead to membrane fouling.

7.2 Schedule for Routine Operation and Maintenance Checkups

Location	Item	Day	Week	Month	Quarter	Year	Comments
Grease Traps	**TNK-101/102/103** **Grease traps must be cleaned whenever the grease film is approx. 1 foot thick in any tank. An unmaintained grease trap does not stop any grease waste from entering the WWTP system.**						Remove vac out grease film from top of tanks and any food particles from the bottom of tanks.
PROCESS	**Perform visual check**	X					Refer to Plant Visual Checks
	Record permeate flow rate	X					
	Record DO in the aeration tank	X					
	Record pH in the aeration tank	X					
	Record vacuum pressure at the membranes	X					Normal range: 0.07 – 0.25 bar (28” -100” WC)
Note: When the vacuum at the membranes reaches 0.25 bar/3.5 psig/100" WC), it may be necessary to stop the permeation and perform recovery cleaning (please see Section 7.6.1 for membrane fouling troubleshooting and subsection 7.3 for membrane cleaning procedures)							
MECHANICAL & PROCESS	**Inspect membranes and permeate withdrawal system**		**X**				1 hour
	Clean the DO sensor – DO-501 Replace DO probe every second year in accordance with vendor manual.		**X**				In accordance with vendor manual in Appendix E
	Clean and calibration (as required) PH-501					X	In accordance with vendor manual in Appendix E

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Location	Item	Day	Week	Month	Quarter	Year	Comments
MECHANICAL & PROCESS	**Inspect and maintain valves & fittings for leaks.**		**X**				
	Membrane in-situ cleaning				X		2-4 hours
	Remove membrane module for mechanical cleaning and inspection					X	Drain membrane tank. Roll out membrane cassette. Remove membranes and inspect. (1 -2 days)
	Remove, inspect and maintain diffusers in aeration and membrane tanks					X	This involves a complete draining of tanks (1-2 days). In accordance with vendor manual in Appendix E
	P-201/202, 301/302, 401/402, 501/502, 553/554, 551/552 – Price Pumps **-General Condition (Temperature, Unusual Noises or Vibrations, Cracks, Leaks, Loose Hardware, Etc.)** **- Pump Performance (Gauges, Speed, Flow)** **-Clean electrical motor and keep ventilation openings clear**				**X**		See vendor manual at Appendix E.
	P-701/702 – Permeate Pumps **-General Condition (Temperature, Unusual Noises or Vibrations, Cracks, Leaks, Loose Hardware, Etc.)** **- Pump Performance (Gauges, Speed, Flow)** **-Clean electrical motor and keep ventilation openings clear** **-Do Not let the pump run dry!**				**X**		See vendor manual at Appendix E.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Location	Item	Day	Week	Month	Quarter	Year	Comments
MECHANICAL & PROCESS	**P-801 – Backwash Pump** **-General Condition (Temperature, Unusual Noises or Vibrations, Cracks, Leaks, Loose Hardware, Etc.)** **- Pump Performance (Gauges, Speed, Flow)**						Submersible pumps contain oils which becomes pressurized and hot under operating conditions - allow 2½ hours after disconnecting before attempting service.
	B-301/302 , 601/602 – EQ and Membrane Tank Blowers **-Clean electrical motor and keep ventilation openings clear** **-Check inlet filter. Clean or replace as necessary.**			**X** **X**			In accordance with vendor manual in Appendix E
	B-501/502 – Aeration Tank Blowers **-Clean electrical motor and keep ventilation openings clear** **- Check V-belts for tightness** **- Check and add fresh oil as required to maintain proper level.** **- Change blower oil.** **-Check inlet filter. Clean or replace as necessary.**		**X** **X**	**X** **X**		**X**	In accordance with vendor manual in Appendix E Semi-annual
	SCR-101/102 **-Inspect inspecting the unit for blockages and general cleaning. Inspection doors are located on the cover guard and screen body. Washing the screen with high water pressure may be necessary.**	**X**					

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

Location	Item	Day	Week	Month	Quarter	Year	Comments
	-Check for wear on the brushes and give the unit a thorough cleaning each week will ensure maximum efficiency. **-Check the oil level in the motor. Grease the bearings with the appropriate grease. Making adjustments to the brushes to maximize contact with perforated sheet.**		**X**	**X**			
	P-6101/6102/6103 – Dosing Pumps **-Check the metering diaphragm for damage** **-Check that the hydraulic lines are fixed firmly to the liquid end.** **-Check that the suction valve and discharge valve are fitted tightly.** **-Check the tightness of the entire liquid end - particularly around the leakage hole** **-Check that the flow is correct: Allow the pump to prime briefly - turn the multifunctional switch briefly to "Test"** **-Check that the electrical connections are intact.** **-Check the integrity of the housing.** **-Check that the dosing head screws are tight.**				**X**		In accordance with vendor manual in Appendix E
	Container Fans **-Dust and dirt on the exterior surface of the motor, fan panel and the entire fan wheel should be removed.** **-Inspect of all fasteners to ensure they have not loosened due to vibration.**					**X**	In accordance with vendor manual in Appendix E

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Location	Item	Day	Week	Month	Quarter	Year	Comments
	Container Heaters **Once a year, remove the dust accumulation inside the heater using a vacuum cleaner or compressed air. Cleaning should be done while the heater is disconnected from the supply circuit.**					**X**	In accordance with vendor manual in Appendix E
ELECTRICAL	**Check electrical leads**				X		
	Check panel fan filter and replace/clean as necessary.			X			
	Inspect and maintain breakers, fuses, resets and anodes			X			
	Check motor mounting bolts			X			
	Clean dust away from electric motor			X			
	Check PLC and control panel functionality		X				



All connections (hoses, hose clamps, camlocks) have to be checked periodically (on a monthly basis) to make sure all of them are in good condition with no leaks.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.3 MBR Membrane Cleaning

7.3.1 Membrane In-situ Chemically Enhanced Backflush (CEB)



Chemical cleaning is only to be carried out by qualified and trained personnel! Chemicals can lead to serious injuries. Always wear personal protective equipment (PPE) when handling chemicals! Obey the chemical safety handling procedure as listed in the Material Safety Data Sheets.

It is recommended that in-situ CEB be carried out before the TMP exceeds 0.25 bar (or permeability drops rapidly to 50 LMH/bar) This is typically done once every couple weeks/months depending on biomass characteristics and system operating condition.

On certain occasions, membrane module/cassette may need to be physically inspected for membrane integrity if membrane permeability performance is not recovered after the cleaning (i.e., suspect of membrane deterioration); please refer to subsection **7.3.3**.



The maximum backflush pressure of MicroClear™ MCXL filter is 0.1 bar or equivalent to a 100 cm water line. Only use gravity force to perform the backflush.

Note: Membrane have a maximum active chlorine tolerance of 100,000 ppm.h.

For better cleaning performance, it is recommended:

- Potable water (permeate is acceptable if potable water is unavailable)
- Water temperature is above 20 ^{0}C (better cleaning efficiency if water temperature ranges from 20 to 30 ^{0}C)

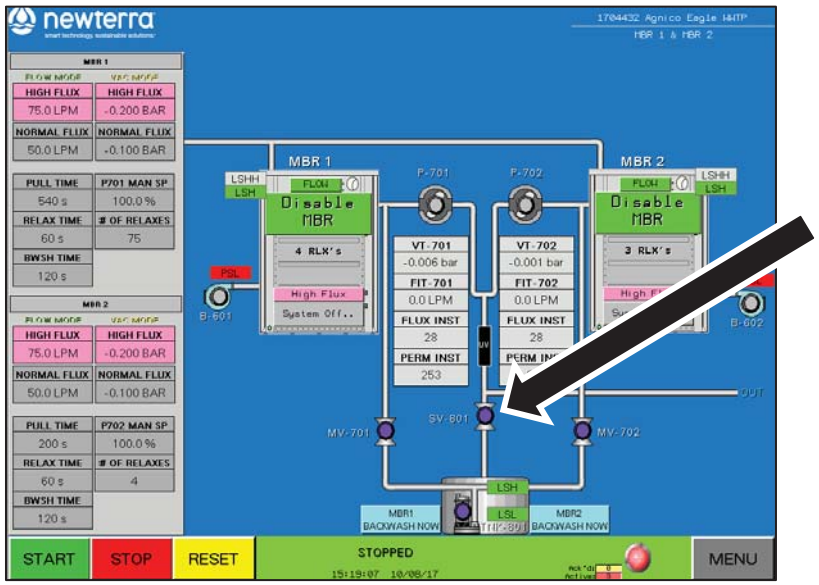
© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

7.3.1.1 Procedure – Backwash Solution Preparation

Note: It is recommended that only one membrane module at a time be cleaned (backwash).

Prepare the backwash solution as follows:

1) If backwash tank TNK-801 is empty:
    a. Ensure membrane is enabled and pulling, and turn SV-801 solenoid valves on hand ("H") until backwash tank is filled with required volume for chemical backwash (3L per cassette X 20 cassettes per module = 60 L OR approx. 1/4 capacity of TNK-801). Note TNK-801 capacity is 272L.
    b. Turn SV-801 series solenoid valves off ("O")

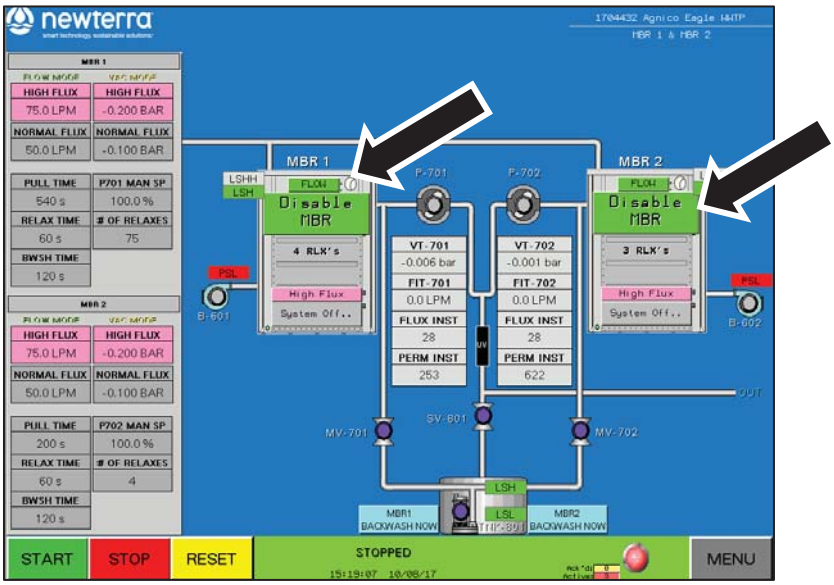


    c. Skip to step 3

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

2) If backwash tank TNK-801 is full:

   a. Disable membrane by holding down the disable membrane button for about 5 seconds



   b. Turn SV-801 solenoid valves to off (“O”)

   c. Turn MV-701/702 (depending on the membranes to be cleaned) motorized valves to hand (“H”)

   d. Turn pump P-801 to hand (“H”) until the backwash tank has drained to the required volume for chemical backwash (3L per cassette X 20 cassettes per module = 60 L OR approx. 1/4 capacity of TNK-801) – the exact volume can be determined by backwash tank level drop. Note TNK-801 capacity is 272L.

   e. Turn P-801 to off (“O”)

7.3.1.2 Procedure – Organic Fouling Solution

Organic Fouling - NaOCl: 500 mg/L solution (acceptable range of 200 to 1000 mg/L). Used for removal of organic fouling, which is the most common type of fouling in MBRs.

Volume of concentrated NaOCl required can be calculated with the following formula,

$$V_x = \frac{V_m \times 0.05}{C_s}$$

$\boldsymbol{V_m}$: Volume of the solution (Gallon, or Litre), equal to 3 L multiplying the number of MCXL cassettes 20 (60L per module);
$\boldsymbol{C_s}$: Concentrated NaOCl concentration (%)
$\boldsymbol{V_x}$: Volume of concentrated NaOCl required (Gallon, or Litre)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.3.1.3 Procedure – Organic Fouling Solution

Inorganic Fouling - Citric Acid: 2 g/L solution (up to 20 g/L). Used for removal of inorganic fouling. This is typically only required for systems treating water with a high hardness.

Rinse membrane filter and backwash tank thoroughly with potable water to completely remove NaOCl solution before treatment with citric acid. Mixing NaOCl with citric acid releases toxic chlorine gas!

7.3.1.4 Procedure

1) Ensure MV-701/2 series motorized valves and SV-801 solenoid valve are set to off (“O”). The system is now ready for a chemical backwash. Note: only one membrane module should be backwashed at a time. The modules can be isolated by closing the permeate valves (there are valves per module)



2) Turn off all blowers in the membrane tank to be backwashed (B-601)
3) Turn the MV-701/702 motorized valve to hand (“H”) then turn pump P-801 to hand (“H”) until the backwash tank has drained.
4) Turn pump P-801 to off (“O”) and then turn the MV-701/702 motorized valve to off (“O”).
5) Let membranes soak for 45 mins or so.
6) After soaking membranes, turn the blowers back on (B-601) and allow blowers to scour for ~15 minutes.
7) After the 15 minute scour turn all valves and pump back to auto (“A”)
8) Turn SV-801 solenoid valves to off (“O”)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

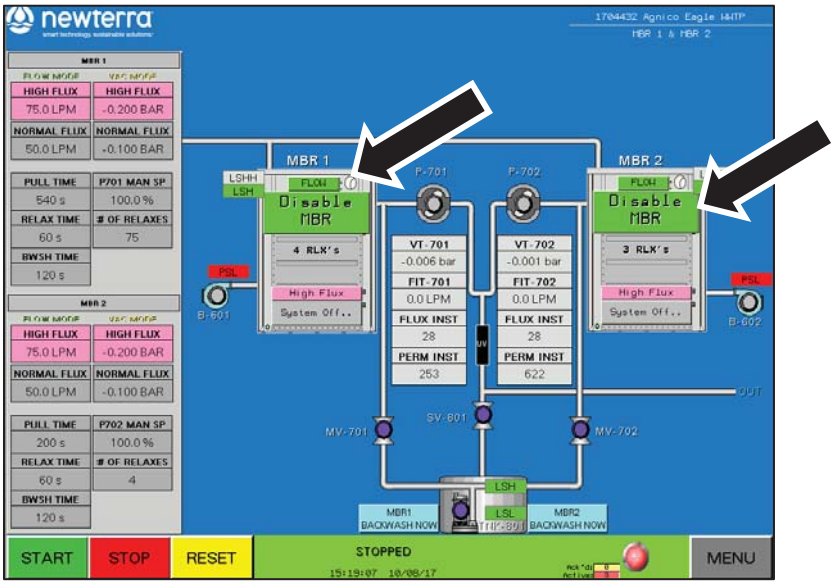
9) Enable membranes by holding down the enable membrane button for about 5 seconds
10) Allow membranes to permeate for 5 minutes, and then turn SV-801 solenoid valves back to auto (“A”)
11) Record TMP and flux, and ensure that the permeability has recovered
12) Repeat procedure for the second membrane module.

7.3.2 Membrane Recovery Cleaning

The membrane recovery cleaning is to be done once a year at a minimum. On certain occasions, membrane cassette may need to be inspected for membrane integrity (suspect of membrane deterioration, membrane permeability performance does not recover after the cleaning, etc.).



Disable operation of the membrane tank by pressing the disable membrane button on the screen.



For better cleaning performance, it is recommended:

- Potable water is used
- Water temperature is above 20 ^{0}C (better cleaning efficiency if water temperature ranges from 20 to 30 ^{0}C)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

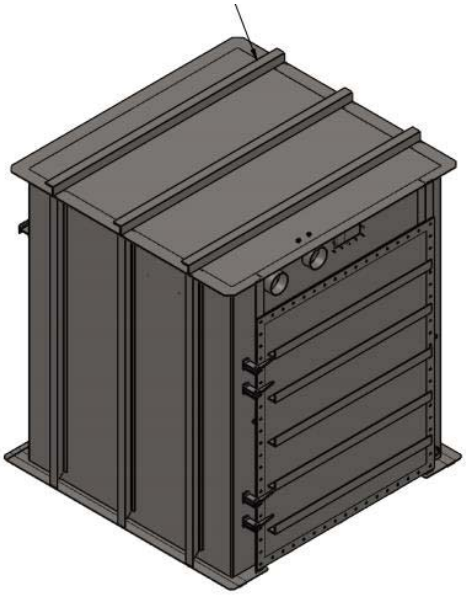
newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.3.2.1 Step 1 - Preparation

1. Turn off air scour – B-601/602

2. Drain all mixed liquor from the membrane.

3. Open the MBR tank hatch. Clean (wash down) the membrane tank with water and vacuum out the dirty liquid. Close the MBR tank hatch.



4. Fill the membrane tank with potable water until the membranes are completely covered. The membrane tank (TNK-601/2) holds approx. 8.0 m3 / 6000L.

7.3.2.2 Step 2 – Cleaning with High pH Solution

This step is to be done if membrane fouling is a result of high FOG. Note: FOG in influent wastewater should be maintained below 30 mg/L.

5. Confirm that the membrane tank (TNK-601/2) has been cleaned and refilled with water (Section 7.3.2.1).

6. Add a suitable chemical – normally caustic soda (Sodium hydroxide (NaOH)) - to the membrane tank to raise the pH to 12.

    a. Volume of NaOH required can be calculated as follows. A starting dose for NaOH would be 400 mg/L. For example: if using a 50% solution of sodium hydroxide, approximately 0.5 L of solution would be required per m3 of membrane tank. Additional NaOH may be required depending on the alkalinity of the water. The operator should measure pH after addition of 400 mg/L and add more until the pH is 12.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

b. TNK-601 holds approx. 8 m3 or 8000L.

7. Turn on air scour for 2 min to mix the solution and turn it off during membrane soak.

8. Allow membranes to soak for 1 to 2 hours.

9. Drain spent solution.

7.3.2.3 Step 3 - Cleaning with Sodium Hypochlorite (NaOCl)

1. Turn off air scour

2. Confirm that the membrane tank (TNK-601) has been cleaned and refilled with water (Section 7.3.2.1).

3. Add NaOCl into the membrane tank to a concentration of 500 mg/L as free chlorine (max. 1,000 mg/L). Turn on air scour for 2 min to mix the solution and turn it off during membrane soak.

   Volume of NaOCl required can be calculated with the following formula:

$$V_x = \frac{V_m \times 0.05}{C_s}$$

   $\boldsymbol{V_m}$: Volume of membrane tank - TNK-601 holds approx. 8.0 m3 / 8000L.
   $\boldsymbol{C_s}$: NaOCl concentration (%)
   $\boldsymbol{V_x}$: Volume of NaOCl required (m3 or Litre)

4. Keep the membranes soaked for 8 to 12 hours in the NaOCl solution (longer soak time required if severe fouling is evident).

5. Drain spent NaOCl solution.

6. Rinse membrane filter thoroughly with potable water by filling and draining the entire tank. Rinse waters are drained to the sump/recycle back to the headwork.

7. Repeat step 6 to ensure all NaOCl has been thoroughly removed.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.3.2.4 Step 4 - Cleaning with Citric Acid

This step is only required in case of inorganic fouling caused by the high hardness. The recommended concentration is 2 g/L solution (up to 20 g/L).



Rinse membrane filter thoroughly with potable water to completely remove NaOCl solution before treatment with citric acid. Mixing NaOCl with citric acid releases toxic chlorine gas!

1. Turn off air scour
2. Confirm that the membrane tank (TNK-601) has been cleaned and refilled with water (Section 7.3.2.1).
3. Add Critic Acid into the membrane tank to a concentration of 2 g/L solution (up to 20 g/L) – reducing the membrane tank to a pH of 2.0.
    a. Volume of Critic Acid required can be calculated as follows. A starting dose for Critic Acid would be 2g/L (up to 20g/L). For example: if using a 50% solution of Critic Acid, approximately 3.2 L of solution would be required per m3 of membrane tank. Additional Critic Acid may be required depending on the alkalinity of the water. The operator should measure pH after addition of 2g/L and add more until the pH is 2.
    b. TNK-601 holds approx. 8 m3 or 6000L.
4. Keep the membranes soaked in the citric acid solution for 2 hours (longer soak time required if severe fouling is evident).
5. Drain spent citric acid solution, rinse membranes thoroughly with potable water and drain all the rinse waters. Spent citric acid solution and rinse waters are drained.

7.3.2.5 Step 5 - Resume normal operation

Turn all equipment back to Automatic mode “A”, and enable the membranes.

7.3.2.6 Step 6 - Checking Permeability

Normal permeability after cleaning: 200 to 300 LMH/bar.

Repeat the cleaning procedures If normal permeability is not achieved.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Note: Membrane maintenance (CEB) and recovery cleaning has to be recorded according to Membrane Cleaning Log Sheet presented in Appendix J of the manual.

7.3.3 Membrane Physical Check



***WARNING**: A membrane cassette that has been in operation weighs more than dry membrane cassette before installation.*
Failure to comply with the instructions provided in this manual can cause equipment & property damage or severe personal injury, and will render the warranty null and void.

To removing membrane module from membrane tank

This procedure is required if the membranes are being inspected as part of routine maintenance for physical check or being replaced.



Once membrane inspection or replacement has begun, it must be completed promptly. It is important that the membranes DO NOT DRY OUT OR FREEZE during this procedure.

1. Confirm that the eStop switch on the main panel is pushed in. Confirm that the Main Disconnect is ON. Stop the system operations by using the HMI screen button.

2. Empty the MBR tank (TNK-601) via the tank drain valve or recycle back to Aeration Tank using P-601.

3. Open the MBR tank hatch.

4. Wash remainder of waste water in the tank with reuse water and vacuum out.

5. Install the cassette rails and Disconnect the permeate hoses from the top of the membranes.

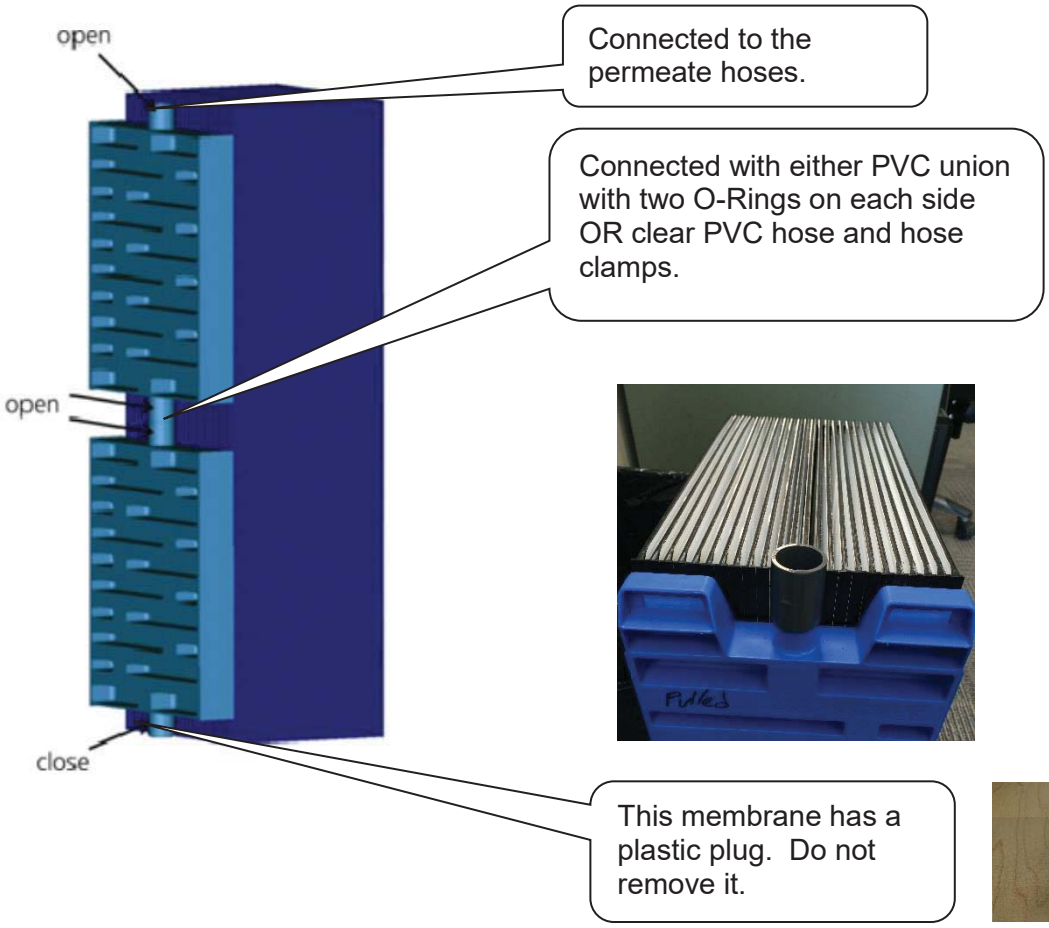
6. Slide out the cassette and further clean the membranes.

Membrane module replacement - ***If membranes require changing*** verify membrane modules are secured within the membrane tanks after re-installing the new modules – i.e. verify wheel chocks are in the correct location and that there is no lateral movement (less than an inch) of the membrane modules on the wheel tracks in the tank.

7. Remove the membranes from the cassette. NOTE. The membranes are triple stacked. The bottom membrane has a plug in the bottom opening. Do not remove this plug. Note the membrane orientations for re-installation. The membranes are joined together with either a PVC union with two O-Rings on each side OR clear PVC hose and hose clamps.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com



8. After membranes are separated, wash with clean water. Remove the blue backing plate and gently separate the membrane plates and clean with water to remove any debris. Replace backing plate.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.





9. Place bottom membrane cassettes in the MBR tank and then integrate top membranes into the triple stack configuration. Slide in the cassette and reconnect the permeate hoses. Close the MBR tank door and start system operation.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.4 Sludge Decanting (TNK-901)

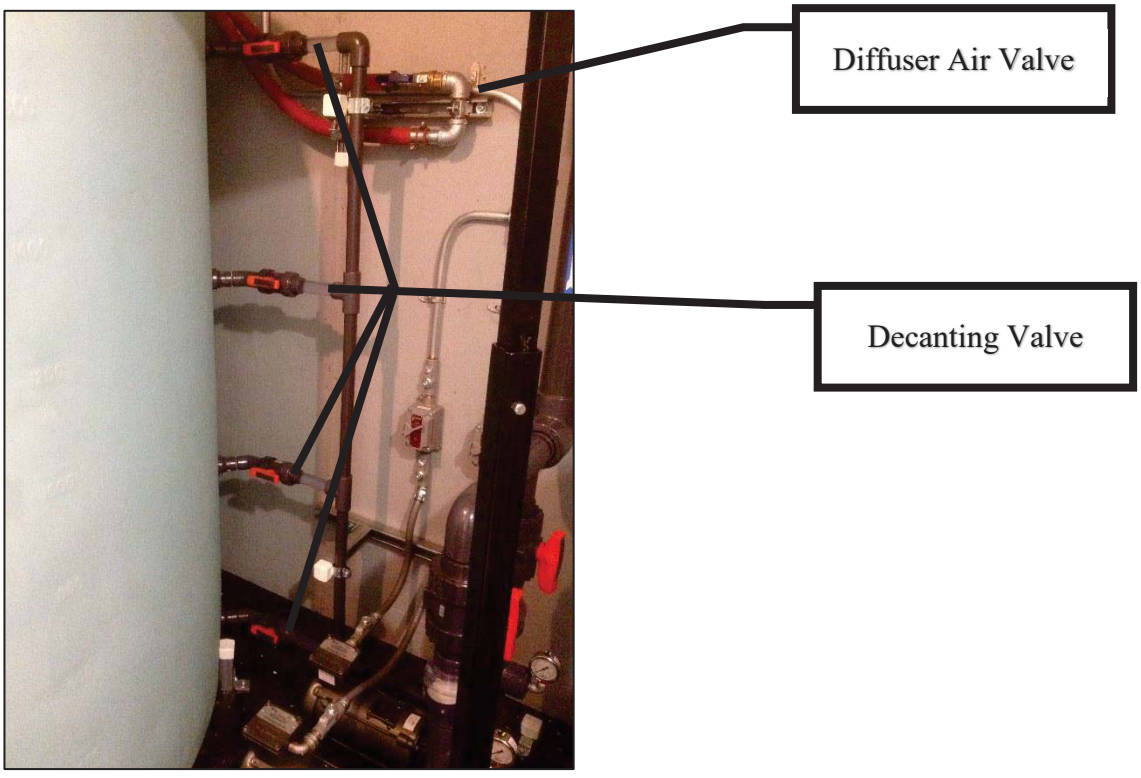
In order to maintain an optimal concentration of mixed liquor suspended solids (MLSS) (typically 10 g/L), a portion of the mixed liquor is periodically wasted by pumping from the Aeration Tank (TNK-501) to the sludge holding tank (TNK-901). Wasted sludge in the sludge holding tank is thickened by decanting supernatant back to the screen tank. Thickened sludge accumulates in the sludge holding tanks until it is eventually pumped out for disposal.

Excess sludge will be wasted by P-503 from the Aeration Tank (TNK-501) every 10 mins at noon. See below.

Tag	Description	Factory Setpoint	Setpoint Range and Units
P503 WASTE HOUR	When P-503 will waste	12pm	0-23
P503 WASTE SP	Time that P-503 wastes for	10min	0-99

In order to decant the water from the sludge, the air to TNK-901 diffuser must be turned off. See valve location below.

After the sludge has settled, that the operator would open the appropriate valve on TNK-901 to decent off the water.



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5 Trouble Shooting

7.5.1 MBR Membrane Fouling

Introduction

MBR operation relies critically on the ability of the membrane unit to pass all flow incoming to the plant. If membrane permeability is impaired, the MBR plant cannot process all flow with potentially catastrophic results even though effluent quality remains consistently high. This contrasts with typical operation of activated sludge system where the plant hydraulic capacity is rarely exceed but effluent quality is much more variable. Hence, membrane fouling (and associated reduction of flux or increase of TMP) remains as an operational challenge.

Membrane Fouling in MBR is a result of the interaction between the incoming water quality, mixed liquor filterability, system operation condition, and membrane material. There are four categories of membrane fouling. They are microbial fouling, particle/colloids fouling, inorganic fouling, and organic fouling. A brief description on the nature of fouling and control measures is summarized below.

7.5.1.1 Microbial/Biological Fouling

Microbial fouling is a result of formation of biofilms on membrane surfaces. Living materials, such as bacteria, fungus and algae, or soluble microbial products (SMP) and extracellular polymetric substances (EPS) bound to the activated sludge attach to the membrane; they start to multiple and produce EPS to form a viscous, slimy, hydrated gel. EPS typically consists of heteropolysaccharides and have high negative charge density. This gel structure protects bacterial cells from hydraulic shearing and from chemical attacks of biocides such as chlorine.

7.5.1.2 Particulate/colloid Fouling

This type of fouling may be associated with high concentrations of colloidal solids present in mixed liquor. In most cases, particles and colloids do not really foul the membrane because the flux decline caused by their accumulation on the membrane surface is largely reversible by hydraulic cleaning measures such as backwash and air scouring. However, the accumulation of solids between the membranes can create increased membrane resistance to permeation and permanent physical membrane damage.

To distinguish the different fouling phenomena, particles and colloids here are referred to biologically inert particles and colloids that are inorganic in nature.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.1.3 Inorganic Fouling

Inorganic fouling or precipitative fouling is caused by the accumulation of inorganic precipitates such as metal hydroxides, and “scales” on membrane surface or within pore structure. Precipitates are formed when the concentration of chemical species exceeding their saturation concentrations. Scale can be caused by high pH and extremely hard feed water. For the ultrafiltration (UF) membranes in our MBR system, inorganic fouling can exist most likely due to interactions between ions and other fouling materials (i.e., organic polymers) via chemical bonding.

7.5.1.4 Organic Fouling

Organic fouling is the attachment of materials such as oil or grease to the membrane surface. It is common in MBR systems used for treating industrial effluent. Organic fouling often leads to surface and internal pore fouling. More importantly, organic fouling progressively leads to biological fouling (i.e., biofilm growth/build up on membrane surface). Sometimes the adsorption process is irreversible when the organic substances are hydrophobic or positively charged polymers with high molecular weight. Such organic substances including organics present as an emulsion must be removed in the pretreatment.

The following pictures are examples of clean membranes





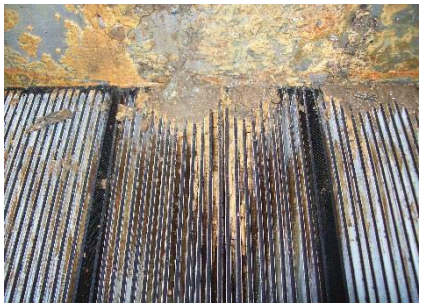
The following pictures are examples of fouled membranes

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com





7.5.1.5 Fouling Prevention

Control of fouling and clogging in practice is generally limited to six main strategies:

1. Applying appropriate pretreatment to the feed water. Fine screen helps to eliminate the build-up of trash, hair, lint and other fibrous materials, and decrease the risk of solids accumulation.

2. Maintaining operation within the design conditions, such as HRT, SRT, MLSS, temp, BOD/COD loading, pH, DO, F/ M ratio. Sludge wasting is a key in controlling the target operating SRT (typically ≥ 15 day) in the system. Table F.1 shows some examples.

Relationship between various operating parameters and their effect on membrane fouling

Parameter	**Effect on membrane fouling**
MLSS concentration ↑ **or** ↓	Fouling potential ↑
SRT ↑ **or** ↓	Fouling potential ↑
HRT ↓	Fouling potential ↑
Temperature ↓	Viscosity ↑ **=>** membrane permeability ↓
Filamentous bacteria ↑	Viscosity ↑ **=>** membrane permeability ↓
Air scour intensity ↑	membrane permeability ↑
EPS ↑	Fouling rate ↑
SMP ↑	Fouling potential ↑

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

3. Employing appropriate physical or chemical cleaning protocols. For example, sodium hypochlorite and citric acid solutions are used to remove organic and inorganic foulants respectively.

4. Chemically or biochemically modifying the mixed liquor, such as addition of coagulants and powdered activated carbon (mostly in industrial effluent).

5. Reducing the flux. Particulate/colloid fouling is "reversible" in the sense that a reduction of the forward flux (through lowering of the membrane flux or solids concentration) or an increase of backwash intensity restores membrane permeability.

6. Ensure sufficient air scouring is being maintained to slough off excessive biofilm layer on the membrane surface.

7.5.1.5 MBR WWTP Fouling Control & Troubleshooting Chart

Combination of membrane physical cleaning operations as air **scouring, backwashing and relaxation** are efficient in membrane fouling control.

7.5.1.5.1 Air Scouring

Aeration generates a shear stress at the membrane surface, which provides a scouring action and reduces membrane cake fouling.

Membrane air scouring check is essential procedure for newterra MBR WWTP. Air scour has to be observed for uniformity of bubbling action all across the membrane module/cassette on regular basis. It is easy to observe through clear window in membrane tank. Operator should note any unusual patterns of air distribution. Operator has to check for:

- damage of air diffusers and if this occurs, empty the tank and fix the diffuser;
- air leakages: if this occurs, tighten up the fittings.

If there is insufficient air scouring, localized dewatering (**clogging, sludging, caking and plugging**) may occur and as a result, membrane fouling occurs.



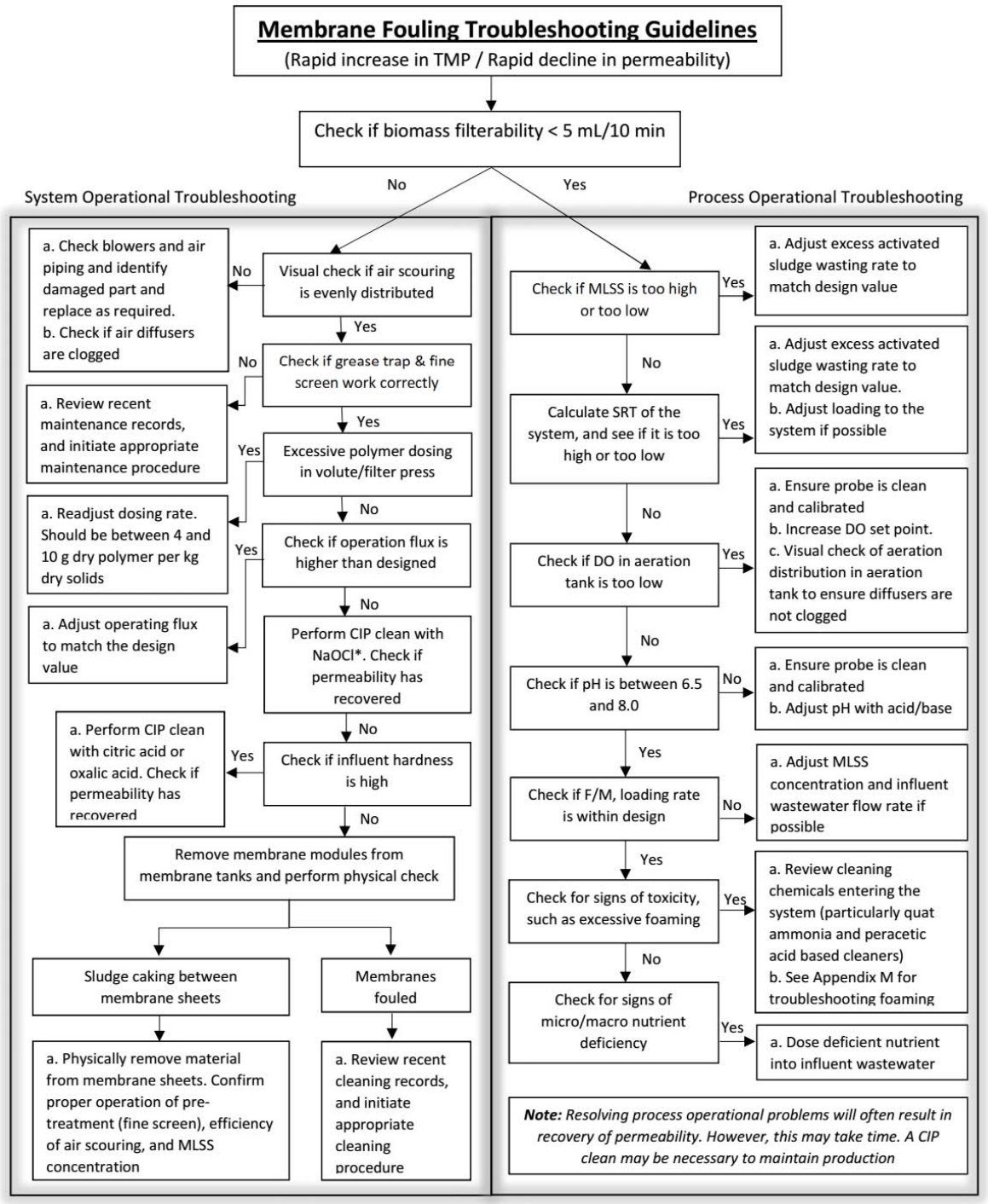
Proper air scouring in membrane tank



Uneven aeration in membrane tank

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.2 MBR Alarm Trouble Shooting

Alarm Name	Alarm Location	Alarm Description	Beacon Status	Troubleshooting Recommendation	Remedy Action
PLC ALM	CP	SHUTDOWN PLC Fault	FLASH	Turn off entire system. Wait 10 seconds before restoring power.	Please contact newterra -PLC problem
PWR FAIL ALM	CP	WARNING, Power Fail	SOLID	Power has failed to the unit	Press Reset
ESTOP ALM	Panel	E-Stop	FLASH	Check all locations of E-Stop Buttons to ensure they are not pushed in.	Pull out E-Stop
TALL-201	Clarifier	Temperature alarm low low	FLASH	Check for building heater malfunction. Assess influent water temperature	Replace heater. Take action to increase influent water temperature.
B-201/ B-202 Fail	Clarifier	Blower B-201/B-202 has potentially failed	FLASH	Check blower for failure. Check breaker	Replace blower B-201/B-202.
LAHH-401	SCREEN DISCHARGE	High high level alarm in Screen Module discharge tank	FLASH	Potential discharge tank pump P-401/P-402 failure Check Breaker	Replace pump
P-401 or P-402 FAIL	SCREEN PUMP	P-401/P-402 has potentially failed	FLASH	P-401/P-402 for failure. Check Breaker	Replace pump P-401/P-402

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Alarm Name	Alarm Location	Alarm Description	Beacon Status	Troubleshooting Recommendation	Remedy Action
SCN-401 Or SCN-402 FAIL	SCREEN	Potential screen paddle wheel motor failure.	FLASH	Check screen motor for failure. Check Breaker	Replace motor
LAHH-301	EQ Tank	Level Alarm High High, EQ Tank	FLASH	Investigate if pump P-301, P-302 has failed, or system is receiving higher than design flow, or membrane is fouling.	Replace pump, divert flow, perform membrane chemical cleaning.
LALL-301	EQ TANK	Low Low Level Alarm	WARN	Check for level transmitter operation or upstream pipe obstruction or pump failure.	Clear obstruction or repair/replace faulty equipment.
P-301 or P-302 FAIL	EQ PUMP	Pump P-301 has potentially failed	FLASH	Check pump P-301 or P-302 for failure or if it is unplugged. Check Breaker	Plug in or replace pump P-301 or P-302.
PAL-301	EQ TANK	Pressure Alarm low on air inlet to EQ Tanks	FLASH	Check if blower B-301 or B-302 have failed. Check Breaker	Replace blowers if required.
LAHH-501 or LAHH-502	AERATION TANK	High High level alarm in Aeration Tank	FLASH	Check pump P-501/P-502 for failure	Replace faulty pump
LALL-501	AERATION TANK	Low Low Level Alarm	WARN	Check level in the tank and ensure Level switch or transmitter is functioning correctly.	Clear obstruction or repair/ replace faulty equipment

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Alarm Name	Alarm Location	Alarm Description	Beacon Status	Troubleshooting Recommendation	Remedy Action
PHAL-501	AERATION TANKAERATION TANK	Low pH AlarmLow low in Aeration Tank	WARN WARN	Check if caustic injection system is working and or needs refill Check if the pH probe is fouled or if the probe requires calibration. Check setpoint temperature.	Replace caustic injection system or refill. Clean pH probe. Calibrate pH probe. Adjust set point temperature.
PHAH-501	AERATION TANKAERATION TANK	High pH alarm	WARN WARN	Check if caustic injection system is malfunctioning or if PH probe is calibrated or fouled.	Replace caustic soda injection. Calibrate pH probe or clean sensor
DOAL-501	AERATION TANKAERATION TANK	Dissolved Oxygen Alarm low	WARN WARN	Investigate if there is septic smell & check the mixing pattern. If system smells septic with no uniform mixing, air diffuser might be clogged, blowers may not work or plant is overloaded. Ensure DO probe is calibrated and clean.	Increase aeration rate to maintain DO above 1.5 mg/L, or replace clogged diffuser, or change blower, or calibrate or clean DO probe. Replace caustic soda injection. Calibrate pH probe or clean sensor
P-501 or P-502 FAIL	AERATION TANK	Pump P-501 or P-502 has potentially failed	FLASH WARN	Check pump P-501 or P-502 for failure. Check Breaker	Replace pump P-501 or P-502.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Alarm Name	Alarm Location	Alarm Description	Beacon Status	Troubleshooting Recommendation	Remedy Action
P-503 FAIL	AERATION TANK	Pump P-503 has potentially failed	FLASH FLASH	Check pump P-503 for failure. Check Breaker	Replace pump P-503
PAL-501	AERATION	Blower motor tripped off on overload Pressure	WARN FLASH FLASH	Check blower air line equipment and blower motor Check if 500 series blowers have failed	Replace faulty equipment Replace blowers if required
PAL-601 or PAL-602	MEMBRANE TANK	Pressure Alarm low on air inlet to correspondi ng Membrane Tank. Blower motor tripped off on overload	FLASH WARN	Check if blower B-601 or B-602 has failed. Check blower air line equipment and blower motor	Replace blower if required. Replace faulty equipment.
LAHH-601 or LAHH-602	MEMBRANE TANK	High High level alarm in Membrane	FLASH WARN	Check pump P-601 for failure	Replace pump P-601 Replace faulty equipment
FLT-701 or 702	PERM VFD 1 or 2	VFD Fault	FLASH WARN	Check VFD fault	Replace pump and VFD Replace faulty equipment
VTAL-701 or 702	MEMBRANE 1 or TANK 2	Low vacuum alarm on permeate line from MBR1 or MBR2	FLASH WARN	Check for vacuum leak and membrane or pump fail	Repair and replace as required

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Alarm Name	Alarm Location	Alarm Description	Beacon Status	Troubleshooting Recommendation	Remedy Action
VTAH-701 or 702	MEMBRANE 1 or TANK 2	High vacuum alarm on permeate line from MBR1 or MBR2	FLASH WARN	Check for closed valve on permeate side or check membranes for severe fouling	Open valve or clean membranes Repair and replace as required
FTAL-701 or 702	MEMBRANE 1 or TANK 2	Low permeate flow alarm on permeate line from MBR1 or MBR2	FLASH WARN	Check for closed valve or permeate pump failure Check for closed valve on permeate side or check membranes for severe fouling	Open valve or repair/ replace permeate pump Open valve or clean membranes Repair and replace as required
FTAH-701 or 702	MEMBRANE 1 or TANK 2	High permeate flow alarm on permeate line from MBR1 or MBR2	FLASH WARN	Check for vacuum leak or membrane failure and operation of permeate pump	Repair and replace as required Open valve or repair/ replace permeate pump Open valve or clean membranes
UVA-811 or 812	PERM	UV-811 or UV-812 has failed.	FLASH WARN	Check if UV lamp has failed	Change UV lamp
UVA-BOTH	PERMEATE	UV-light 811 and UV-812 have failed	FLASH WARN	Check if UV lamp has failed Check if UV lamp has failed Check if UV lamp has failed	Change UV lamp Change UV lamp Change UV lamp Repair and replace as required
BACKWASH1 or BACKWASH2 FAILED	BACKWASH PERM1 or PERM2	Backwash to TNK-601 or TNK-602 failed	FLASH WARN	Backwash did not complete – system skipped backwash	Check function of back-wash pump and valve

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Alarm Name	Alarm Location	Alarm Description	Beacon Status	Troubleshooting Recommendation	Remedy Action
P-901 FAIL	MEMBRANE PERM 1	Pump P-901 has potentially failed	FLASH WARN	Check pump P-901 for failure Check for vacuum leak or membrane failure and operation of permeate pump	Replace pump P-901 Repair and replace as required
TALL-7901	BLDG-7901	Low low Temperature alarm for building	FLASH WARN	Check if electric heaters have failed or if BLDG door is open	Repair or replace heater(s) if required. Repair and replace as required
B-7901 FAIL	AIR EXCHANGE BLDG-7901	Potential blower failure	FLASH WARN	Check motor breaker	Turn breaker on

7.5.3 MBR Process Trouble Shooting

The following **newterra MicroClear™ MBR WWTP troubleshooting guide** can be used as a quick reference. If any of the problems discussed in this section or other difficulties persist, consult **newterra** ltd.

7.5.3.1 Biological System

Condition	Possible Cause	Potential Remedies
Mixed liquor is black or dark brown	Insufficient aeration is supplied for mixed liquor and/or plant is under-loading	Increase aeration rate and keep it above 1 mg/L Waste more sludge Increase influent feed rate if required
Mixed liquor concentration is too high or too low	Sludge wasting rates are incorrect	Review operation of the activated sludge process and revise the sludge wasting rates as necessary
No mixing in tanks	Blowers failure	Check for electrical/blower failure, and replace blowers as necessary

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Condition	Possible Cause	Potential Remedies
Unpleasant odour from tanks	Mechanical/electrical failure, e.g. blower and air piping are not operating correctly	Ensure good order of mechanical/electrical components
	System is overloading	Check the maximum flow and BOD loading rate to the MBR unit to see whether it is within the limits as per design specification Check the quality and contents of the flow into the MBR unit for any abnormal or prohibited substances
Effluent quality does not meet discharge criteria	Mixed liquor characteristics are not within proper operating standards	Improve the process operating conditions of the activated sludge system (confirm operating SRT and loading is within design and no present of toxic compounds)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.3.2 Foaming

Condition	Possible Cause	Potential Remedies
Excessive foaming (white foam accumulating over the liquid surface) in aeration and/or membrane tanks	Influent inhibition/biomass toxicity occurs	Check the quality and contents of the flow into the MBR system for any abnormal or prohibited substances
	MBR system is overloading	Check the flow rates, BOD/COD loading and F:M ratio and then reduce flow/loading and/or increases MLSS concentration accordingly
	Mixed liquor characteristics are not within proper operating standards	Improve the operating conditions of the activated sludge system
	Membrane air scour system is over aerating	Review operation of the membrane scour system
	Foam control strategies are not operating correctly	Review foam removal equipment, anti-foam chemical dosing system (if applicable)
	MBR system are undergoing start-up	Remove foam and use approved defoamer as necessary (consult **newterra** Ltd);
		Control foam and ensure sprayer pump is running at all time during start-up,
		Ensure that MLSS concentration is increased, after start-up is completed

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.3.3 Permeate

Condition	Possible Cause	Potential Remedies
Cloudy permeate (The permeate turbidity or TSS is above the specific setpoint)	Faulty operation of instrumentation	Confirm proper operation of control systems and instrumentation, clean, replace, recalibrate as required
	Membrane cassette sheets are damaged	Take out membranes and visually inspect the individual membrane sheets, and repair or replace the membrane sheets as necessary
	Membrane module assembly are damaged	Identify damaged part, e.g. leaking tube, pipe, O-ring, gasket, and replace as required
	Permeate piping leak	Identify the leak and repair as required, e.g. tighten connections
Lower permeate flow than expected	Mechanical equipment failure	Ensure proper operation of permeate pumps
	Incorrect operation of permeate piping and valves	Check permeate piping for leaks
High TMP and lower permeability than expected	Membrane sludging	Confirm proper operation of pretreatment Take out membranes and visually inspect the individual membrane sheet. Remove sludge material from membrane sheets**
	Mixed liquor characteristics are contributing to poor filterability	Test the filterability of the mixed liquor; review and improve operating conditions of the activated sludge system as necessary
	Desired operating flux or flowrate is higher than design	Adjust operational flux or flowrate to match the design flux or flowrate

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Condition	Possible Cause	Potential Remedies
	Membrane surface is fouled	Review recent cleaning records, and initiate appropriate cleaning procedure
	MLSS is too high, SRT is too low or insufficient dissolved oxygen in aerobic zone	Improve the characteristics of sludge by adjusting the activated sludge process operation
Uneven permeate and/or MLSS flow between membrane tanks	More recent completion of maintenance or recovery cleanings for one of the membrane tank	Review membrane cleaning records
	Uneven flow distribution to each membrane tank	Confirm proper operation of flow distribution system (pumps/control valves, etc)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.3.4 Membrane air system

Condition	Possible Cause	Potential Remedies
Uneven aeration of membrane module	Membrane diffuser clogging; Loose air piping connections	Wash or clean the diffusers Tighten pipe connections
Uneven aeration in membrane tank	Membrane diffusers or membrane modules are not level	Level the equipment
Air scour rate fails to reach the specified values	Improper operation of membrane blowers and/or air scour system, malfunctioning diffusers	Repair or replace the blowers Review and repair air piping as necessary Repair the diffusers

7.5.3.5 Membrane Cleaning

Condition	Possible Cause	Potential Remedies
Increased frequency of cleaning	Mixed liquor characteristics are contributing to poor filterability Improper operation of membrane cleaning Membrane operate at higher flux than designed	Test the filterability of the mixed liquor Review and improve operating conditions of the activated sludge system as necessary Confirm cleaning is done correctly, such as controls, cleaning cycles or durations, chemical concentration, and dosing system Review MBR flow records
Cleaning fails to recover flux, permeability of membranes	Improper operation of membrane cleaning Improper operation of permeate pumps, piping, and control valves Irrecoverable fouling of membranes	Confirm cleaning is operated correctly, such as controls, cleaning cycles or durations, and chemical concentration etc. Repair equipment as necessary Review operating history with the goal of identifying contributing factors to fouling;

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Condition	Possible Cause	Potential Remedies
		Perform membrane autopsy on membrane cassettes

7.5.3.6 Mechanical / Electrical Issues

Condition	Possible Cause	Potential Remedies
Indicator light at the control panel is on.	Air intake is blocked	Clean intake screens on blower housing Check air filter on blower for blockage
	Air discharge or vent line is blocked	Check discharge line and vent line visually or with drain cleaning equipment for obstructions
	MBR is flooded	Determine the cause of flooding, e.g., line obstruction, high flows, etc., and fix it
	Blower failed	Determine if blower failure was caused by an obstructed intake or discharge line Investigate overheating (i.e. internal thermal overload protection), short-circuiting, or other electrical failure, and mechanical failure (i.e. bearing failure) and correct it
Wastewater is backing up	Obstruction in the incoming sewer	Check the inlet pipe leading to the MBR visually or with drain-cleaning equipment
	Obstruction in the discharge piping	Check the permeate piping and later field piping visually or with drain-cleaning equipment
	Pumps failed	Check the operation of pumps as per pump manufacturer's specifications
	Flow rate to the MBR is too high	Check if the maximum flow rate to the MBR is within the limits as per design specification
Blower/pump not working	Fuse blown	Electrician to check
	Motor is overloading	Electrician to check
	Power failed	Electrician to check
System not in run mode	Kill switches are mistakenly pushed in	Ensure kill switches (on control panel/wall) are not pressed;
	Power failure/outage	Electrician to check

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.4 P-201/2, 301/2, 401/2, 501/2, 553/4, 551/2 - Trouble Shooting

TROUBLESHOOTING

1. Pump fails to build head pressure:

Check for:

a. Pump not primed.

b. Incorrect pump rotation.

c. Driver speed too low.

d. Suction line restricted.

e. Driver failure.

f. Plugged or damaged impeller.

g. Pump or impeller undersized.

h. Pump cavitation.

i. Improper impeller clearance.

2. Pump fails to provide enough flow rate.

Check for:

a. System resistance too high.

b. Pump undersized.

c. Pump not primed.

d. Driver speed too low.

e. Poor suction conditions.

f. Improper impeller clearance.

3. Excessive noise or vibration during operation.

Check for:

a. Motor bearing failing.

b. Pump cavitation.

c. Improper impeller clearance.

4. Leaking mechanical seal.

Check for:

a. Improper assembly.

b. Worn or cracked seal faces.

c. Abrasive material in fluid.

d. Liquid flashing at seal faces (Fluid temperature too high).

e. Seal pressure rating too low for the service.

f. Chemical attack of seal components.

g. Seal operated dry or with a liquid having poor lubricating properties.

5. Pump gradually loses pressure and head.

Check for:

a. Increasing temperature causing cavitation or liquid vaporization.

b. Driver failure.

c. Suction lift too high.

d. Air entering suction line.

6. Motor overheating.

Check for:

a. Excessive flow and amp draw (Throttle discharge).

b. Low voltage or frequency.

c. Flow rate too low with resulting heat rise.

d. Bearing failure.

e. System temperature too high.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.5 P-701/702 Trouble Shooting

TROUBLESHOOTING

WARNING: Before making adjustments, disconnect power source and thoroughly bleed pressure from system prior to disassembly. Failure to do so could lead to electric shock or serious bodily harm.

Failure To Pump.

1. Motor will not start: Check power supply. Voltage must be ± 10% of nameplate rating when motor is in locked rotor condition. Check for faulty capacitor on 1 phase Models.
2. Motor runs and thermally kicks out: Check for excessive discharge pressure. Check for defective centrifugal switch on 1 phase Models. Increase ventilation to motor. Do not use less than #14 wire size.
3. Stator torn; possible excessive pressure: Replace stator, check pressure at discharge port.
4. Flexible joint broken; possible excessive pressure:

   Replace joint, check pressure at discharge port.
5. Wrong rotation (3 phase only): Rotation must be clockwise when facing pump from motor end. Reverse the connections of any two line leads to the motor.
6. Excessive suction lift or vacuum.

Pump Overloads.

1. Excessive discharge pressure: Check pressure at discharge port for maximum ratings given in Table 1.
2. Fluid viscosity too high: Limit fluid viscosity to 100 CP or 500 SSU.

Noisy Operation.

1. Excessive suction lift or vacuum: Maximum suction lift is 25 feet for water.
2. Suction line too small: Check pipe size. Be sure lines are free from obstructions.
3. Pump Cavitates: Pump speed is 1725 rpm. Viscosity of fluid should not exceed 100 CP or 500 SSU.
4. Flexible joint worn: Replace joint. Check pressure at discharge port.
5. Insufficient mounting: Mount to be secure to a firm base. Vibration induced noise can be reduced by using mount pads and short sections of hose on suction and discharge ports.

Seal Leakage.

1. Leakage at startup: If leakage is slight, allow pump to run several hours to let faces run in.
2. Persistent seal leakage: Faces may be cracked from freezing or thermal shock. Replace seal.

Pump Will Not Prime.

1. Air leak on suction side: Check pipe connections.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.6 P-801 Trouble Shooting

CONDITION	COMMON CAUSES
A. Pump will not start or run.	Check fuse, low voltage, overload open, open or incorrect wiring, open switch, impeller or seal bound mechanically, defective capacitor or relay when used, motor or wiring shorted. Float assembly held down. Switch defective, damaged, or out of adjustment.
B. Motor overheats and trips overload or blows fuse.	Incorrect voltage, negative head (discharge open lower than normal) impeller or seal bound mechanically, defective capacitor or relay, motor shorted.
C. Pump starts and stops too often.	Float tight on rod, check valve stuck or none installed in long distance line, overload open, level switch(s) defective, sump pit too small.
D. Pump will not shut off.	Debris under float assembly, float or float rod bound by pit sides or other, switch defective, damaged or out of adjustment.
E. Pump operates but delivers little or no water.	Check strainer housing, discharge pipe, or if check valve is used vent hole must be clear. Discharge head exceeds pump capacity. Low or incorrect voltage. Incorrect motor rotation. Capacitor defective. Incoming water containing air or causing air to enter pumping chamber.
F. Drop in head and/or capacity after a period of use.	Increased pipe friction, clogged line or check valve. Abrasive material and adverse chemicals could possibly deteriorate impeller and pump housing. Check line. Remove base and inspect.

7.5.7 B-501/502 - Trouble Shooting

PROBLEM	POSSIBLE CAUSES	SOLUTION
Knocking	1. Unit out of time. 2. Distortion due to improper mounting or pipe strains. 3. Excessive pressure differential. 4. Worn gears. 5. Worn bearings.	1. Re-time impellers 2. Check mounting alignment and relieve pipe strains. 3. Reduce to manufacturer's recommended pressure. Examine relief valve, re-set if necessary. 4. Replace timing gears. 5. Replace bearings..
Excessive blower temperature.	1. Too much oil in gear case. 2. Too low operating speed. 3. Dirty air Filter. 4. Clogged filter or muffler. 5. Excessive pressure differential. 6. Worn impeller clearances. 7. Internal contact.	1. Reduce oil level. 2. Increase blower speed. 3. Clean or replace air filter 4. Remove cause of obstruction. 5. Reduce pressure differential across the blower. 6. Replace impeller. 7. Correct clearances.
Impeller end or tip drag.	1. Insufficient assembled clearances. 2. Case or frame distortion. 3. Excessive operating pressure. 4. Excessive operating temperature.	1. Correct clearances. 2. Check mounting and pipe strain. 3. Remove cause. 4. Remove cause
Lack of volume.	1. Slipping belts. 2. Worn clearances. 3. Dirty air filter	1. Tighten belts. 2. Re-establish proper clearances. 3. Clean or replace air filter.
Excessive bearing or gear wear.	1. Improper lubrication.	1. Correct lubrication level. Replace dirty oil.
Loss of oil.	1. Headplate, gear case or drive cover vents plugged. 2. Worn Seal.	1. Clean vents. 2. Replace seals.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.8 B-301/302, B-601/602 - Trouble Shooting

Fault	Cause	Remedy	Carried out by
Motor does not start; no motor noise.	At least two power supply leads interrupted.	Eliminate interruption by fuses, terminals or power supply cables.	Electrician
Motor does not start; humming noise..	One power supply lead interrupted.	Eliminate interruption by fuses, terminals or power supply cables.	Electrician
	Impeller is jammed.	Open vacuum pump/compressor cover, remove foreign body, clean.	Service*)
		Check or correct impeller gap setting if necessary.	Service
	Impeller defective.	Replace impeller.	Service*)
	Rolling bearing on drive motor side or vacuum pump/compressor side defective.	Replace motor bearing or vacuum pump/compressor bearing.	Service*)
Protective motor switch trips when motor is switched on. Power consumption too high.	Winding short-circuit.	Have winding checked.	Electrician
	Motor overloaded. Throttling does not match specification on rating plate.	Reduce throttling.	Service*)
		Clean filters, mufflers and connection pipes if necessary.	Service*)
	Compressor is jammed.	See fault: "Motor does not start; humming noise." with cause: "Impeller is jammed.".	Service*)
Pump-motor unit does not generate any or generates insufficient pressure difference.	Leak in system.	Seal leak in the system.	Operator
	Wrong direction of rotation.	Reverse direction of rotation by interchanging two connecting leads.	Electrician
	Incorrect frequency (on pump-motor units with frequency converter).	Correct frequency.	Electrician
	Shaft seal defective.	Replace shaft seal.	Service*)
	Different density of pumped gas.	Take conversion of pressure values into account. Inquire with Service Department.	Service
	Change in blade profile due to soiling.	Clean impeller, check for wear and replace if necessary.	Service*)
Abnormal flow noises.	Flow speed too high.	Clean pipes. Use pipe with larger cross-section if necessary.	Operator
	Muffler soiled.	Clean muffler inserts, check condition and replace if necessary.	Service*)
Abnormal running noise.	Ball bearing lacking grease or defective.	Regrease or replace ball bearing.	Service*)
Compressor leaky.	Seals on muffler defective.	Check muffler seals and replace if necessary.	Service*)
	Seals in motor area defective.	Check motor seals and replace if necessary.	Service

*) Only when the maintenance manual is at hand: rectification by the operator.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.9 LT-301/501 - Trouble Shooting

1.	**Symptom**:	***Transducer fails to give output of any kind.***
	Procedure:	Isolate the problem to either the transducer or the power supply/readout. See the Quick Check Procedures (above) for this check. If it can be determined that the transducer is no longer operable, remove it from service for further analysis. If the transducer output falls within the limits described above, the fault lies somewhere else in your system.
2.	**Symptom**:	***Transducer has failed and has been removed for analysis.***
	Procedure:	Inspect the cable for physical damage. Cuts in the cable jacket can result in liquid incursion into the transducer housing, which can cause permanent damage. If operational, the cable can be repaired by using a splice kit (P/N 830) supplied by Pressure Systems. Inspect the transducer housing. It should be intact and free of corrosion. If the outer surface of the transducer is pitted, this could be an indication of galvanic corrosion caused by stray ground currents. If this is the case, the transducer will probably require replacement. If the external case exhibits none of these characteristics, carefully unscrew the nosepiece and look into the pressure sensing end of the transducer. The concentric rings of the sensing diaphragm should be visible. If they are not, it could be that residue has accumulated on the diaphragm, preventing it from responding properly to pressure changes. The transducer can be cleaned by gently swishing the transducer back and forth in a bucket of warm, soapy water until the residue softens and washes off. (See **Cleaning Your Transducer**, page 8.) ***Under no circumstances should any object or tool be used to remove residue from the sensing diaphragm or else permanent damage will be done.*** If cleaning the diaphragm does not solve the problem, the transducer should be returned to the factory for repair or replacement.
3.	**Symptom**:	***Transducer develops a negative offset and gets worse over time (actual level exceeds specified level).***
	Procedure:	This may be a sign that moisture has entered the reference (vent) tube in the cable and is inside the transducer housing. This is usually the result of not maintaining the desiccant vent filter or of operating the transducer without a desiccant filter or aneroid bellows. If caught early enough, the transducer can be saved by coiling the cable and transducer in a pan and baking it in an oven at 50°C (122°F) for a minimum of 2 hours. *Be careful that the oven temperature does not exceed 50°C (122°F)* or both the transducer and the cable can be damaged. **Alternatively**, suspend both the cable and transducer in a vertical position (with vent tube down), overnight to allow water to drain from the transducer and vent tube.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

4. **Symptom:** ***Transducer suddenly fails during or just after a nearby lightning event.***

   Procedure: This failure is usually caused by overvoltage due to ground transients resulting from a direct or indirect lightning event. These transients can travel distances of a mile or more. The transducer may be returned to the factory for repair and optional retrofit of our ***lightning protection system.*** This system carries a lifetime warranty against transducer damage due to lightning.

5. **Symptom:** ***Transducer response to pressure/level input changes becomes sluggish.***

   Procedure: This is usually a sign that the sensing end of the transducer has become fouled with residue. The transducer must be removed from service and the sensing diaphragm cleaned as described in Item 2, (warm, soapy water). If fouling persists, the transducer may be replaced with a Series 705 or Series 750 (non-fouling) transducer, which is specifically designed for trouble-free operation in a high residue environment.

6. **Symptom:** ***Output reading is within limits but "freezes" at one point.***

   Procedure: In certain environments "crust" may form over the sensing diaphragm, preventing the sensor from identifying change in level. Removing the transducer from service and cleaning it (as described in Item 2) will generally solve the problem. To combat marine growth, you might try wrapping the transducer with copper wire similar to that found in wire scouring pads for cleaning dishes. Marine growth occurs on the copper and eventually erodes the copper and drops off or the copper is manually removed during routine maintenance. Alternatively, there are various companies that will impregnate/coat the 316 stainless steel with anti-fouling chemicals of coatings. Level transducers temporarily removed from the well or sump should not be stored dry, but should be stored in a bucket of fresh water in order to prevent "crust" formation.

7. **Symptom:** ***Readings increase very slowly over time***.

   Procedure: Our cable is shipped coiled and consequently takes time to straighten when installed. Attaching a weight to the transducer (e.g., one of our sacrificial anodes) will help. To prevent cable stretch with lengths greater than 200 feet (60 m), secure the Kevlar fibers (just under the cable jacket) to your junction box or other secure object.

8. **Symptom:** ***No electrical output from your transducer.***

   Procedure: Check all electrical connections to ensure they are correct and secure. Double check your power supply or use a battery (as described previously) to ensure the transducer is getting power. If all checks OK, the problem could be a circuit board or the sensor in your transducer. The unit must be returned to the factory for evaluation. The most probable cause of this type of failure is damage to the submersible cable jacket allowing water to leak down the cable and into the transducer housing or lightning damage.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

9.	**Symptom:**	***Formation of marine growth on a submersible transducer.***
	Procedure:	Certain transducer construction materials, for example, 316 stainless steel, attract marine life (snails) and algae. Clean the transducer diaphragm by soaking it in a bucket of warm water with a non-aggressive cleaning solution. You can also coat the transducer with marine grease. This may be the most effective and inexpensive way to protect your transducer.
10.	**Symptom:**	***Submersible transducer exhibits corrosion or pitting on body or diaphragm***
	Procedure:	Dissimilar metals (for example, your transducer housing and your pump housing) in an electrolytic environment (fluid in your well) can lead to *galvanic corrosion* of the metal that is nearer the anodic end of the galvanic series. Likewise, a voltage potential between the ground wire of the transducer and the ground of other equipment in the well can lead to *galvanic corrosion*. Installation of a P/N 820 or 825 sacrificial anode will help protect your transducer from *galvanic corrosion*. Our sacrificial anodes are made of a zinc alloy that, being nearer the anodic end of the galvanic series than the 316 stainless steel or titanium housing of the transducer, will corrode before the transducer.
11.	**Symptom:**	***The transducer is buried in dirt or silt and the readings seem to be erroneous.***
	Procedure:	Use of a piezometer nosepiece in this application would help. This nosepiece can be easily installed in the field and features a very fine screen to keep dirt from fouling the diaphragm, but allows the diaphragm to sense moisture levels.
12.	**Symptom:**	***Transducer has an offset error.***
	Procedure:	Our submersible transducers perform best when the sensing end is pointing in a downward manner. Keep in mind that you can experience offset error due to the position sensitivity or orientation change of the sensor. Offset errors are more prominent in low pressure applications with the sensing end of the transducer lying flat or pointing upward.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

13. Symptom: ***I am testing a Series 700 4-20mA sensor for use with our data logger. On page A-2 of the KPSI Level and Pressure Transducers User's Manual, I see the standard 4-20mA configuration. Does the recording channel of my data logger become the mA meter?***

Procedure: Most data loggers cannot measure current (mA) directly. When this is the case a load resistor must be used to convert the current (mA) output into an appropriate voltage. If the User's Manual for your particular instrument does not illustrate a preferred method for recording current (mA) data then you should attach your transducer signal wires to your data logger in the following manner.

Transducer red wire **+** Data Logger Excitation Terminal
(The minimum excitation for a Series 700 Transducer is 9VDC)
Transducer black wire **–** Data Logger signal input (+) terminal

Attach a Load resistor between the Data Logger signal input (+) terminal and the Data Logger signal input (-) terminal.

Attach a separate piece of wire between the Data Logger signal input (-) and analog ground.

In this configuration you will turn your data logger into a milliammeter. The size of your load resistor can be calculated in the following manner.

D/0.02=R

Where:

Data logger input range = D
Full scale output of transducer = 0.02 A (20 mA)
Load Resistor Value = R

Pick an appropriate standard value

250 Ohms results in 1 to 5 VDC at 4 and 20 mADC
125 Ohms results in 0.5 to 2.5 VDC (500 to 2500 mVDC) at 4 and 20 mADC

At this point the discussion needs to address IR loss (voltage drop) in series circuits. Note that Series 700 transducers need a minimum of 9 VDC to operate correctly. When the transducer is operating correctly it will output a current which, when driven through a resistor, will generate some amount of voltage drop. If the resistor value is 250 Ohms then the voltage measured across that resistor will be 0.004 A * 250 Ohms = 1.000 VDC and 0.020 A * 250 Ohms = 5 VDC. Notice that, if the available voltage from the data logger is12 VDC then 12 VDC - 5 VDC = 7 VDC which is less than the voltage required by the transducer to operate. If this scenario were to occur the transducer would actually stop functioning correctly when its output reached 12 mADC (50% of transducer full scale range). In this case the appropriate choice for a load resistor value is 125 Ohms.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

14. Symptom: ***I have a Series 700 4-20mA transducer rated for 7.5 PSIG attached to a pressure source that is outputting 7.5 PSIG. With 20VDC being supplied I am getting 19.94 mA. I can't find the upper range allowance for the sensor, but this seems low to me. Does this mA reading fall into the acceptable range for the transducer with the settings I've specified?***

Procedure: When evaluating a transducer it is sometimes convenient to make some broad generalizations in order to rapidly determine the condition of the unit. In general, transducers that output a 4-20 mADC signal have a 16 mADC span (4 - 20 = 16). If the transducers accuracy is reported as being some percentage of its full-scale range then the following table could be used in conjunction with the instructional notations to determine whether a more detailed analysis of data quality is required.

Model	Accuracy	Accuracy in mADC
700	1.00%FS	±0.16 ma
710	0.50%FS	±0.08 ma
720	0.25%FS	±0.05 ma
730	0.10%FS	±0.016 ma
735	0.05%FS	±0.008 ma

In order to approximately determine how many milliamps a transducer should output at a given depth.

1. Determine the depth (in feet) at which the transducer is sited.
2. Divide the depth value (from step 1) by the transducer full-scale range (in feet). - Record the value.
3. Multiply the value calculated in step 2 by 16 (the transducer span in milliamps).
4. Add 4 to the product of step 3. This is the approximate value in milliamps that should be output by the transducer at its current depth.

In order to approximately determine the depth of a transducer (in feet) using a given value of milliamps.

1. Divide the full-scale range of the transducer (in feet) by 16. Record this value.
2. Subtract 4 from the milliamp output of the transducer. Record this value
3. Multiply the result of step one by the result of step 2. This is the approximate depth at which the transducer is sited.

If the resulting numbers are reasonably close to some verified value for current water depth, then the unit is functioning. In order to determine the quality of measurement, additional steps need to be performed.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

7.5.10 PH-501 - Trouble Shooting

Fault reporting and troubleshooting

Display	Description / cause	Status[1]	Mode[2]	Measured variable output[3]	Correction variable output[4]
pH/mV RANGE ↓	Input voltage too low	Error	Basic load	Fault current	-
pH/mV RANGE ↑	Input voltage too high	Error	Basic load	Fault current	-
T RANGE ↓	Measured temperature beneath measuring range	Error	Basic load	Fault current	Fault current
T RANGE ↑	Measured temperature above measuring range	Error	Basic load	Fault current	Fault current
CAL ERROR	No valid user calibration exists	Error	-	-	-
NO PROBE	If activated: pH sensor monitoring outputs: no sensor	Error	Basic load	Fault current	-
PROBE ERR	If activated: pH sensor monitoring outputs: sensor break	Error	Basic load	Fault current	-
CHECK-TIME	Control checkout time elapsed	Error	Basic load	Fault current	-
mA RANGE ↑	mA output current has an upper limit	Error	-	-	-

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

Display	Description / cause	Status[1]	Mode[2]	Measured variable output[3]	Correction variable output[4]
mA RANGE ↓	mA output current has a lower limit	Error	-	-	-
LIMIT ↑	Measured variable exceeds upper set limit	Warning	-	-	-
LIMIT ↓	Measured variable falls below lower set limit	Warning	-	-	-
T LIMIT ↑	Correction variable exceeds upper set limit	Warning	-	-	-
T LIMIT ↓	Correction variable falls below lower set limit	Warning	-	-	-
LIMIT ERR	Set checkout time for monitoring the measurement variable limits has elapsed	Error	Stop	Fault current	-
TLIMITERR	Set checkout time for monitoring the correction variable limits has elapsed	Error	Stop	Fault current	Fault current
NO CAL	No valid user calibration exists	Warning	-	-	-
CONTACTIN	If activated: Power relay is activated in *'PAUSE/HOLD'*	Error	-	-	-

1 = *[Status]* Error status after occurrence of the fault (error means: alarm relay deactivates, "*" is displayed before the error message, can be acknowledged with OK)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

2 = *[Mode]* Resulting controller mode (relates to control variable and thus, as necessary, mA output)

3 = *[Measured variable output]* Consequence for the current output, if this is set as *'a measured variable output'*

4 = *[Correction variable output]* Consequence for the current output, if this is set as *'a correction variable output'*

7.5.11 MV-701/702 - Trouble Shooting

Conditions	Possibilities	Solutions
Motor does not operate	1. Is the supplied power and voltage correct? 2. Any blisters on the capacitor? 3. Are the gear trains free?	1. Checking by meter. 2. If so replace. 3. Remove motor to check.
Motor stops running	1. Is power supply short circuited? 2. Any foreign objects in flow stream?	1. Check wiring. 2. Check for obstructions.
Unable to fully open/close	1. Loose/Misaligned cam? 2. Bent valve stem? 3. Mechanical stop adjustment incorrect?	1. Adjust/Tighten using spanner. 2. Replace valve stem. 3. Check position of stops.
Valve stops operating when motor is running.	1. Gear worn out? 2. Sleeve adapter worn out or broken? 3. Broken valve stem or actuator transmission shaft?	1. Replace gear. 2. Replace sleeve adapter. 3. Replace valve stem or actuator transmission shaft.
Abnormal control for operating two or more actuators simultaneously.	1. Controlling circuit connects in tandem or parallel?	1. Please refer to the wiring diagram.
Motor overheats.	1. Is the voltage correct? 2. Is valve too tight to operate? 3. High working frequency? 4. Is motor stem or bearing binding?	1. Checking by meter. 2. Replace valve. 3. Check duty cycle. 4. Replace the binding parts.
Abnormal on/off angle on 3-phase voltage.	1. Wrong phase wiring?	1. Change phase wiring.
Occasional on/off actuator failure.	1. Simultaneous input power on/off.	1. Check if the selection switch is normal.
Vibration when valve is closed.	1. Motor brake spring fatigued or Teflon worn?	1. Replace spring or Teflon.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

8.0 SHUT DOWN

8.1 MBR Temporary Shut Down

A temporary shutdown for a few days requires continuous aeration of the biomass to keep the DO level at least 2 mg/L and continuous biomass recycle between the bioreactors.

8.2 MBR Permanent Shut Down / Winterizing

Permanent shut down is required if system operation stops for at least 2 weeks without inflow. Permanent shut down includes the following procedure:

8.2.1 Process Shut Down Procedure

- Conduct a “Backwash Now” operation on the system
- Stop influent flow into the System
- Ensure all pumps are in the “OFF” position using the HOA HMI screen
- Ensure all Blowers are in the “AUTO” position using the HOA HMI screen. This is to be done until a vacuum truck can be provided or contracted locally to clean out the tanks.
- Ensure all automated valves are in the “OFF” position using the HOA HMI screen.
- Ensure that the MBR is disabled using the HMI screen button
- Conduct all maintenance procedures on Section 7 Table – regardless of schedule time

8.2.2 Cleaning - General

- Conduct general system interior cleaning
- Open all tanks, wash out with a garden hose and Vacuum out.
- Clean all sensors and level switches

8.2.3 Membranes

- Ensure that the membrane tanks (TNK-601/602) are drained before opening the membrane tanks.
- Open TNK-601/602 doors with hand/power tools.



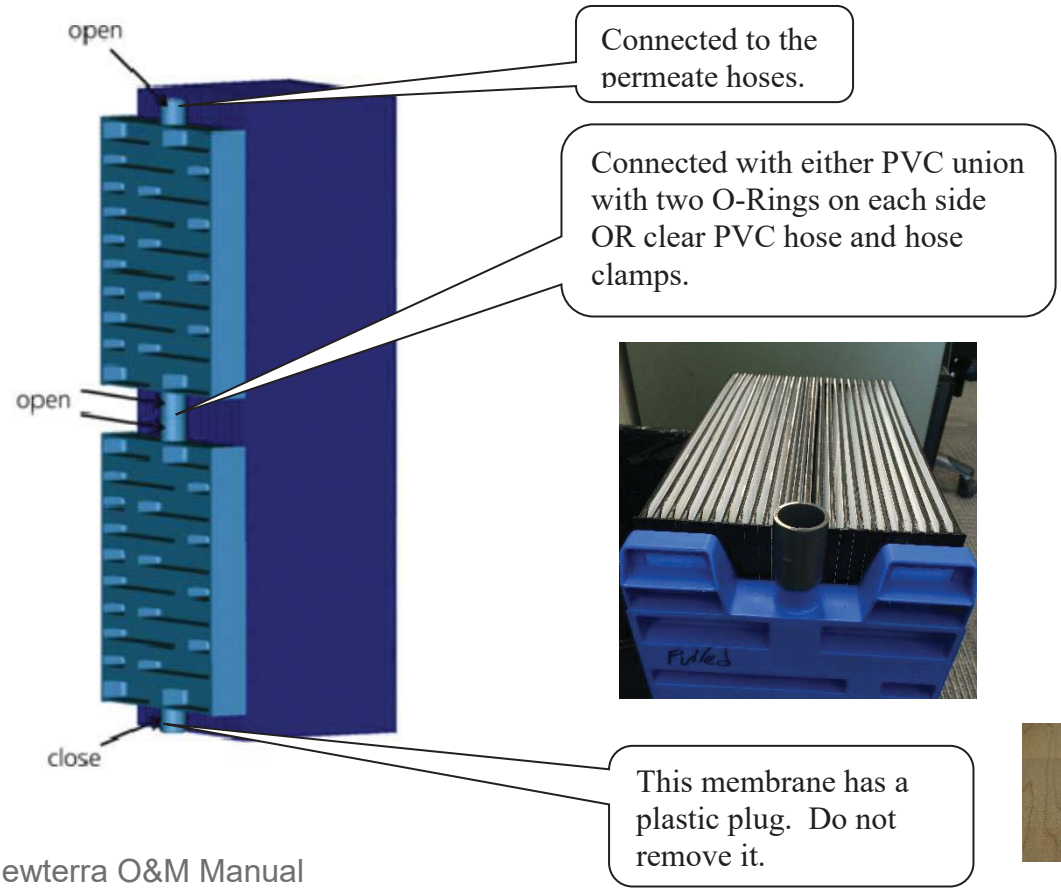
© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

- Using a garden hose, wash the inside of the tanks and vac out any remaining waste water. **DO NOT USE A PRESSURE WASHER!**
- Disconnect the permeate hoses from the top of membrane the membrane stack.
- Remove the membranes from the membrane frame using hand tools.



- **CAUTION** – the membranes are contaminated with waste water. PPE required.
- **NOTE**. The membranes are double stacked. The bottom membrane has a plug in the bottom opening. Do not remove this plug. Note the membrane orientations for re-installation. The membranes are joined together with either a PVC union with two O-Rings on each side OR clear PVC hose and hose clamps.



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

- After membranes are separated, wash with clean water. Remove the blue backing plate and gently separate the membrane plates and clean with water to remove any debris.





- Replace backing plate and let the membranes dry out.
- Shrink wrap the membrane cassettes in multiple film layers and seal the membranes cassettes with tape. Note and mark which membranes have the bottom plug in them.
- Store the preserved membrane cassettes at room temperature (never expose the membrane cassettes to frost, dust, or direct sunlight).

8.3 General Components

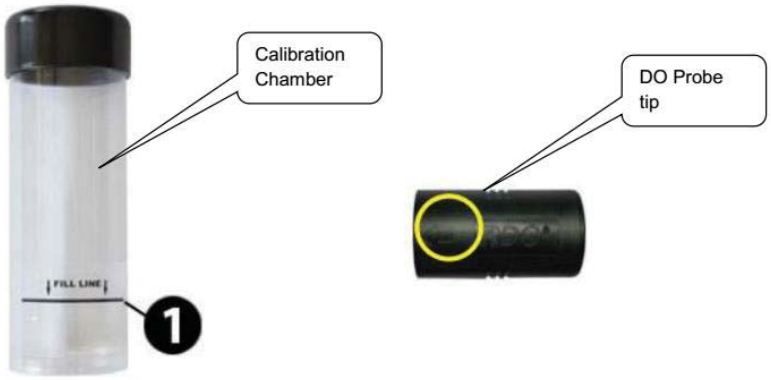
- Conduct all preventative maintenance as listed in Section 7.
- Drain/Vacuum Out and wash out all tanks.
- Clean and Wash out SCR-201/202
- Disassemble all PVC ball valves and drain any water inside (open and close to ensure trapped water escapes).
- Leave all valves ½ open during reinstallation
- Open all drain valves and leave open.
- Find all check valves and make sure water is not being held by valve (Wet/Dry Vac works well here).
- Drain / remove all pumps from tanks, ensure no water is left inside the pump.
- Use RV Antifreeze that is suitable for potable water systems
    - Refill any check valve

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

- Dump in 2 (qty) 4-L bottles in each tank

- Remove power from system.
- Double check and ensure that there is no water left in any pipes, fittings etc. If it is not possible to remove the water fill with antifreeze.
- Drain the chemical tanks and dispose of chemicals in accordance with manufacturer's recommendations and local regulations.
- Remove pH (PH-501) and DO (DO-501) probes from TNK-501 and store with membranes in a heated area ensure probes are kept wet.

- **NOTE: Remove DO probe tip from the DO sensor (DO-501) in accordance with vendor directions in Appendix E and store in the calibration chamber with the storage cap attached with a few drops of clean water. Store with the membranes in a heated area and ensure probe tip is kept wet.**



© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

8.4 Blowers – B-501/502

STORAGE

Your Gardner Denver Blower was packaged at the factory with adequate protection to permit normal storage for up to six (6) months.

If the unit is to be stored under adverse conditions or for extended periods of time, the following additional measures should be taken to prevent damage.

1. Store the blower in a clean, dry, heated (if possible) area.
2. Make certain inlet and discharge air ports are tightly covered to prevent foreign material from entering the air box.
3. All exposed, non-painted surfaces should be protected against rust and corrosion.
4. Provide adequate protection to avoid accidental mechanical damage.
5. In high humidity or corrosive environments, additional measures may be required to prevent rusting of the blower internal surfaces.
6. To prevent rusting of gears, bearings, etc., the oil reservoirs may be filled with normal operating oil.

⚠ CAUTION
Before running the blower, drain the oil and replace to the proper operating level with clean, fresh lubricant.

7. Rotate the blower shaft (10 to 25 turns) weekly during storage. Inspect the blower shaft (near the shaft seal area) monthly and spray with rust inhibitor if needed.
8. For long term storage (over six (6) months), contact Gardner Denver Compressor Division Customer Service for recommendations.

REMOVING PROTECTIVE MATERIALS

The shaft extension is protected with rust inhibitor which can be removed with any standard solvent.

⚠ CAUTION
Follow the safety directions of the solvent manufacturer.

Blower inlet and outlet are temporarily capped to keep out dirt and other contaminants during shipment. These covers must be removed before start-up.

The internal surfaces of all Sutorbilt units are mist sprayed with a rust preventative to protect the machine during shipment. Remove this film upon initial startup, using any commercial safety solvent. Position the blower so that the inlet and discharge connections are in the vertical position (vertical airflow). On vertically mounted units, it will be necessary to lay the unit on its side supporting the ends of the unit so as not to restrict the port on the bottom side. Place a shallow pan on the under side of the unit. With the blower disconnected from power, spray the solvent in the top port, rotating the impellers by spinning the shaft manually. Continue this procedure until the unit is visibly clean.

⚠ WARNING
Rotating components will cause severe injury in case of personal contact. Keep hands and loose clothing away from blower inlet and discharge ports.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

8.4 Chemical Dosing Pumps – P-6101/6102/6103

1. Disconnect the pump from the mains power supply.
2. Empty the liquid end by turning the pump upside down and allowing the feed chemical to run out.
3. Flush the liquid end with a suitable medium; flush the dosing head thoroughly when using hazardous feed chemicals!

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

9.0 SERVICE & SUPPORT

9.1 Commissioning and Start-up

newterra MicroClear™ MBR System's **commissioning & start-up** is the last step of the **newterra** project execution process.

As part of your order, the following on site services will be provided by experienced factory trained newterra representative:

- Includes five (5) 8-hour days of onsite startup/commissioning by one (1) factory trained newterra representative
- Includes five (5) 8-hour days of onsite training by one (1) factory trained newterra representative

9.1.1 Startup/Commissioning

Typical System Startup/Commissioning includes the following:

- Equipment checks - Electrical, mechanical, and controls
- Functional test - Equipment and control system
- Hydraulic test
- Operation during plant seeding

9.1.2 Training

On-site operator training including the following topics:

- General MBR theory & process
- Specific system instruction
    - Components
    - Controls and operating philosophy
    - Alarms and alarm troubleshooting
    - Maintenance
    - Troubleshooting
    - MBR fouling control (Biology, physical, and chemical)

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

9.2 Post commissioning Services

A comprehensive range of post commissioning services are available from **newterra** beyond system design and installation. Specific services include:

- Technical support (including after-hours emergency telephone support).
- Spare parts order and delivery.
- Training program.
- Plant optimization and upgrades.
- Telemetry control and monitoring.
- Assistance in preparing system performance reports (process data monitoring & analysis).
- Preventive maintenance cleaning (including membrane cleaning).
- System audits for reviewing the performance and efficiency of all MBR subsystems..

9.2.1 Technical Support

Technical support is available to assist in troubleshooting of **newterra** MBR systems during normal working hours 8:30 am to 5:00 pm (Eastern Time Zone for **newterra** ltd.). Telephone service is available via **1.800.420.4056**.

Emergency **24/7 telephone technical support –** This will be activated upon subscribing to **newterra's** 24/7 technical support service. If a problem cannot be resolved through telephone or e-mail support, **newterra** technicians and engineers are available for site visits.

9.2.2 Spare Parts

newterra has spare parts to provide quick response to any critical system breakdown. Contact **newterra** parts department at **1.800.420.4056.**

All parts and components associated with **newterra** MBR Systems are available from within service departments and manufacturing facilities of **newterra** ltd across Canada and abroad.

Potentially required spare parts are:

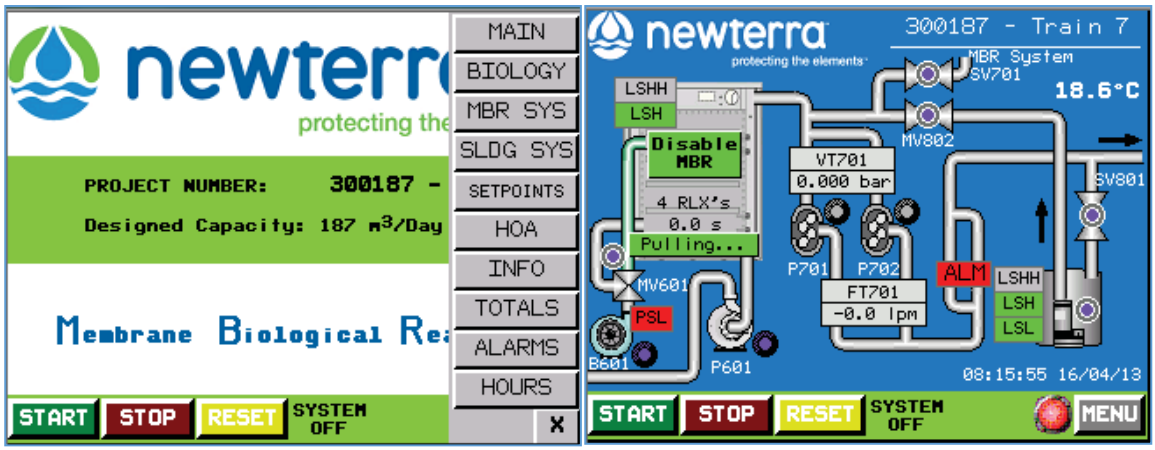
- membrane modules/membrane cassettes;
- parts for repair/replacement (valves, transmitters, switches, gauges, pH & DO probes, pump motors, analyzers, PLC components, fuses, etc.);
- maintenance spare parts (air blowers, air filters, pumps, immersion heaters, chemical metering pumps, etc.).

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

9.2.3 Assistance in telemetry control and monitoring

newterra SITE-LINK is a customized software program and hardware configuration which provides a real-time link to a treatment system via cellular modem or customer supplied internet connection using our secure Site-Link Server.



newterra Site-Link comes with the following customizable features:

- Customized P&ID layout with system status
- Start/Stop/Reset of system
- Manual control of all system components
- Data logging downloads in .csv format†
- Daily system status reports (E-Monitor)
- Alarm history including current alarm status
- Hour meters for applicable equipment
- Customization of all system set points†
- Live and historical trending
- Immediate text & email on alarm (E-Alarm)

†certain restrictions apply

The basic system requires that the customer provide a standard computer network cable to the control panel. If the customer's computer network is accessible to the internet, this system can also be monitored from any internet enabled computer. Static IP is not required but is recommended and must be provided by customer.

This system is not available if customer supplied internet connection or cellular service is not available at the site. During internet outages, reports cannot be sent and system status cannot be monitored remotely.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

9.2.4 Site visits and system audits

Site visits and system audits can be arranged at an additional cost. Contact **newterra** for all financial aspects of **newterra** initial and post-commissioning services.

During a system audit, technical reviews of the performance of all **newterra** MBR subsystems and the efficiency of the biological process can be performed. Based on the site visit and agenda discussed with the client, we can assist in:

- Maintenance coordination and scheduling, including membrane maintenance and cleaning.
- Validation of chemical dosing settings.
- MBR System inspection for the proper operation of the membrane system in accordance with the O&M manual; equipment calibration, process optimization and upgrades.
- Continued on-site operator training and coaching.

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

10.0 WARRANTY

General Warranty Statement

1. **newterra** warrants and guarantees products of its manufacture against defective workmanship or material for a period of one year from the date of notice of readiness to ship.
2. This warranty is expressly and strictly limited to replacing, without charge, any part or parts which prove to **newterra**'s satisfaction upon examination, to have been defective in design, material or workmanship, and which have not been neglected, abused or misapplied, provided the buyer gives **newterra** immediate written notice upon discovery of any claimed defect.
3. During the warranty period, parts will be shipped as necessary with instructions to replace, which can be further elaborated over phone or email; visit(s) of our technician to site can be covered if there is a service agreement in place; otherwise, actual charges will be quoted to the owner at that time, if required.
4. **newterra** will also guarantee component parts manufactured by others to the extent of the guarantee made by the manufacturer of such equipment. In any case, guarantees on specific components will be extended a minimum of one year from date of notice of readiness to ship.

Warranty Exclusions

1. Warranty coverage does not include:
   - Freight, labor, travel, and living expenses associated with parts replacement
   - Normal maintenance items such as lubrication, fan belts, and cleaning of the equipment
   - System parts damaged as a result of customer changes to the system and/or PLC program without the written consent of **newterra**.
2. In the event that the customer, or any contractor employed by the customer, contracts an outside company, other than **newterra** for modification of system equipment, without knowledge of **newterra**, the warranty in that case may become null & void.
3. In the event that the customer, or any installation contractor employed by the customer, contracts outside **newterra** for installation work or erection of quoted equipment, the customer shall assume full responsibility for said contract.

Warranty Validation and Conditions

1. **newterra** highly recommends that the system be started up by a **newterra** factory trained technician to ensure the correct installation and trouble-free startup. The startup checklist provided in the O&M manual must be completed and returned to **newterra** to validate your equipment warranty which begins on the date of shipment from the factory.
2. In the event that the system is commissioned by a certified technician that is not an employee of **newterra**, the Startup Checklist must be returned to **newterra** within 15 days of the completion of startup

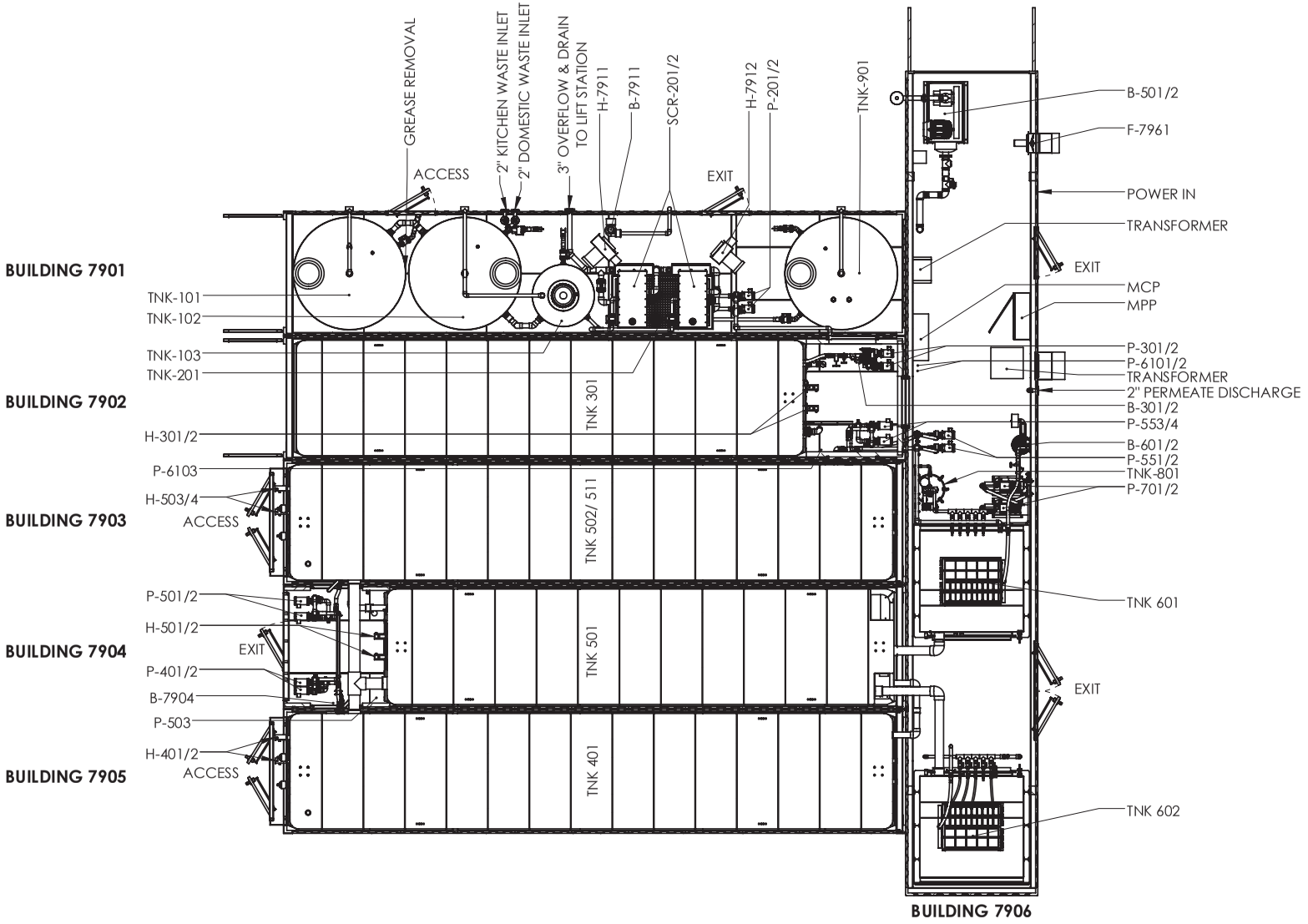
© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.

newterra ltd.
1291 California Avenue, Brockville, ON K6V 5W3
(800) 420-4056 / www.newterra.com

APPENDIX A

Drawings

© 2017 by **newterra**, ltd.
All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of **newterra** ltd.



GENERAL TOLERANCES
.XX ± 1/8 "
.XXX ± 1/16 "
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT WRITTEN CONSENT.

LEVEL	DATE	BY	REVISION
C1	11/08/17	AH	AS BUILT
B1	07/06/17	GH	FOR PRODUCTION
B	06/06/17	GH	FOR PRODUCTION
A2	25/05/17	GH	REVISED LAYOUT
A	19/05/2017	GH	FOR REVIEW

DWG. NO:

PROJECT NUMBER: 1704432

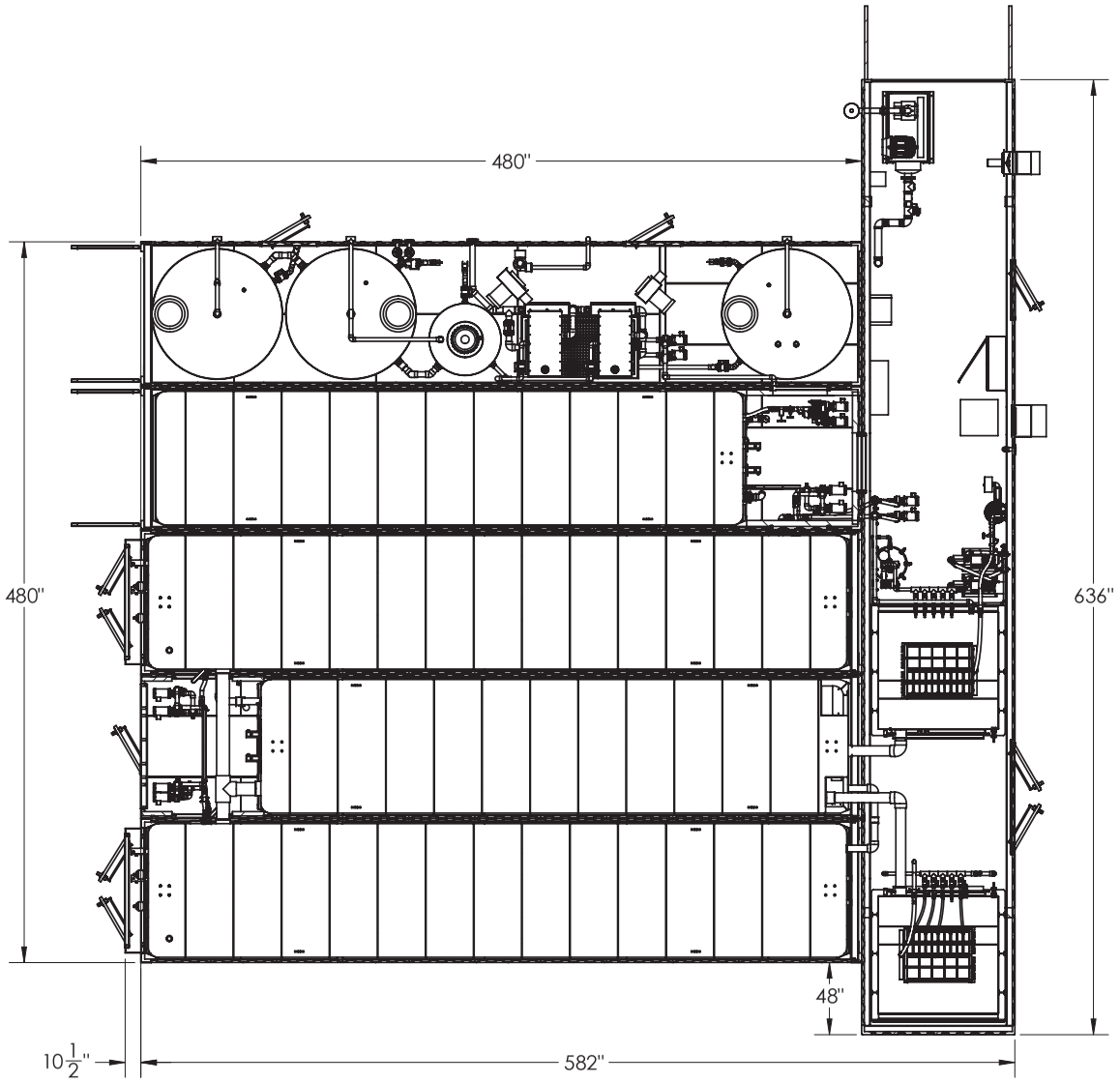
TITLE: SYSTEM LAYOUT

CUSTOMER: AGNICO EAGLE

DRAWN BY: GH

DATE: 19/05/17

SHEET 1 OF 4



GENERAL TOLERANCES
.XX ± 1/8"
.XXX ± 1/16"
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT WRITTEN CONSENT.

LEVEL	DATE	BY	REVISION
C1	11/08/17	AH	AS BUILT
B1	07/06/17	GH	FOR PRODUCTION
B	06/06/17	GH	FOR PRODUCTION
A2	25/05/17	GH	REVISED LAYOUT
A	19/05/2017	GH	FOR REVIEW

DWG. NO:

PROJECT NUMBER: 1704432

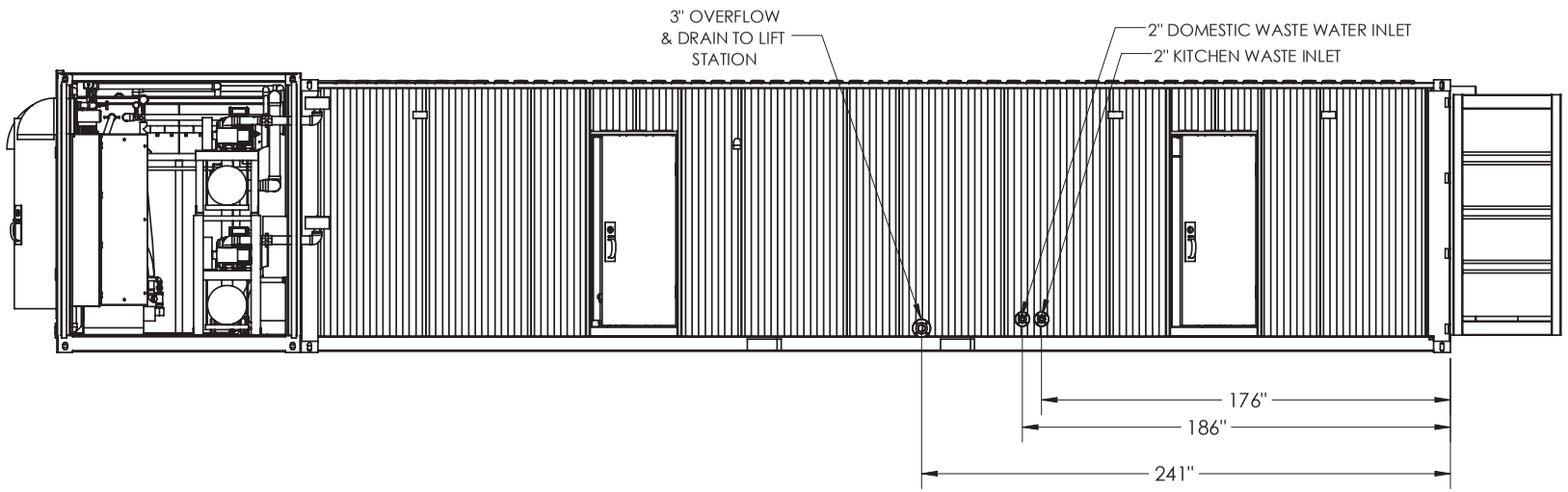
TITLE: SYSTEM LAYOUT

CUSTOMER: AGNICO EAGLE

DRAWN BY: GH

DATE: 19/05/17

SHEET 2 OF 4

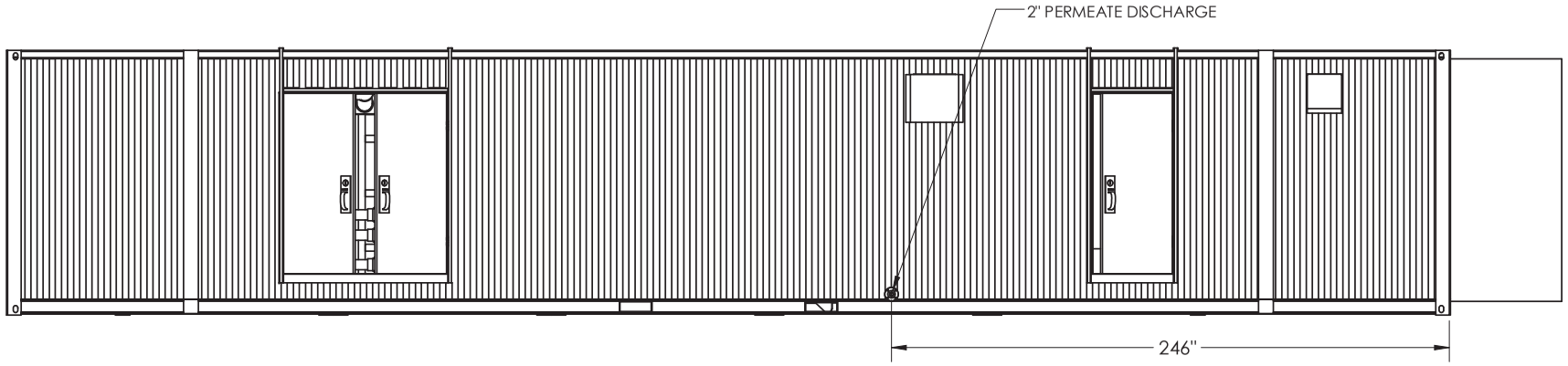


GENERAL TOLERANCES
.XX ± 1/8 "
.XXX ± 1/16 "
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT WRITTEN CONSENT.

LEVEL	DATE	BY	REVISION
C1	11/08/17	AH	AS BUILT
B1	07/06/17	GH	FOR PRODUCTION
B	06/08/2017	GH	FOR PRODUCTION

DWG. NO:
PROJECT NUMBER: 1704432
TITLE: SYSTEM LAYOUT
CUSTOMER: AGNICO EAGLE
DRAWN BY: GH
DATE: 06/06/17
SHEET 3 OF 4



GENERAL TOLERANCES
.XX ± 1/8 "
.XXX ± 1/16 "
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT WRITTEN CONSENT.

LEVEL	DATE	BY	REVISION
C1	11/08/17	AH	AS BUILT
B1	07/06/17	GH	FOR PRODUCTION
B	06/06/2017	GH	FOR PRODUCTION

DWG. NO:

PROJECT NUMBER: 1704432

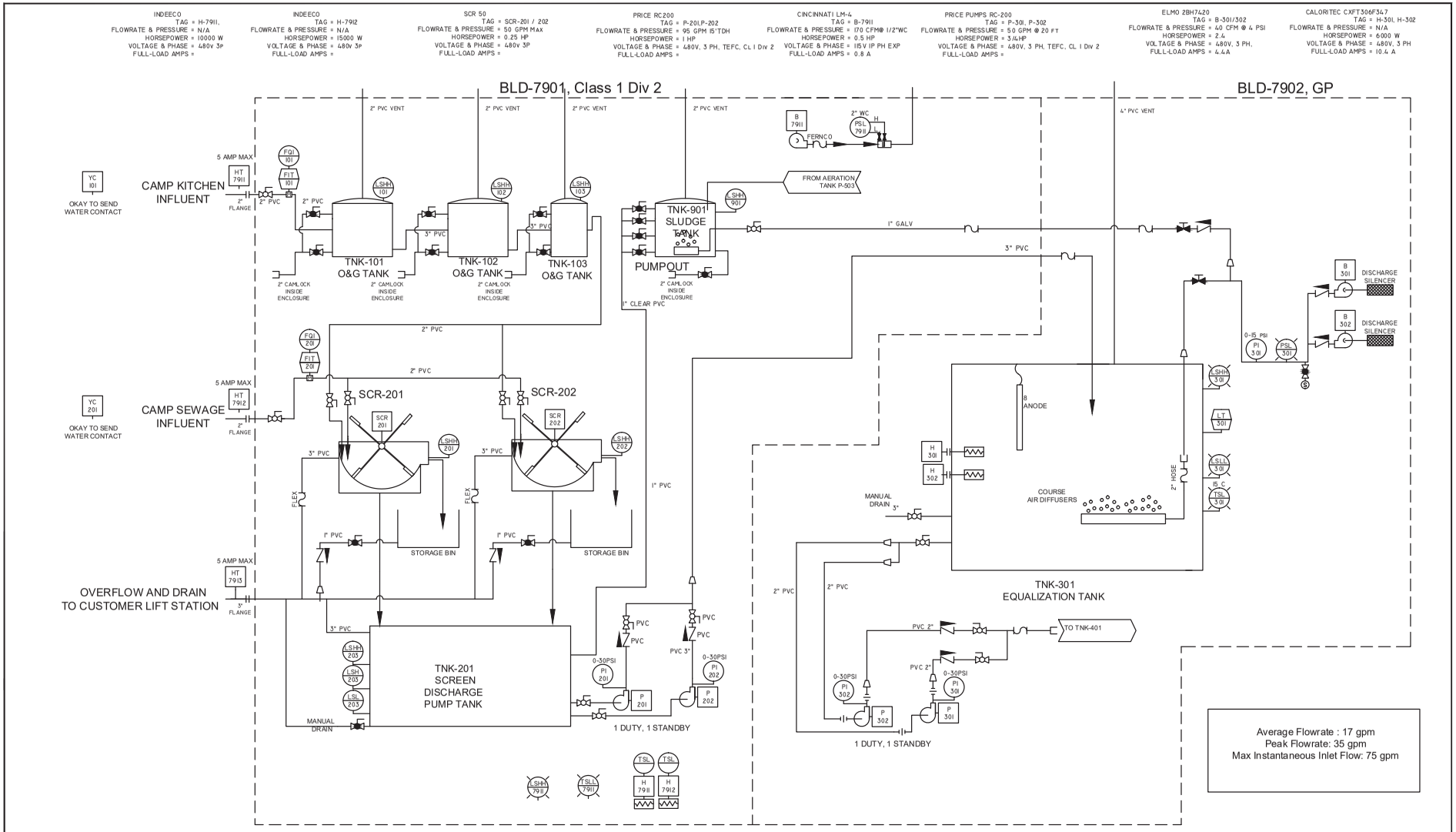
TITLE: SYSTEM LAYOUT

CUSTOMER: AGNICO EAGLE

DRAWN BY: GH

DATE: 06/06/17

SHEET 4 OF 4



NOTES

IS INPUT WIRING TO BE WIRED FOR OUTDOORS, ACCORDING CEC FOR HAZARDOUS LOCATIONS.

WIRING TO BE CLASS I DIVISION 2, AS PER THE CEC.

newterra

PHONE: (800) 420-4056

www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

PROJECT NUMBER: 1704432

TITLE AND LOCATION: P&ID AMARUQ MINE

CUSTOMER: AGNICO EAGLE MINE

DRAWN BY: MH | DATE: | SHEET: 1 | SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra

PRICE PUMPS RC-200
TAG = P-401,402
FLOWRATE & PRESSURE = 300 GPM @ 60 FT
HORSEPOWER = 5HP
VOLTAGE & PHASE = 480V, 3 PH, TEFC, CL I Div 2
FULL-LOAD AMPS =

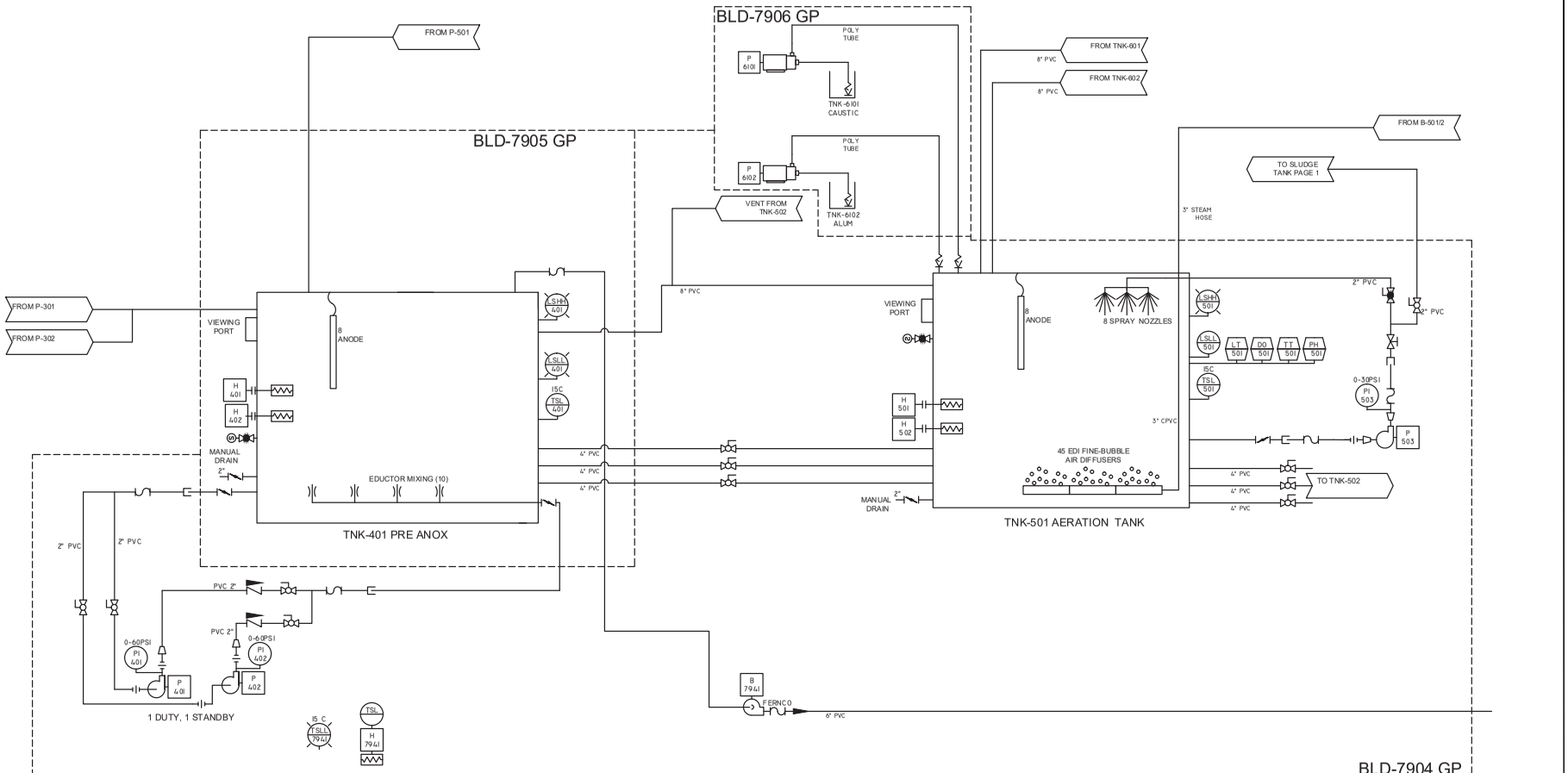
CALORITEC CXFT306F347R83
TAG = H-401,402,501,502
FLOWRATE & PRESSURE = N/A
HORSEPOWER = 6000 W
VOLTAGE & PHASE = 480V, 3 PH
FULL-LOAD AMPS = 10.4 A

CINCINNATI LM6
TAG = B-7941
FLOWRATE & PRESSURE = 700 CFM@ 2"WC
HORSEPOWER = 1.5 HP
VOLTAGE & PHASE = 480V 3P PH
FULL-LOAD AMPS =

OUELLET OAC04808BL
TAG = H-7941
FLOWRATE & PRESSURE = N/A
HORSEPOWER = 4,800 W
VOLTAGE & PHASE = 480 V, 1 PH
FULL-LOAD AMPS = 8.34

PRICE PUMPS RC-200
TAG = P-503
FLOWRATE & PRESSURE = 50 GPM @ 10 FT
HORSEPOWER = 1/4 HP
VOLTAGE & PHASE = 480V, 3 PH, TEFC, CL I Div 2
FULL-LOAD AMPS =

PROMINENT BETA 4
TAG = P-6101, 6102
FLOWRATE & PRESSURE = 3.2 GPH@58PSI
HORSEPOWER = N/A
VOLTAGE & PHASE = 120 V, 1 PH
FULL-LOAD AMPS = N/A



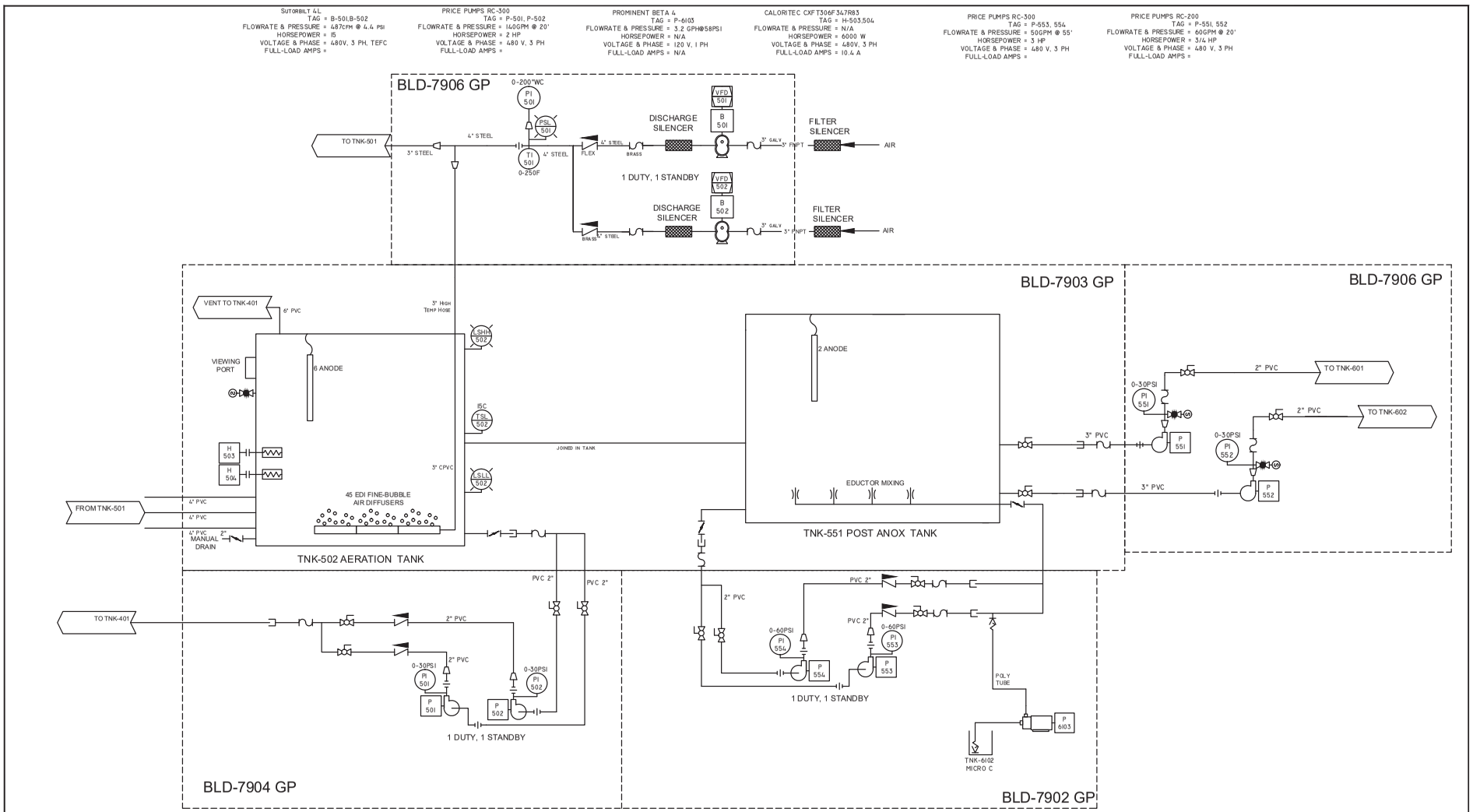
NOTES

newterra
PHONE: (800) 420-4056
www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

PROJECT NUMBER: 1704432
TITLE AND LOCATION: P&ID AMARUQ MINE
CUSTOMER: AGNICO EAGLE MINE
DRAWN BY: MH
DATE:
SHEET: 2
SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra



NOTES

newterra

PHONE:
(800) 420-4056

www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

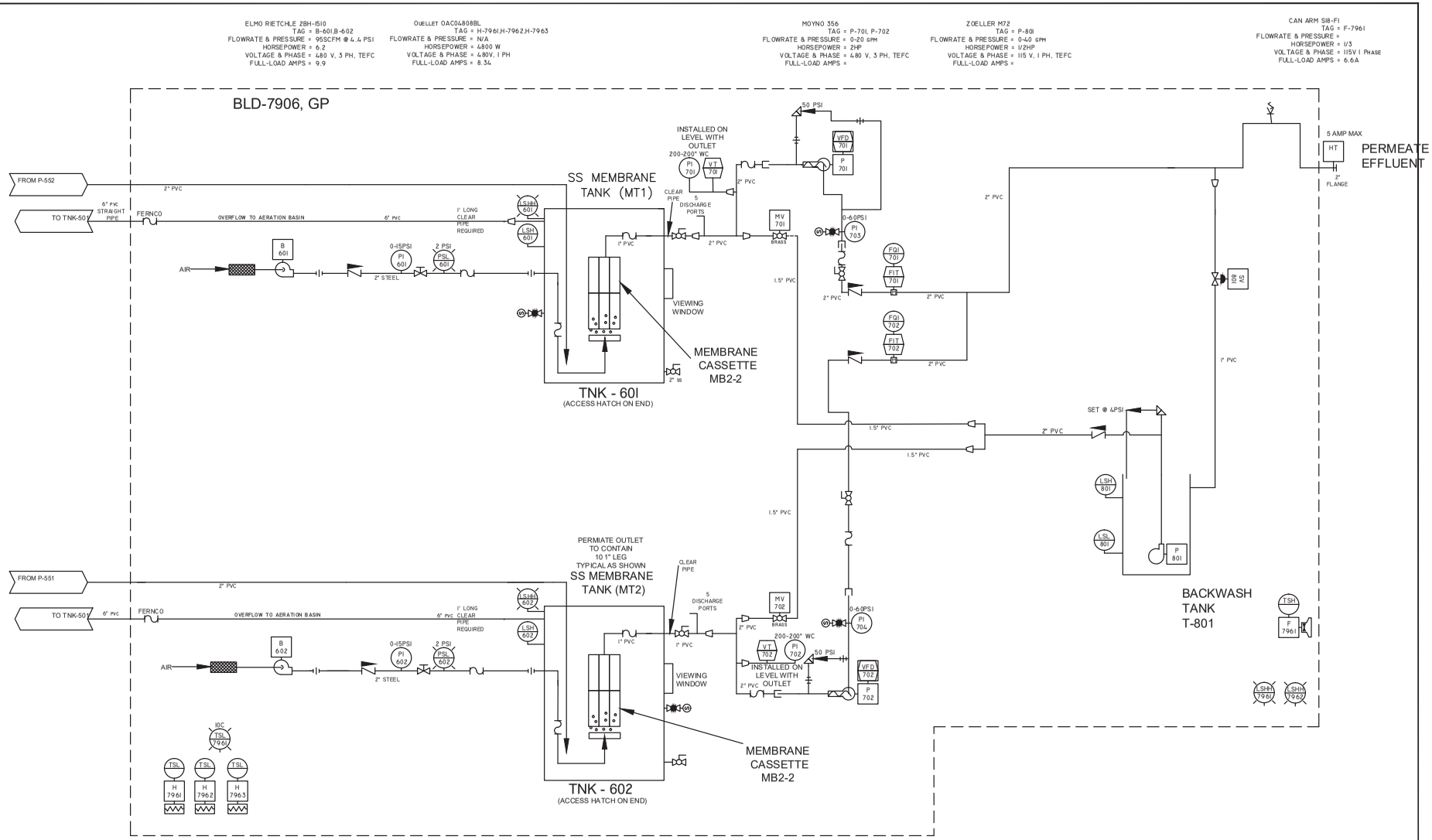
PROJECT NUMBER: 1704432

TITLE AND LOCATION: P&ID AMARUQ MINE

CUSTOMER: AGNICO EAGLE MINE

DRAWN BY: MH | DATE: | SHEET: 3 | SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra



NOTES

newterra

PHONE: (800) 420-4056

www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

PROJECT NUMBER: 1704432

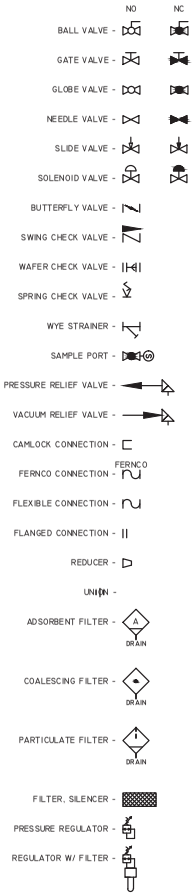
TITLE AND LOCATION: P&ID AMARUQ MINE

CUSTOMER: AGNICO EAGLE MINE

DRAWN BY: MH | DATE: | SHEET: 4 | SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra

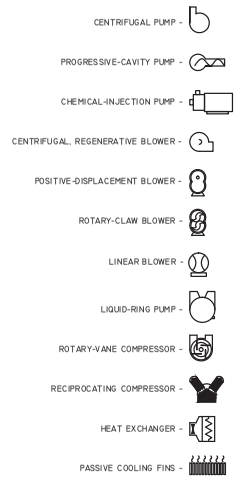
VALVES AND PIPING



EQUIPMENT



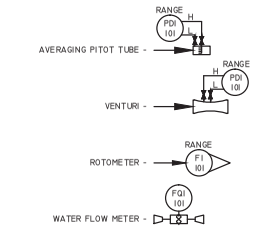
EQUIPMENT



EQUIPMENT

AV - ACTUATED VAVLE
B - BLOWER
F - FAN
H - HEATER
MBR - MEMBRANE BIOLOGICAL REACTOR
MV - MODULATED VALVE
P - PUMP
SV - SOLENOID VALVE
TNK - TANK
UV - ULTRA VIOLET LIGHT
VFD - VARIABLE FREQUENCY DRIVE

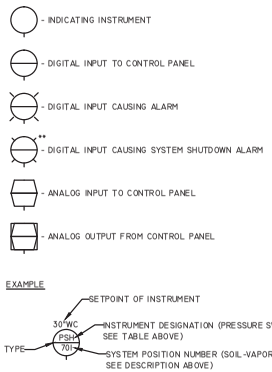
FLOW MEASUREMENT



INSTRUMENT DESIGNATION

	INPUT	1ST MODIFIER	2ND MODIFIER	3RD MODIFIER	OUTPUT	1ST MODIFIER	
A							A
B						BLOWER	B
C	CYCLE					COMPRESSOR	C
D		DIFFERENTIAL				AIR DRYER	D
E							E
F	FLOW					FAN	F
G	GAS (LEL)		GAUGE				G
H				HIGH	HAND	HEATER	H
I	CURRENT		INDICATOR				I
J							J
K							K
L	LEVEL			LOW			L
M					MOTORIZED		M
N							N
O							O
P	PRESSURE				PNEUMATIC	PUMP	P
Q		QUANTITY					Q
R							R
S	SPEED		SWITCH		SOLENOID		S
T	TEMPERATURE		TRANSMITTER				T
U							U
V						VALVE	V
W							W
X							X
Y							Y
Z	POSITION						Z

INSTRUMENT IDENTIFICATION



SYSTEM POSITION DESIGNATION

1000 - LIFT STATION
2000 - INLET SCREEN
3000 - EQUALIZATION TANK
4901 - SCREEN DISCHARGE PUMP TANK
5000 - AERATION TANK
5500 - SLUDGE HOLDING TANK
6000 - MBR TANK
6100 - CHEMICAL INJECTION
7000 - PERMEATE
7500 - UV LIGHT
7900 - BUILDING,TRAILER OR SKID
8000 - DISCHARGE TANK
8200 - CONTROL PANEL
8300 - TELEMETRY
9900 - EXTRAS

NOTES

newterra

PHONE:
(800) 420-4056

www.newterra.com

LEVEL	REVISION	DATE (mm/dd/yy)	BY
C	AS-BUILT	13/08/17	JJK
B	PRODUCTION	06/06/17	JJK
A2	SUBMITTAL REVISIONS	26/05/17	JJK
A	SUBMITTAL	23/05/17	JJK

PROJECT NUMBER: 1704432

TITLE AND LOCATION: P&ID AMARUQ MINE

CUSTOMER: AGNICO EAGLE MINE

DRAWN BY: MH | DATE: | SHEET: 4 | SHEETS: 4

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra

Project:

1704432 - AGNICO EAGLE MINE - C

newterra®

clean water. modular solutions. simple.™

Contents:

2	SYSTEM SPECIFICATIONS
3	LEGEND, ELECTRICAL
4	SINGLE LINE DIAGRAM, SHEET 1 OF 3
5	SINGLE LINE DIAGRAM, SHEET 2 OF 3
6	SINGLE LINE DIAGRAM, SHEET 3 OF 3
7	PLC/COMMUNICATION LAYOUT
8	PANEL LAYOUTS
9	SPARE SHEET
10	600V/480V POWER, DISTRIBUTION
11	480V POWER DISTRIBUTION, SHEET 1 OF 4
12	480V POWER DISTRIBUTION, SHEET 2 OF 4
13	480V POWER DISTRIBUTION, SHEET 3 OF 4
14	480V POWER DISTRIBUTION, SHEET 4 OF 4
15	SPARE SHEET
16	LV DISTRIBUTION PANEL, SHEET 1 OF 2
17	LV DISTRIBUTION PANEL, SHEET 2 OF 2
18	SPARE SHEET
19	MCP - 120VAC, CONTROL POWER
20	MCP - 24VDC, CONTROL POWER
21	MCP DISCRETE INPUTS, SHEET 1 OF 4
22	MCP DISCRETE INPUTS, SHEET 2 OF 4
23	MCP DISCRETE INPUTS, SHEET 3 OF 4
24	MCP DISCRETE INPUTS, SHEET 4 OF 4
25	MCP DISCRETE OUTPUTS, SHEET 1 OF 2
26	MCP DISCRETE OUTPUTS, SHEET 2 OF 2
27	MCP ANALOG INPUTS, SHEET 1 OF 2
28	MCP ANALOG INPUTS, SHEET 2 OF 2
29	MCP ANALOG OUTPUTS, DO/IT, PROBE & CUSTOMER CONNECTIONS
30	SPARE SHEET
31	MCP PANEL LAYOUT
32	MCP PANEL LAYOUT, TOP
33	MCP PANEL LAYOUT, BOTTOM
34	MPP 120VAC & 24VDC, CONTROL POWER
35	MPP OTB I/O, DISCRETE INPUTS/OUTPUTS
36	MPP DISCRETE INPUTS, SHEET 1 OF 2
37	MPP DISCRETE INPUTS, SHEET 2 OF 2
38	MPP DISCRETE INPUTS, & OUTPUTS
39	MPP RELAY OUTPUTS
40	MPP SPARE SHEET
41	MPP PANEL LAYOUT
42	MPP PANEL LAYOUT, TOP
43	MPP PANEL LAYOUT, MIDDLE
44	MPP PANEL LAYOUT, BOTTOM
45	JUNCTION BOX LAYOUTS, JB-7901'S
46	JUNCTION BOX LAYOUTS, JB-7902'S
47	JUNCTION BOX LAYOUTS, JB-7904'S
48	MPP BILL OF MATERIAL, MODULE 8201 - SHEET 1 OF 2
49	MPP BILL OF MATERIAL, MODULE 8201 - SHEET 2 OF 2
50	MCP BILL OF MATERIAL, MODULE 8202 - SHEET 1 OF 3
51	MCP BILL OF MATERIAL, MODULE 8202 - SHEET 2 OF 3
52	MCP BILL OF MATERIAL, MODULE 8202 - SHEET 3 OF 3
53	JB-7901-AC BILL OF MATERIAL, MODULE 8203 - SHEET 1 OF 11
54	JB-7901-DC BILL OF MATERIAL, MODULE 8203 - SHEET 2 OF 11
55	JB-7901-HV BILL OF MATERIAL, MODULE 8203 - SHEET 3 OF 11
56	JB-7901-IS BILL OF MATERIAL, MODULE 8203 - SHEET 4 OF 11
57	JB-7901OS-AC BILL OF MATERIAL, MODULE 8203 - SHEET 5 OF 11
58	JB-7902-AC BILL OF MATERIAL, MODULE 8203 - SHEET 6 OF 11
59	JB-7902-DC BILL OF MATERIAL, MODULE 8203 - SHEET 7 OF 11
60	JB-7902-HV BILL OF MATERIAL, MODULE 8203 - SHEET 8 OF 11
61	JB-7904-AC BILL OF MATERIAL, MODULE 8203 - SHEET 9 OF 11
62	JB-7904-DC BILL OF MATERIAL, MODULE 8203 - SHEET 10 OF 11
63	JB-7904-HV BILL OF MATERIAL, MODULE 8203 - SHEET 11 OF 11
64	BLD-7901 BILL OF MATERIAL, MODULE 8901 - SHEET 1 OF 2
65	BLD-7901 BILL OF MATERIAL, MODULE 8901 - SHEET 2 OF 2
66	BLD-7902 BILL OF MATERIAL, MODULE 8902
67	BLD-7904 BILL OF MATERIAL, MODULE 8904 - SHEET 1 OF 2
68	BLD-7904 BILL OF MATERIAL, MODULE 8904 - SHEET 2 OF 2
69	BLD-7905 BILL OF MATERIAL, MODULE 8905
70	BLD-7906 BILL OF MATERIAL, MODULE 8906 - SHEET 1 OF 2
71	BLD-7906 BILL OF MATERIAL, MODULE 8906 - SHEET 2 OF 2

THIS INFORMATION IS THE PROPERTY OF newterra ltd. AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra ltd.

ELECTRICAL SPECIFICATIONS	
VOLTAGE	600V
PHASE	3Ø
FREQUENCY	60 Hz
FULL LOAD AMPS	172A
MAIN DISCONNECT SIZE	400A - FUSED @ 250A
SCCR SYMMETRICAL (kAMPS)	10
SYSTEM APPROVAL AND CLASSIFICATION	cMET - CL1Div2
PANEL APPROVAL AND CLASSIFICATION	cMETus to UL698A

WIRE LEGEND

BLACK: POWER
RED: 120VAC CONTROL
WHITE: NEUTRAL
BLUE: +24VDC & IS WIRING
BLU/WHT: 0VDC
YELLOW: INTERLOCKS

NOTES:

1325 CALIFORNIA AVE.
BROCKVILLE, ONTARIO
CANADA K6V 5Y6
PHONE: (613)498-1876
www.newterra.com

LEVEL	REVISION	DATE (dd/mm/yy)	BY
C	AS BUILT	14/08/17	DMB
B	FOR PRODUCTION	31/05/17	DMB
A1	FOR REVIEW	23/05/17	DMB
A	FOR SUBMITTAL	12/05/17	DMB

PROJ. NO: 1704432
TITLE AND LOCATION: SYSTEM SPECIFICATIONS

CUSTOMER: AGNICO EAGLE 600 MAN AMARUQ MINE

DRAWN BY:	DATE:	SHEET:	SHEETS:
DMB	08/05/17	2	71

1704432 - AGNICO EAGLE MINE - C

THIS INFORMATION IS THE PROPERTY OF newterra ltd.. AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra ltd.

FLOW SWITCH, NORMALLY CLOSED

FLOW SWITCH, NORMALLY OPEN

FLOAT SWITCH, NORMALLY CLOSED

FLOAT SWITCH, NORMALLY OPEN

LIMIT SWITCH, NORMALLY CLOSED

LIMIT SWITCH, NORMALLY OPEN

PRESSURE SWITCH, CHANGE OVER CONTACTS

PRESSURE SWITCH, NORMALLY CLOSED OPENS ON PRESSURE INCREASE

PRESSURE SWITCH, NORMALLY OPEN CLOSES ON PRESSURE INCREASE

TEMPERATURE SWITCH, CHANGE OVER CONTACTS

TEMPERATURE SWITCH, NORMALLY CLOSED OPENS ON TEMPERATURE INCREASE

TEMPERATURE SWITCH, NORMALLY OPEN CLOSES ON TEMPERATURE INCREASE

PROXIMITY SWITCH, NORMALLY CLOSED

PROXIMITY SWITCH, NORMALLY OPEN

METAL OXIDE VARISTOR
MOV

S7296
DIODE

TANDEM TERMINAL BLOCK

PANEL TERMINAL BLOCK

JUNCTION BOX TERMINAL BLOCK

CUSTOMER TERMINAL BLOCK

FUSED TERMINAL BLOCK

TOGGLE SWITCH, NORMALLY OPEN

TOGGLE SWITCH, CHANGE OVER CONTACTS, 3 WAY

PUSH BUTTON, NORMALLY CLOSED

PUSH BUTTON, NORMALLY OPEN

PUSH BUTTON, NORMALLY CLOSED MUSHROOM HEAD

SELECTOR SWITCH, 2 POSITION
2 NORMALLY OPEN

SELECTOR SWITCH, 3 POSITION
2 NORMALLY OPEN

PILOT LIGHT, X=COLOR

COLOR CODE
A - AMBER
B - BLUE
G - GREEN
R - RED
W - WHITE

PILOT LIGHT, PUSH-TO-TEST
X=COLOR

BEACON LIGHT
X=COLOR

CONTACT, NORMALLY CLOSED

CONTACT, NORMALLY OPEN

TIME DELAY CONTACT, INSTANTANEOUS OPEN
TIMED CLOSED ON DE-ENERGIZE

TIME DELAY CONTACT, INSTANTANEOUS CLOSE
TIMED OPEN ON DE-ENERGIZE

TIME DELAY CONTACT, INSTANTANEOUS OPEN
TIMED CLOSE ON ENERGIZE

TIME DELAY CONTACT, INSTANTANEOUS CLOSE
TIMED OPEN ON ENERGIZE

COIL - RELAY, CONTACTOR
TIMER, MOTOR STARTER

ANNUNCIATOR, BELL

ANNUNCIATOR, HORN

ANNUNCIATOR, BUZZER

BATTERY

TRANSMITTER, 2 WIRE
LOOP POWERED

INTRINSICALLY SAFE BARRIERS
(NOT TO SCALE)

4CHANNEL DISCRETE

2 CHANNEL ANALOG

NETWORK SWITCH -ETHERNET
(NOT REPRESENTATIVE OF ALL TYPES)
(NOT TO SCALE)

PANEL METER
AM=AMMETER
VM=VOLT METER

ETM
ELAPSED TIME METER

CURRENT TRANSFORMER

GROUND

INSTRUMENTATION
GROUND

SOLENOID

CURRENT SWITCH

FUSED DISCONNECT
X=AMP RATING

FUSE, X=AMP RATING

CIRCUIT BREAKER
X=AMP RATING

COMBINATION STARTER
X - X AMP=CURRENT RANGE

CONTACTOR

DISTRIBUTION BLOCK

X HP
X FLA
X AWG
3 PHASE MOTOR

X kW
X AMP
X AWG
3 PHASE HEATER

RECEPTACLE, SINGLE OUTLET

RECEPTACLE, DUPLEX

TRANSFORMER
CONTROL POWER
(NOT REPRESENTATIVE OF ALL TYPES)

TRANSFORMER
DISTRIBUTION/LIGHTING
(NOT REPRESENTATIVE OF ALL TYPES)

120VAC
24VDC
72Wat
DC POWER SUPPLY
(NOT REPRESENTATIVE OF ALL TYPES)

REACTOR

COIL: *LOCATION*
4 POLE RELAY
CROSS REFERENCES

LOCATION
COMBINATION STARTER
CROSS REFERENCES

VARIABLE FREQUENCY DRIVE
(NOT REPRESENTATIVE OF ALL TYPES)
(NOT TO SCALE)

GENERAL PURPOSE WIRING
EXTERNAL TO PANEL

CL1Div2 WIRING
EXTERNAL TO PANEL

WIRING BY OTHERS
EXTERNAL TO PANEL

USA 3 PHASE
POWER WIRING COLOR CODE

480V	208/230V(HIGH LEG)
PHASE A - BROWN	PHASE A - BLACK
PHASE B - ORANGE	PHASE B - RED(ORG)
PHASE C - YELLOW	PHASE C - BLUE

CANADIAN 3 PHASE
POWER WIRING COLOR CODE

PHASE A - RED
PHASE B - BLACK
PHASE C - BLUE

WIRE LEGEND

BLACK:	POWER
RED:	120VAC CONTROL
WHITE:	NEUTRAL
BLUE:	+24VDC & IS WIRING
BLU/WHT:	0VDC
YELLOW:	INTERLOCKS

NOTES:

1.

newterra

1325 CALIFORNIA AVE.
BROCKVILLE, ONTARIO
CANADA K6V 5Y6
PHONE: (613)498-1876
www.newterra.com

LEVEL	REVISION	DATE (dd/mm/yy)	BY
C	AS BUILT	14/08/17	DMB
B	FOR PRODUCTION	31/05/17	DMB
A1	FOR REVIEW	23/05/17	DMB
A	FOR SUBMITTAL	12/05/17	DMB

PROJ. NO: 1704432

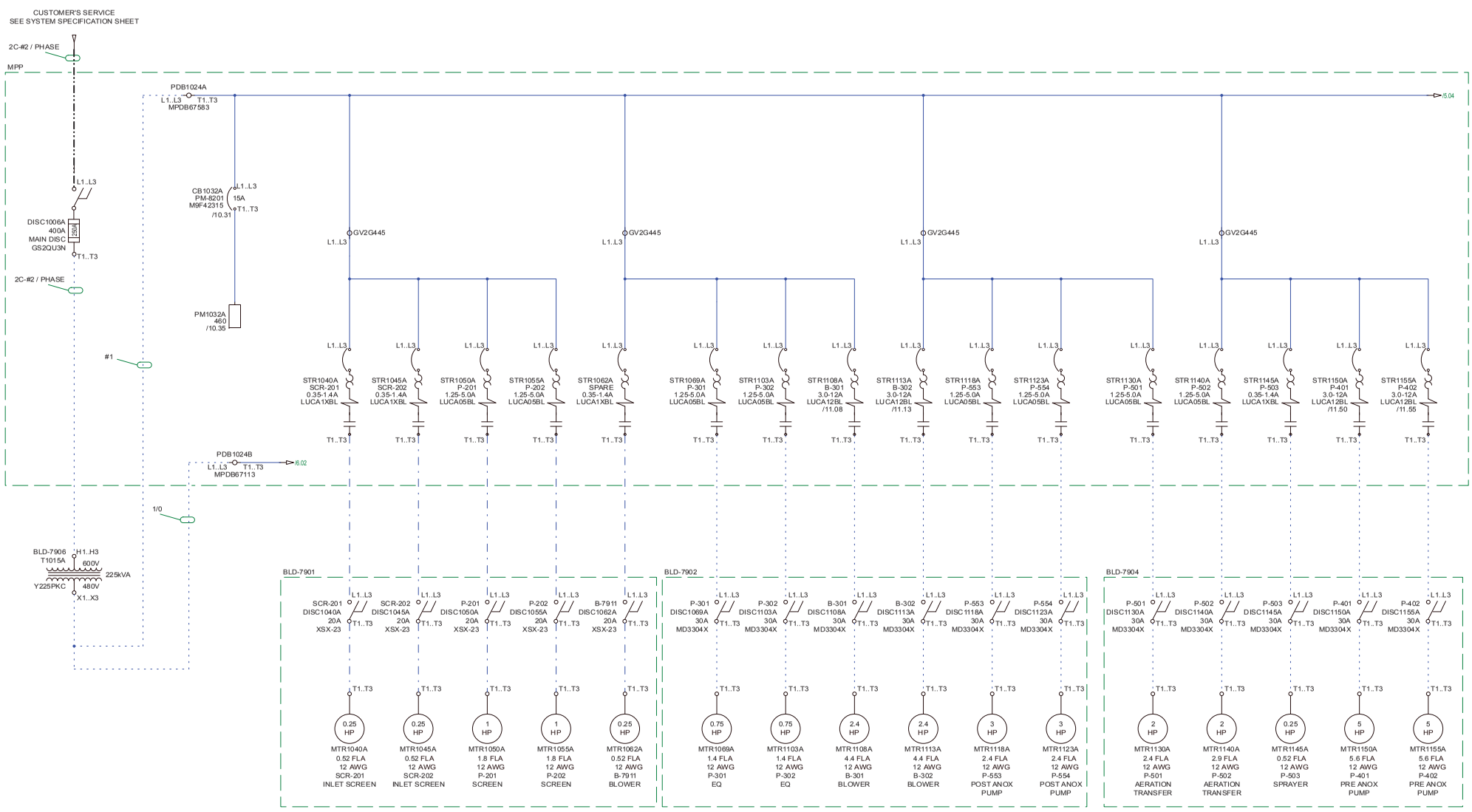
TITLE AND LOCATION: LEGEND ELECTRICAL

CUSTOMER: AGNICO EAGLE 600 MAN AMARUQ MINE

DRAWN BY:	DATE:	SHEET:	SHEETS:
DMB	08/05/17	3	71

1704432 - AGNICO EAGLE MINE - C

THIS INFORMATION IS THE PROPERTY OF newterra ltd.. AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra ltd.



WIRE LEGEND

BLACK:	POWER
RED:	120VAC CONTROL
WHITE:	NEUTRAL
BLUE:	+24VDC & IS WIRING
BLU/WHT:	0VDC
YELLOW:	INTERLOCKS

NOTES:

1.

newterra

1325 CALIFORNIA AVE.
BROCKVILLE, ONTARIO
CANADA K6V 5Y6
PHONE: (613)498-1876
www.newterra.com

LEVEL	REVISION	DATE (dd/mm/yy)	BY
C	AS BUILT	14/08/17	DMB
B	FOR PRODUCTION	31/05/17	DMB
A1	FOR REVIEW	23/05/17	DMB
A	FOR SUBMITTAL	12/05/17	DMB

PROJ. NO: 1704432

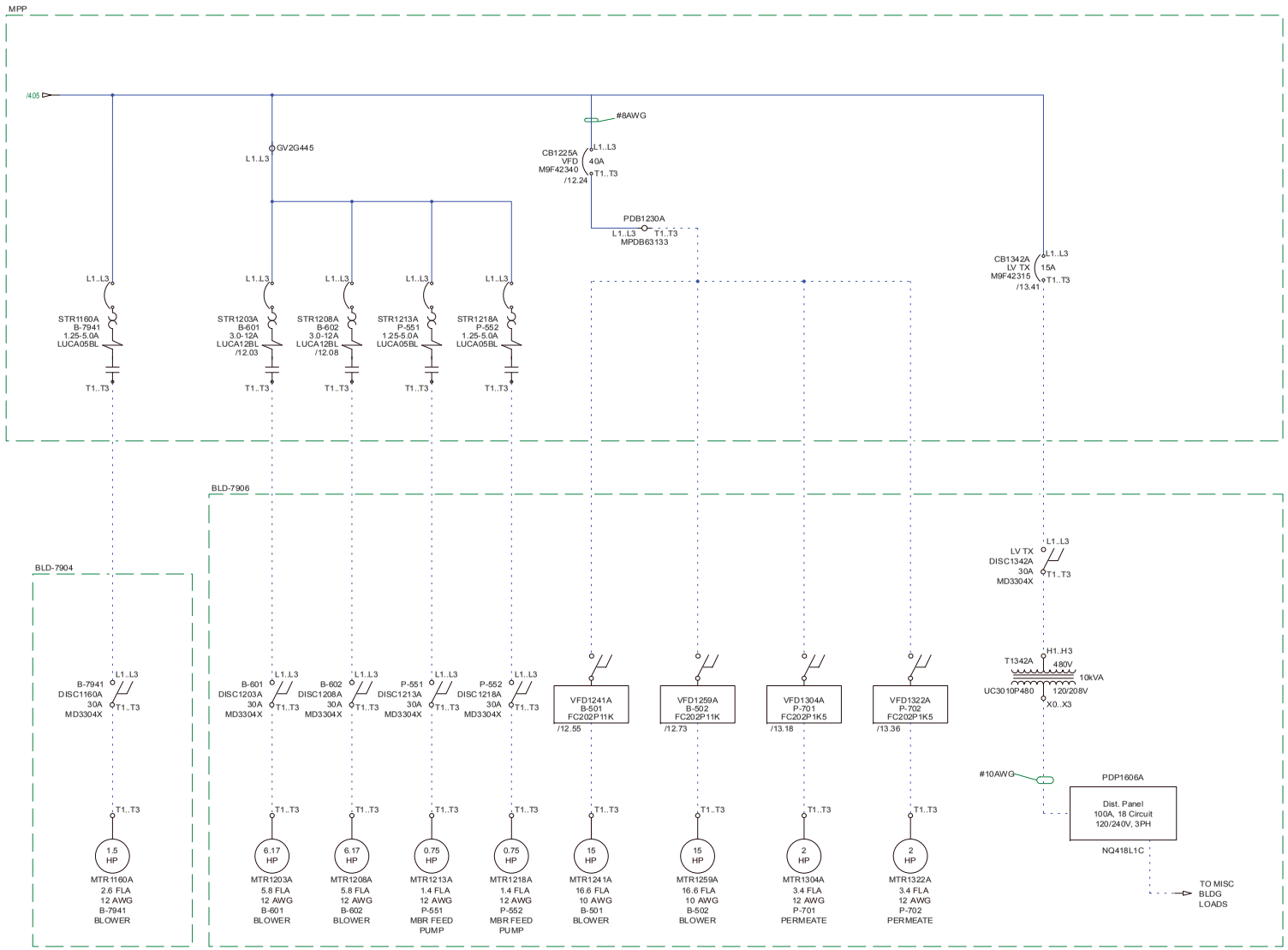
TITLE AND LOCATION: SINGLE LINE DIAGRAM SHEET 1 OF 3

CUSTOMER: AGNICO EAGLE 600 MAN AMARUQ MINE

DRAWN BY:	DATE:	SHEET:	SHEETS:
DMB	08/05/17	4	71

1704432 - AGNICO EAGLE MINE - C

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra



WIRE LEGEND

BLACK:	POWER
RED:	120VAC CONTROL
WHITE:	NEUTRAL
BLUE:	+24VDC & IS WIRING
BLU/WHT:	0VDC
YELLOW:	INTERLOCKS

NOTES:

1.

1325 CALIFORNIA AVE.
BROCKVILLE, ONTARIO
CANADA K6V 5Y6
PHONE: (613)498-1876
www.newterra.com

LEVEL	REVISION	DATE (dd/mm/yy)	BY
C	AS BUILT	14/08/17	DMB
B	FOR PRODUCTION	31/05/17	DMB
A1	FOR REVIEW	23/05/17	DMB
A	FOR SUBMITTAL	12/05/17	DMB

PROJ. NO: 1704432

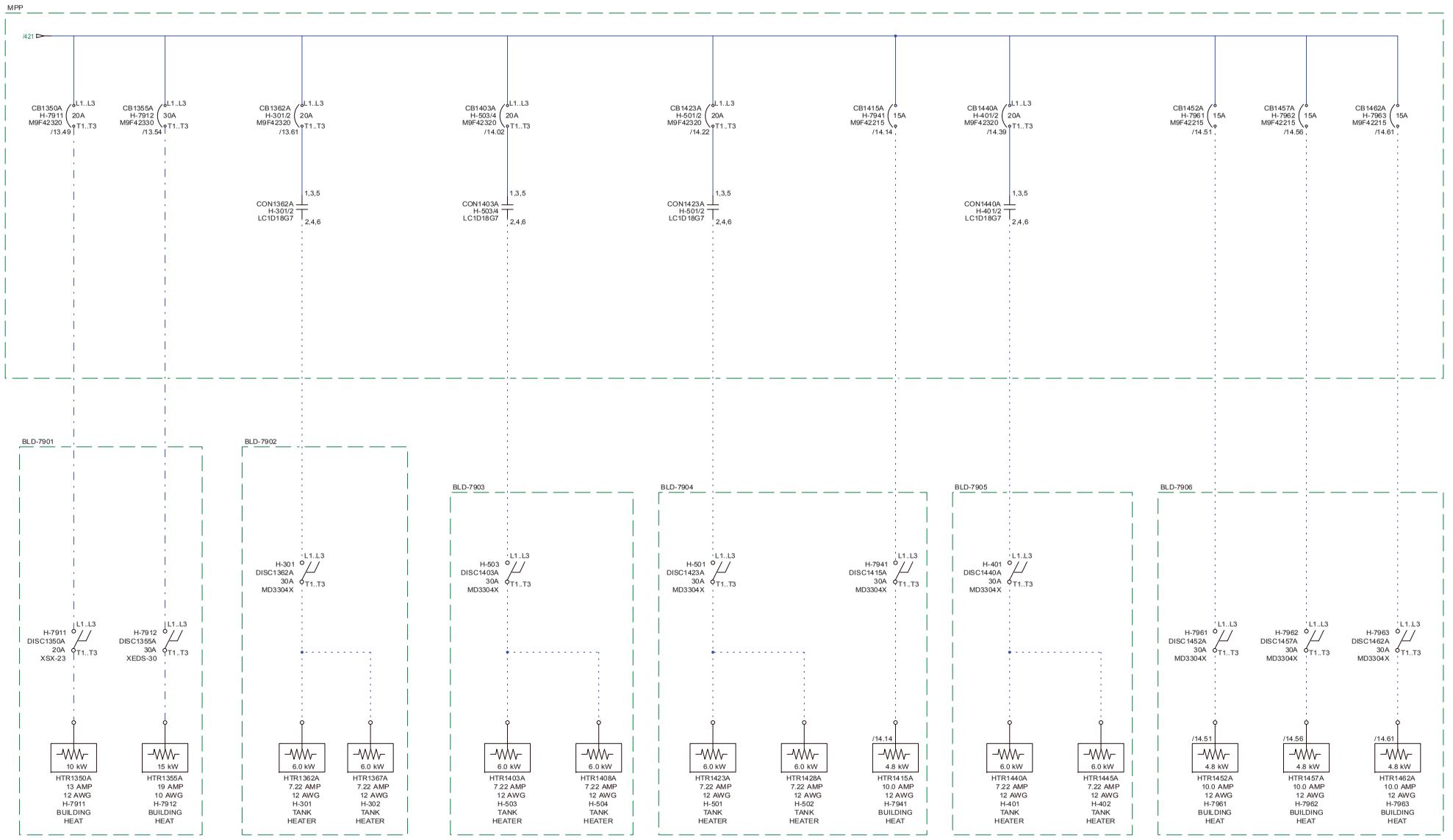
TITLE AND LOCATION: SINGLE LINE DIAGRAM SHEET 2 OF 3

CUSTOMER: AGNICO EAGLE 600 MAN AMARUQ MINE

DRAWN BY:	DATE:	SHEET:	SHEETS:
DMB	08/05/17	5	71

1704432 - AGNICO EAGLE MINE - C

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra



WIRE LEGEND

BLACK:	POWER
RED:	120VAC CONTROL
WHITE:	NEUTRAL
BLUE:	+24VDC & IS WIRING
BLU/WHT:	0VDC
YELLOW:	INTERLOCKS

NOTES:

1.

newterra

1325 CALIFORNIA AVE.
BROCKVILLE, ONTARIO
CANADA K6V 5Y6
PHONE: (613)498-1876
www.newterra.com

LEVEL	REVISION	DATE (dd/mm/yy)	BY
C	AS BUILT	14/08/17	DMB
B	FOR PRODUCTION	31/05/17	DMB
A1	FOR REVIEW	23/05/17	DMB
A	FOR SUBMITTAL	12/05/17	DMB

PROJ. NO: 1704432

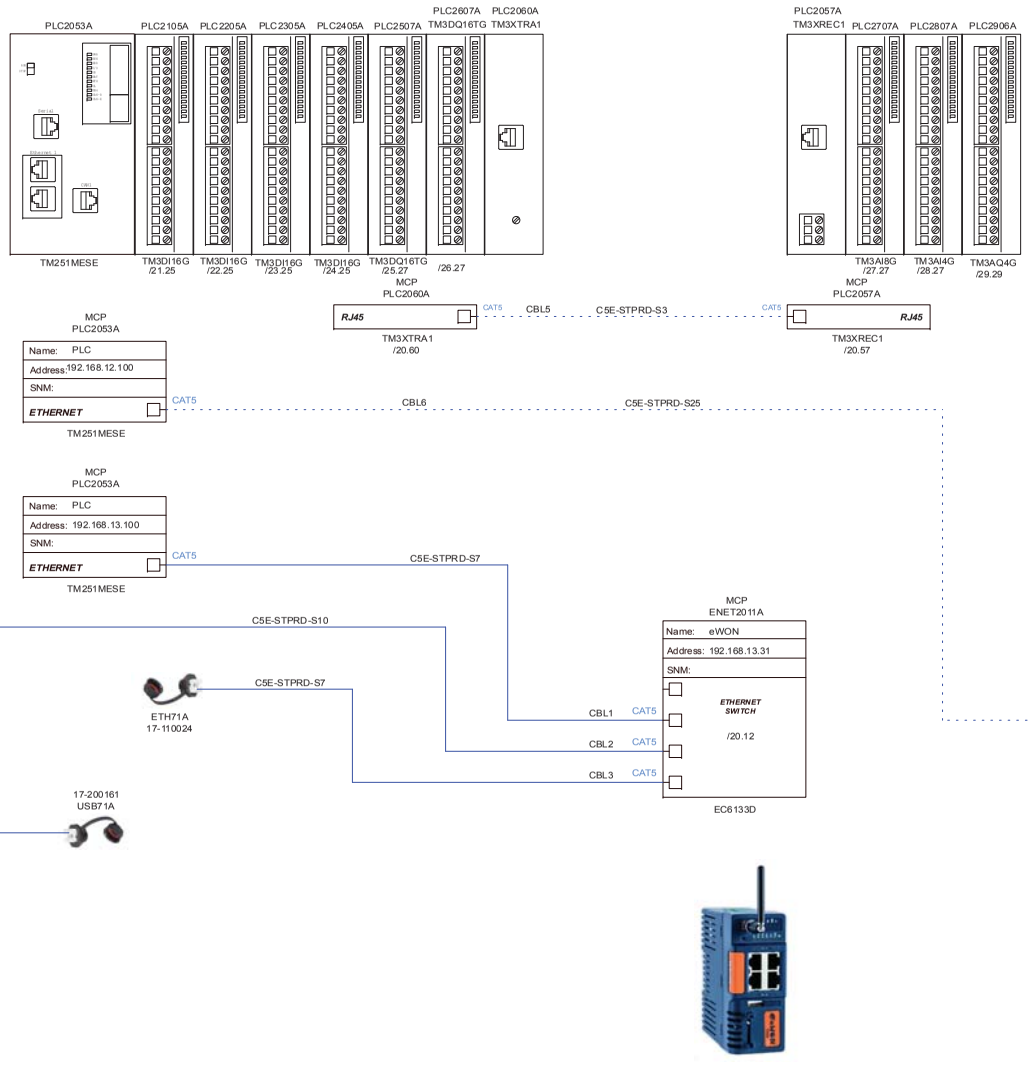
TITLE AND LOCATION: SINGLE LINE DIAGRAM SHEET 3 OF 3

CUSTOMER: AGNICO EAGLE 600 MAN AMARUQ MINE

DRAWN BY:	DATE:	SHEET:	SHEETS:
DMB	10/05/17	6	71

1704432 - AGNICO EAGLE MINE - C

THIS INFORMATION IS THE PROPERTY OF newterra AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra



WIRE LEGEND

BLACK:	POWER
RED:	120VAC CONTROL
WHITE:	NEUTRAL
BLUE:	+24VDC & IS WIRING
BLU/WHT:	0VDC
YELLOW:	INTERLOCKS

NOTES:

1.

newterra

1325 CALIFORNIA AVE.
BROCKVILLE, ONTARIO
CANADA K6V 5Y6
PHONE: (613)498-1876
www.newterra.com

LEVEL	REVISION	DATE (dd/mm/yy)	BY
C	AS BUILT	14/08/17	DMB
B	FOR PRODUCTION	31/05/17	DMB
A1	FOR REVIEW	23/05/17	DMB
A	FOR SUBMITTAL	12/05/17	DMB

PROJ. NO: 1704432

TITLE AND LOCATION: PLC/COMMUNICATION LAYOUT

CUSTOMER: AGNICO EAGLE 600 MAN AMARUQ MINE

DRAWN BY:	DATE:	SHEET:	SHEETS:
DMB	08/05/17	7	71

1704432 - AGNICO EAGLE MINE - C

THIS INFORMATION IS THE PROPERTY OF newterra ltd.. AND CANNOT BE REUSED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF newterra ltd.