Baffinland

Attachment 2

Civil Design Criteria

Baffinland Iron Mines Corporation:

Civil Design Philosophy

Mary River Expansion Project

H353004

Civil Design Philosophy

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1. Introduction

This document establishes the Employers requirements for civil design and engineering for the Mary River expansion Project.

This document is intended to address the key criteria required for the design of site infrastructure.

2. Units and Coordinate System

2.1 The International System of Units (SI units and prefixes) shall be used for all design calculations and on all drawings.

2.2 The grid coordinates shall be based on: projection – Universal Transverse Mercator (UTM) Zone 17 and horizontal datum – NAD 83 Canadian Spatial Reference System (CSRS).

2.3 Vertical datum shall based on the Canadian Geodetic Vertical Datum of 1928 (CGVD28).

3. References

3.1 Codes, Regulations and Standards

3.1.1 Unless specifically stated otherwise, civil design shall be based on the applicable sections of the latest revisions of the following codes, specifications, standards, regulations and other reference documents. In addition, the design must comply with all laws or regulations of federal and Nunavut territorial authorities.

3.2 General

3.2.1 All applicable federal, territorial (Nunavut) and local laws and regulations.

- OHSA Occupational Health and Safety Act
- CSA Canadian Standards Association
- MHSA Mine Health and Safety Act (Nunavut – S.N.W.T. 1994)
- OHSR Occupational Health and Safety Regulations
- NBCC National Building Code of Canada (2010)

- ASTM American Society for Testing and Materials
- ASCE American Society of Civil Engineers
- NFPA National Fire Protection Association
- NRC Natural Resources Canada – Explosives Safety and Security Branch

3.3 Roads

- TAC Transportation Association of Canada – Geometric Design Guide for Canadian Roads
- AASHTO American Association of State Highway and Transportation Officials
- USBM Design of Surface Mine Haulage Roads – A Manual (US Department of the Interior, Bureau of Mines)
- MSHA Haul Road Inspection Handbook – MSHA Document Number PH99-I-4
- MTO Ministry of Transportation, Ontario – Ontario Traffic Manual.

3.4 Stormwater Management

- MOE Ministry of the Environment - Stormwater Management Planning and Design Manual
- MTO Ministry of Transportation, Ontario – Drainage Manual
- CDA Canadian Dam Association – Dam Safety Guidelines

3.5 Reference Documents

Reference will be made to/contents have been used as general guidance from the following documents, articulated during the previous phases of the project, during the development of these criteria:

- H337697-0000-10-122-0001: Stormwater Management and Drainage System Design
- H337697-6170-10-122-0001: Milne Port Drainage System and Stormwater Management Ponds

- H337697-6170-10-122-0002: Mine Site Drainage System, Stormwater and Sediment Management
- H337697-0000-15-124-0004: Geotechnical Data Report – Infrastructure
- Standard Specification S311213: Quarried Fill Materials
- Standard Specification S003120: Site Conditions
- NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012
- Updated Design Peak Flow Assessment. Knight Piesold, 2016
- BIM - Early Revenue Phase Tote Road Design Criteria
- Final Environmental Impact Statement (FEIS), Mary River Project, February 2012
- Nunavut Impact Review Board (NIRB) Project Certificate (No.:005), Dec 28, 2012
- H349000-2133-10-220-0001: Runoff Coefficient for the Milne Port Ore Stockpile Pad, Project Memo
- H349000-1000-10-220-0001: Stormwater Sedimentation Pond Design Criteria, Project Memo
- E349000-1000-00-124-0005: Design Brief – Milne Inlet Landfarm, November 2012, EBA File E14101174.

4. Site Development

Site development refers to construction of civil infrastructure to support construction and operation of facilities. The following sections list the site development activities and establish criteria that shall be adhered to when carrying out site development design works.

All site development including toe lines of pads and roads shall be designed and positioned so that it is not closer than 31m from the edge of a stream or waterbody. The edge of a stream or water body shall be defined by using the existing surface obtained from the 1m density lidar survey (2016). 1

4.1 Site Preparation

4.1.1 Temporary drainage systems shall be provided at construction areas prior to construction activities taking place as required to control surface runoff.

4.1.2 During the summer months, wetlands or areas with standing water shall be drained and the drying of such shall be promoted prior to construction. Watercourses shall be re-routed with the use of cut-off ditches, or re-aligned engineered channels.

4.1.3 Waste material shall be stockpiled in designated areas with the appropriate erosion and sedimentation control measures in place.

4.2 Earthworks

4.2.1 Earthworks is defined as the activity of moving soil and/or rock. Earth-moving activities are required to obtain the required design elevations of the ground surface. Earthworks includes cut (if required) and fill for roads, buildings and equipment pads, utility berms, foundation excavation, and construction of ditches, diversion channels and berms, dikes, etc. Earthworks shall be carried out in accordance with the following general guidelines:

- Existing unsuitable soils shall be removed and replaced with suitable material to be decided by the Resident Engineer
- Fill materials shall be placed and roller compacted over the proof-rolled subgrade to achieve adequate bearing capacities, as required for specific construction activities
- Rocks/boulders and similar objects adjacent to areas which shall undergo excavation must be removed or secured, if they potentially endanger workers/machinery.

4.2.2 Table 4-1 provides the minimum slope ratios that shall be used in permanent cuts/excavations or fills/embankments. It must be noted that specific studies must be carried out by geotechnical engineers, if these slopes are to be modified with the aim of lowering costs of cut and/or fill.

Table 4-1: Minimum Slope Ratios

Type of Earthworks	Layer	Ratio H:V
	Overburden (ice-rich)	2:1

Type of Earthworks	Layer	Ratio H:V
Permanent unsupported cuts	Overburden (non ice-rich)	1.5:1
	Rock (less than 4m)	1:8
Permanent fills (on natural, firm ground)	Granular fill	1.5:1
	Base and Subbase	1.5:1
	Rock fill	1.5:1
	Frozen Permafrost (During winter)	1:8

Notes:

1. The maximum heights and ratios shall be determined considering slopes with typical geometry and no surcharge.
2. The above-listed parameters serve as minimum requirements, and shall be updated/modified based on confirmation/update of the site-specific conditions and/or geotechnical recommendations, or as per BIM's directions.
3. Any geometry and load condition not covered by the table above shall be reviewed by the geotechnical engineer.
4. The granular fill is assumed to be in a drained condition.
5. If the total fill height is greater than 2 m, geotechnical stability analysis and benching requirements shall be considered on a case-specific basis.
6. For overburden cut/fill heights of greater than 5 m, 1.5 m wide benching with minimum 2% cross slope shall be provided.
7. The absolute minimum fill slope for granular material is 1.5H:1V. However, the desirable slope is 2H:1V.
8. The absolute minimum fill slope for rock fill material is 1.25H:1V. However, the desirable slope is 1.5H:1V.
9. For the haul road, the fill side slopes shall be 2H:1V, depending on the site conditions and slope stability.
10. Stability assessments of some cut and fill slopes may be required.
11. For rock cut heights greater than 4 m, 1H:4V slope shall be used with 2 m wide benching and minimum 2% cross slope at every 6 m.

4.2.3 Pits, trenches and similar which will later be stabilized by backfill shall be excavated at a safe slope as determined by the field engineer. Slope ratios listed in Table 4-1 shall be used for planning purposes. Slope ratio of 1:8 shall be used for planning purposes for frozen permafrost ground excavated and backfilled during winter.

4.2.4 In general, cut activities in permafrost shall be avoided/minimized. However, cut may be required to reduce large fills and high embankments that may affect/endanger slope stability. In addition, within areas where the cut materials can be reused as fill, the suitability of performing cuts in the native soil shall be reviewed by BIM and the geotechnical engineer for requirements of soil treatment/improvement, including geogrids and geotextiles, prior to implementation into the final design.

4.3 Site Grading

4.3.1 If applicable, finish grade elevations for roads and yards shall be set a minimum of 100 mm below the finish floor elevation of buildings/sheltered areas, with local ramps provided at doorways, as required.

4.3.2 Finish grading and yard grading shall be set to slope away from planned structures at a minimum of 0.5% to 2%, and drain to a storm drainage collection system. For very long-run and localized areas, the slope shall be reduced or increased, depending on the existing ground slope and the grading around the buildings and facilities.

4.3.3 Site grading shall produce a useable and easily maintainable ground surface, not subject to flooding or erosion. The rough grades and finish grades shall adhere to the following:

- Final road and site grades shall ensure suitable pedestrian and vehicular access to buildings and facilitate adequate drainage of the site
- Building floor elevations shall be established such that the ground floor of the buildings will not be subject to flooding in the event that the storm drainage system fails
- Elevations of buildings/sheltered areas shall be established to permit gravity connections into sanitary sewers if possible, to avoid the need for pumps.

4.4 Infrastructure Facilities, Pads and Laydown Areas

4.4.1 Temporary/permanent equipment and construction material laydown areas shall be provided as per the applicable Contract Drawings. The sizes of the footprints shall be optimized to keep disturbed areas to a minimum and still provide enough room for storage of material/equipment and circulation of mobile cranes/vehicles.

4.4.2 The subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. The following material shall be used:

- Type 12 (ROQ 600mm minus).

4.4.3 In general, following attainment of the subgrade, the pavement shall be laid on top, with the following minimum thicknesses/material types for infrastructure facility pads and other areas:

- 300 mm, Type 8 (150 mm minus) sub-base
- 100 mm, Type 5 (32 mm minus) base/wearing surface course.

4.4.4 Temporary construction pads shall be constructed with:

- Minimum 300mm fill Type 8 for fill depth <600mm or Type 12 for fill depth>600mm
- 100 mm, Type 5 (32 mm minus).

4.4.5 Depending upon the area and specific requirements such as insulation for permafrost protection, the minimum pavement thicknesses and placement of wearing courses may differ from the above-listed.

4.4.6 Sub-grade insulation shall be installed under the footprint of all slab-on-grade and similar buildings to reduce heat transfer into the underlying permafrost. Sub-grade insulation shall comply with geotechnical recommendations and shall generally comprise of 150mm thickness of Styrofoam insulation capped with 400mm thickness of Type 5 (32mm minus) fill.

4.4.7 Refer to Appendix A for typical layer works.

4.5 Milne Port Stockpile Area

4.5.1 The lump ore stockpile (Stockpile No. 2) shall be situated on an earthworks platform that shall be used as a laydown area before the stockpile becomes operational. Before the stockpile is operational, the earthworks shall be cut to an appropriate level to ensure that it is a minimum of 300mm below the reclaim level. 2

4.5.2 The fine ore stockpile (Stockpile No. 1) shall be situated on the existing stockpile area. Additional earthworks will be constructed where required to ensure that there is sufficient area for the stockpile placement. 2

4.6 Milne Port Design High Tide

4.6.1 The design High Tide levels for the Project shall be as follow:

- The Higher High Water Level (HHWL) for large tides at the Milne Port is +2.3 m above Chart Datum (CD) which corresponds to +1.1 m above Mean Sea Level (MSL)
- The Highest Astronomical Tide (HAT) at the Milne Port is +2.4m above CD which corresponds to +1.2 m above MSL
- The Lower Low Water Level (LLWL) for large tides at the Milne Port is +0.0 m above CD which corresponds to -1.2 m below MSL.

4.7 Retaining Walls

4.7.1 Retaining walls and structures shall be designed based on site-specific conditions. Lateral pressure coefficients for design of retaining walls shall be as per the geotechnical recommendation.

4.7.2 Retaining walls shall be avoided to the greatest extent possible. Concrete, gabion walls, crib walls, reinforced earth and/or other systems of retaining structures shall be used, if required.

4.8 Erosion and Sediment Control

4.8.1 Erosion and sediment control measures shall be installed as required, in and around the project sites to minimize sediment transport off the site.

4.8.2 Control measures shall be designed to:

- Minimize the size of disturbed areas
- Remove sediments from on-site runoffs prior to the runoff leaving the sites
- Prevent sediments from off-site runoffs flowing across disturbed areas
- Reduce runoff velocity flowing across the site
- Meet local requirements for erosion and sediment control plans as defined in the FEIS. 2

4.8.3 A minimum set back of 31 m from fish-bearing streams and lakes or water bodies shall be provided. Any exception to this shall be consulted with and approved by the Project's environmental team.

5. Road Design

5.1 General

5.1.1 The access roads at the two project sites may be temporary or permanent. An access road is defined as temporary if it will be used only during the construction period including site predevelopment or site capturing. Permanent roads are defined as roads that are requried for operarations. Permanant roads may be primary secondary or tertiary depending on frequency and type of traffic.

5.1.2 The design and construction of mine haul roads, access and internal site roads at the project sites shall provide a safe environment for construction, operations and maintenance personnel, and shall facilitate the mining operations, ore transport and port operations in an efficient manner. In addition, the design shall comply with the relevant standards, guidelines, acts, approvals, permits, and other contractual environmental requirements of Baffinland as defined in Section 1 of this document.

5.2 Road Category

5.2.1 For the purposes of this design criteria, the roads are classified in three categories:

- **Mine Haul Roads –** The purpose of this type of road is for the mining operation at the mine site - hauling of ore from the open pit to the crusher pad and for maintenance purposes, from the crusher pad to the maintenance building. The mine haul road shall be segregated from the other project roads for safety considerations, and shall comply with the applicable Nunavut MHSA.
- **Primary Roads –** These roads provide two-way access. Frequent traffic is expected.
- **Secondary Roads –** These roads provide two-way access to various facilities/areas within each site, where light vehicles will travel in both directions. They are expected to be used daily.
- **Tertiary Roads –** These roads are generally single lane width and are used in areas where traffic is infrequent / rare.

- **Temporary Roads –** These roads provide access for construction only and are not required for ongoing operation.

5.2.2 Special purpose roads, such as for module transport, may be required and will be determined on a case by case basis.

5.3 Design Vehicle

5.3.1 The following design vehicles shall be utilized for the design of the associated project roadways:

- CAT 793G Haul Truck for the Mine Haul Road
- Other types of design vehicles have been used for the remainder of the Project roadways and a fire truck has been considered as the minimum design vehicle for fire access routes.

5.4 Geometric Design Criteria

5.4.1 All roads shall be designed as gravel roads and shall accommodate the design vehicle specified in Section 5.3 of this document. The roads' geometric design parameters are specified below.

Table 5-1: Road Geometric Design Criteria

Road Type	Mine Haul Road	Primary Road	Secondary Road	Tertiary & Temporary Roads
Number of Lanes	2	2	2	1
Design Speed (km/h)	50	60	40	40
Posted Speed (km/h)	40	50	30	30
Total Road Width (m)	25	10	6	4
Minimum Horizontal Curve C/L Radius (m)	100	35	35	35
Minimum Intersection Inner Radius (m)	30	15	15	15

Road Type	Mine Haul Road	Primary Road	Secondary Road	Tertiary & Temporary Roads
Minimum Cross Slope (%)	3	2	2	2
Maximum Grade (%)	10	10	10	10
Minimum K Value (Vertical Sag Curve)	12	8	8	8
Minimum K Value (Vertical Crest Curve)	16	4	4	4
Maximum Super-elevation (%)	4	4	4	4
Minimum Vertical Clearance	9	7	5	5

Notes:

1. The road design parameters are based on the desirable design speeds. Specific parameters such as the minimum turn radii may be modified for some areas locally on a case-by-case basis, via adjustment of the design speeds.
2. The Haul Road width shall be based on the Nunavut Mine Health and Safety Act which requires a minimum travel width three times the width of the widest haulage vehicle for dual lane traffic and two times the width of the widest haulage vehicle for single lane traffic.
3. Shoulder barriers (safety berms or guardrails) for the Haul Road shall be based on the Nunavut Mine Health and Safety Act which requires shoulder barriers of at least ¾ the height of the largest tire of any vehicle using the road and shall be provided along the edge of the haul road wherever a drop-off greater than 3.0m exists. For CAT 777G, the shoulder barrier (safety berm or guardrail) height shall be 2.0 m based on standard tire 27.00 R49 (E4).
4. Total road width includes shoulder width and snow allowance but doesn't include the safety berm width for the haul road.
5. Widening shall be provided in roadway curves as necessary.
6. Need for geotextiles or geogrids shall be considered on a case-specific basis.
7. For the Tote Road design criteria, refer to H349000-3100-10-122-0001.
8. Provide safety stations, emergency ramps or escape lanes in accordance with the local and mine safety requirements. Hatch will only provide two escape ramps at the most critical locations as per BIM's instruction. Escape ramp design shall be carried out as per the USBM manual.
9. For cut/fill heights of greater than 5 m, provide 1.5 m wide benching with minimum 2% cross slope at every 5 m.
10. The ramp leading down to the sea lift from the laydown area at the Milne Port shall have a maximum grade of 8%.
11. The maximum grade for ramps to the buildings is 6%.
12. Fill toe key shall be provided in areas where the existing ground is steeper than 3H:1V away from the road.
13. Design speeds may be reduced locally if needed.

5.4.2 The following general rules shall apply to the geometric design of the project roads:

- Roadway grades shall not exceed the maximum grades specified in Table 5-1 except for short ramps which shall be considered on a case-specific basis
- Signage shall be provided for speed and caution at steep horizontal and/or vertical curves, and where the design criteria can't be met
- Traffic signs and shoulder barriers (safety berms or guardrails), shall be placed at the outer edges of the roads, as required.

5.5 Pavement Thickness

5.5.1 For the project internal site roads, the subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. Type 12 Run-of-Quarry and/or suitable earth fill material shall be used for subgrade where appropriate and approved by the Engineer. Otherwise type 8 (150mm minus) shall be used. The voids of each layer of Type 12 material shall be filled with rock fragments prior to placement of the next layer.

5.5.2 Pavement thickness for each road type shall comply with:

Road Type	Primary / Secondary Roads	Tertiary & Temporary Roads
Minimum sub-grade (Type 12 / Type 8)	-	300 mm
Sub-base (Type 8)	300 mm	-
Base / surface (Type 5)	100 mm	100 mm

5.5.3 Pavement details for mine haul road to be confirmed.

5.5.4 Sub-grade fill shall be placed as required to achieve specified sub-grade elevations with minimum thickness as specified and:

- For sub-grade fill depth >600mm Type 12 shall be used. Where no Sub-base is placed over the Type 12 the top of Type 12 material shall be chinked with smaller rock fragments and compacted to minimize infiltration of Base / surface Type 5 material
- For sub-grade fill depth <600mm Type 8 material shall be used.

5.5.5 Pavement thickness for special purpose roads shall be determined on a case by case basis.

5.5.6 Refer to Appendix A for typical layer works.

5.5.7 Design Vehicles, Traffic Volume and Load

5.5.7.1 Vehicle types have been selected for the project roads based on the expected usage and transportation requirements of the area (Section 5.3).

5.5.7.2 All pavement, slabs, bridges, trenches, trench covers and underground installations accessible to trucks shall be designed to withstand the load associated with an HS 20-44 wheel load or its equivalent, as defined by the American Association of State Highway and Transportation Officials (AASHTO) under Standard Specification for highway bridges. However, within areas of special equipment operation, this shall be considered as per the actual vehicle loading.

5.6 Parking

5.6.1 Parking areas shall be designed to accommodate their intended use. In general, all parking areas shall be surfaced with granular materials.

5.6.2 Vehicle parking area design shall adhere to the following:

- The area shall be graded to direct stormwater away from the parking
- Alignment and gradients shall be coordinated with the grading plans to control drainage
- Walking distance from parking areas shall be kept to a minimum
- Barrier-free parking spaces as well as walkways shall be provided according to the applicable regulations
- Designated turnaround areas shall be provided at dead ends

- Parking lot design criteria shall be as shown in Table 5-2.

Table 5-2: Parking Lot Design Criteria

Topic	Criteria
Gradient	Maximum 5% Minimum 0.5% Optimum 2%
Cross Slope	Maximum 5% Minimum 2% Optimum 3%
Pavement Structure	300 mm Type 8 (150 mm minus) subbase 100 mm Type 5 (32 mm minus) base/wearing surface course
Parking Stall Dimensions	Driving Lane • Width 7.5 m Standard • Depth 6 m • Width 2.75 m Barrier-free • Depth 6 m • Width 3.5 m • Access Aisle Width 1.5 m

5.7 Signage

5.7.1 Traffic control signs and road edge markers shall be provided as required to ensure safe movement in and about the site.

5.7.2 Direction and information signs for both vehicle and pedestrian traffic shall be provided for parking areas, restricted areas, shipping and receiving.

5.7.3 Primary identification signs shall be free-standing and sited according to the applicable standards as listed in Section 3.3.

5.7.4 Other signs shall be free-standing, fence-mounted or wall-mounted.

5.7.5 Security signs shall be provided at the sites and along the site property boundaries.

5.7.6 Signs for the site access roads shall be compliant with the local traffic regulations.

5.7.7 Signs shall be lighted, if deemed necessary.

5.7.8 All signs and pavement markings (if applicable) shall be well maintained during the construction and operational periods.

5.8 Bollards

5.8.1 Concrete blocks and /or tires shall be provided where required to protect buildings and hazardous areas.

5.8.2 Where available, tires must be used. If tires are not available, concrete blocks must be placed be placed based on the engineer's recommendations.

5.9 Shoulder Barriers (Safety Berms/Guardrails)

5.9.1 Shoulder barriers (earth safety berms or guardrails) shall be provided in accordance with the Nunavut Mines Health and Safety Act.

5.9.2 Barriers shall be provided where a 3.0 m or more drop-off exists at the edge of vehicular areas including roads, pads, lay down areas and similar.

5.9.3 Height of barrier shall be minimum 0.75 times the maximum wheel diameter of traffic expected to operate in the area, including:

- For areas where heavy mining equipment travels barrier height shall be minimum 2.7m high (based on CAT793 tire, 40.00R57)
- For general vehicular areas barrier height shall be minimum 1.0m high (based on typical transport, vac and tanker trucks used on site).

5.9.4 Safety berms side slopes shall be 1H:1V.

5.9.5 Discontinuous openings shall be provided in berms at maximum 25 m spacing for drainage and snow clearance, with openings smaller than half the blade width of vehicles constructing or maintaining the berms.

5.9.6 Runaway vehicle collision berms or escape lanes shall be provided in accordance with industry requirements as described in the Nunavut MHSA.

5.10 Utility Berms

5.10.1 Utility Berms may travel along the project roadways to the greatest extent possible, shall be of trapezoidal cross-sections. Berms with power cables shall be minimum 0.6 m high from the road edge or the existing ground, and shall have maximum fill side slopes of 1.5H:1V, as validated by the geotechnical engineer. They shall be constructed with the use of 300 mm of granular Type 8 (150 mm minus) and 50 mm of granular Type 5 (32 mm minus) material. Berms for pipes may be level with adjacent roads or pipe may be placed directly on existing grade without berm construction where risk of damage is low.

The top width of utility berms will depend on the pipe and cable duct sizes. Utility berms shall cross roadway intersections through utility sleeves. After crossing the intersections, they shall resume the alignments within the utility berms.

6. Stormwater Management System

6.1 Allowance for Snow Melt Runoff Volume

A specialist study will be undertaken and all recommendations from the study will be taken into account for the design of stormwater infrastructure. 2

6.2 Internal Surface Drainage

6.2.1 Internal surface drainage areas are defined as areas where the catchment consists out of areas where the natural surface has been disturbed through excavation, mining activity or bulk earthworks such as the construction of pads and roads. The general criteria for the site internal storm water management systems are described below. 1

- All interior site grading and roads shall be designed to provide continuous overland flow without erosion to a drainage ditch system
- All drainage ditches should be of trapezoidal cross sections, where possible
- Ditches shall be designed to convey a 1 in 25 year flood event. 2
- Provision must be made to ensure that there is a safe flow path for events up to the 1 in 100 year event, such that the runoff will not flood key mining areas, cause significant erosion, pick up excessive contaminants or cause other significant problems 2
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 6-2
- For supercritical flow conditions, the ditches shall be designed to maintain the energy line within the ditch. 2

  Minimum set back distance of structures from top of drainage ditch slopes shall be 3 m
- Roof and yard drainage shall be collected in open ditches
- Appropriately sized rip rap shall be provided at locations throughout the stormwater drainage system which are susceptible to erosion, including ditch sections subject to high-velocities (greater than 1.5 m/s), sections of super critical flow, ditch outlets, storm sewers outfalls, and culverts inlets and outlets
- If the ditch is in rock, no rip rap is required
- Energy dissipaters shall be used where the flow velocities may reach values high enough to cause severe erosion or hydraulic jumps.

6.3 External Surface Drainage

External surface drainage areas are defined as areas where the catchment consists of undisturbed areas where the environment is mostly in its natural state. Criteria for drainage of the external areas are as follows:

- Runoff from undisturbed areas surrounding the mine site shall be collected in perimeter ditches and diverted around and/or through the site perimeter
- To the extent possible, these perimeter ditches shall be designed to discharge at locations that best retain the characteristics of the existing (i.e., pre-development) natural drainage patterns
- Diversion ditches shall be designed to convey the 1 in 100 year flood event.
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 6-2.
- For supercritical flow conditions, the ditches shall be designed to maintain the energy line within the ditch.
- Where diversion around and/or through the site perimeter is not achievable due to the natural topography and infrastructure, clean water ponds shall be created. These ponds will be designed as follows:
    - Ponds will be sized to contain the runoff from the 1:10 year, 24 hour storm event. Any additional inflow, including flow resulting from snowmelt, will be accommodated in the emergency overflow weir and spillway which will drain to the natural environment.
    - The pond walls shall be lined with an appropriate impermeable geomembrane
    - Ponds <u>must</u> be operated as empty and stormwater pumped out at regular intervals.
    - Ponds shall contain emergency overflow weirs of sufficient capacity to safely convey a 1 in 200 year return period storm event or the Probable Maximum

Flood (PMF), maximum wind-induced waves, or unexpected operational difficulties.

- Berm/embankment side slopes for the ponds shall be 3H:1V.
- Ponds with storage volumes greater than 30,000 m^3 and heights exceeding 2.5 m shall be classified as dams and shall meet the dam safety requirements as per the Canadian Dam Association's Dam Safety Guidelines (CDA 2007). 2

6.4 Peak Flow Estimation

The following estimation for sizing of stormwater conduit infrastructure shall be calculated as follows: 2

6.4.1 For Catchment Areas Greater than 0.5 km² 2

Runoff peak flow estimation shall be based on the following equations developed by Knight Piésold Consulting from the *Baseline Hydrology Report, January 4. North Bay, Ontario. Ref. No. NB102-181/30-7, Rev 1* and updated in *VA16-01950 on 13 December 2016*:

$Q_2 = 0.72\ A^{0.86}$

$Q_5 = 1.10\ A^{0.84}$

$Q_{10} = 1.32\ A^{0.83}$

$Q_{25} = 1.70\ A^{0.82}$

$Q_{100} = 2.27\ A^{0.80}$

$Q_{200} = 2.53\ A^{0.80}$

Where:

Q=peak flow instantaneous flow in m^3/s

A = drainage area in km^2 ($0.5\ km^2 \leq A \leq 1000\ km^2$)

The equation above account for any snow melt since the equations were developed from measured streamflow data which contains runoff due to snow melt.

6.4.2 For Catchment Areas less than 0.5 km²

Peak flow for catchment areas that are less than 0.5 km^2 shall be calculated as the sum of the baseflow (from snow melt) and Rainfall stormwater runoff.

6.4.2.1 *Baseflow:*

Baseflow as a result of snow melt shall be calculated as per the specialist recommendations.

6.4.2.2 *Rainfall Stormwater Runoff:*

The Rational Method shall be used for peak flow estimation, as follows:

$Q = 0.28\ CIA + Q_{Base}$

Where:

Q = peak instantaneous flow in m^3/s

A = drainage area in km^2

C = runoff coefficient = 0.90

I = rainfall intensity corresponding to the time of concentration (mm/hr), estimated using Table 6-1 below.

- Time of Concentration shall be computed with the modified Kirpich equation: 2

$T_c = 0.06628\ (L^{0.77}/S^{0.385})$

Where:

T_c = time of concentration (hours)

L = main channel length (km)

S = main channel slope (m/m)

Minimum T_c = 10 min

6.5 Rainfall Intensity

6.5.1 Table 6-1 displays the Intensity-Duration-Frequency data which shall be used for peak flow runoff approximation as per *NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012*:

Table 6-1: Rainfall Intensity (mm/h)

Duration	2 yrs	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	50 yrs	100 yrs	200 yrs
5 min	9.5	12.0	14.0	15.1	15.9	16.5	18.3	20.1	22.0
10 min	7.2	9.0	10.5	11.3	11.9	12.4	13.7	15.1	16.5
15 min	6.0	7.5	8.7	9.4	9.9	10.3	11.4	12.6	13.7
30 min	5.0	6.3	7.3	7.9	8.3	8.6	9.5	10.5	11.4
1 hr	4.0	5.2	6.1	6.6	7.0	7.3	8.1	9.0	9.9
2 hr	3.0	3.9	4.6	5.0	5.2	5.5	6.1	6.8	7.4
6 hr	2.0	2.7	3.3	3.6	3.9	4.0	4.6	5.1	5.7
12 hr	1.3	1.8	2.2	2.4	2.6	2.7	3.1	3.4	3.8
24 hr	1.0	1.4	1.7	1.9	2.0	2.1	2.4	2.7	3.0

6.5.2 Figure 6-1 displays the 200 year design storm distribution:

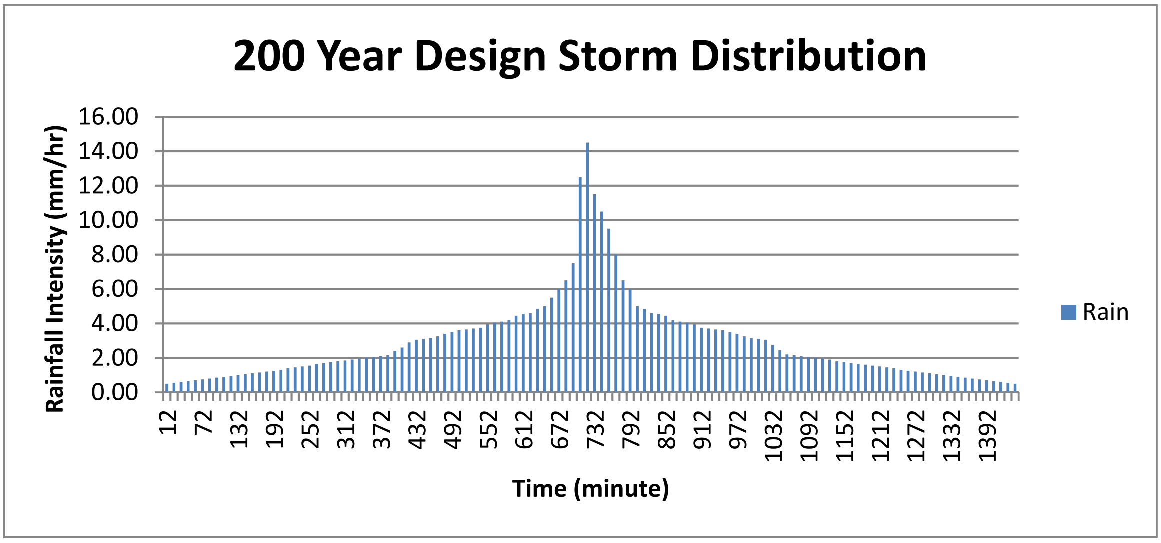


Figure 6-1: 200 Year Storm Distribution

6.5.3 The 200 year 24-hour balanced storm depth is 71 mm.

6.6 Sedimentation Ponds

6.6.1 Sedimentation ponds shall be provided at Milne Port at the following areas: 2

- Crusher Feed Stockpile
- Fines Stockpile
- Stockpile No. 2

6.6.2 A sedimentation pond shall be provided for the Crusher Pad at the Mine Site. 2

6.6.3 Milne Port Stockpile No. 1 shall drain toward the existing sedimentation ponds. These ponds shall be analyzed to determine their capacity and if deemed required be increased in sized based on the design philosophy described in this document. (See Section 6.6). 2

6.6.4 All areas other than the ones mentioned in 6.6.1 and 6.6.2 shall be considered as clean runoff areas and no sedimentation ponds shall be provided. 2

6.6.5 The general design criteria for the project sedimentation ponds are as follows: 2

- Ponds shall be sized based on 1 in 10 year, 24 hour design storm volumes as well as the volume from snow melt that can be expected as per the specialist recommendations. 2
- Runoff coefficient to estimate runoff shall be 0.9. 2
- Sedimentation shall be for Total Suspended Solids (TSS) ≤ 30 mg/l for a single sample and TSS ≤ 15 mg/l for the monthly average. 2
- Ponds shall be operated as empty to ensure enough capacity is available to accommodate the design volumes. Failure to empty the ponds will result in overflow occurring and the prescribed TSS will not be achieved. 2
- Sedimentation ponds shall contain emergency overflow weirs of sufficient capacity to safely convey a 1 in 200 year return period storm event or the Probable 2

Maximum Flood (PMF), maximum wind-induced waves, or unexpected operational difficulties.

- Emergency overflow weirs shall be designed to handle applicable design storms, such that the pond high water level does not increase past the set freeboard elevation. 2
- Emergency overflow weirs shall be designed as broad-crested weirs with rip rap. 2
- Gabion mattresses shall be provided at the downstream locations of emergency overflow weirs as energy dissipation measures to protect against erosion. 2
- The following broad-crested weir capacity flow equation shall be used for sizing the Project emergency overflow weirs: 2

  $Q = CLH^{3/2}$ Where:

  Q = Peak instantaneous flow (m^3/s)

  C = Weir discharge coefficient

  L = Width of weir (m)

  H = Depth of flow (m), measured 2.5H upstream of the weir discharge point
- Deep sedimentation ponds shall be avoided as much as possible. Sedimentation pond depths shall be kept to less than 5 m, to avoid non-compliant TSS removal/efficiency and other safety concerns. 2
- Berm/embankment side slopes for the ponds shall be 3H:1V. 2
- All sedimentation ponds shall be lined with appropriate impermeable geomembrane material. 2 2
- Ponds with storage volumes greater than 30,000 m3 and heights exceeding 2.5 m shall be classified as dams and shall meet the dam safety requirements as per the Canadian Dam Association's Dam Safety Guidelines (CDA 2007).

6.7 Stockpile Footprint 2

The following sections will cover runoff that can be expected from the Stockpile No. 1 and No. 2 areas.

6.7.1 *Stockpile No.1 Runoff*

2

Runoff from Stockpile No.1 would drain towards the existing sedimentation pond to the North West of the stockpile. The existing pond size will be determined from survey information and evaluated to determine if it meets the required design criteria as stated in Section 6.6.

6.7.2 *Stockpile No.2 Runoff*

The entire stockpile area would be surrounded by adequately sized, impermeable geomembrane lined berms to prevent any water from discharging into the natural environment from the stockpiles. Low point sumps will be created inside the stockpile area when reclaiming from where the water can be pumped. Testing on the TSS of the water should be done before pumping to ensure meeting the criteria stated in Section 6.6.5. 2

Runoff from the stacker reclaimer berm shall be conveyed to the enpoints of the berm in open channels through hydraulic head since the berm is required to be level. The water shall discharge at the endpoints and remain within the periphiral lined berm to be pumped out when neccesary. The channels shall be lined to prevent any ingress of water into the Stacker Reclaimer berm. The channels will be designed to facilitate adequate maintenance. Channels will require regular cleaning since the velocity in the channels will be too low to allow for self cleansing. 2

6.8 Culverts, Roadside Ditches and Berms

6.8.1 Drainage ditches and culverts shall be designed for return periods as prescribed in Section 6.2 and Section 6.3 with peak flows calculated as per Section 6.4. such that the inlet headwater level does not exceed the bottom of the road subbase. Their analysis and design shall consider design flow, culvert size and material, entrance structure layout, outlet structure layout and erosion protection.

6.8.2 Drainage ditch design shall also be subject to the criteria stated in Table 6-2.

Table 6-2: Drainage Ditch and Culvert Design Criteria

Maximum permissible flow velocity in ditch without rip rap (m/s)		1.5
Minimum ditch and culvert slope (%)		0.2
Ditch side slopes (H: V)	Rock	1:4
	Soil	2:1
Minimum culvert diameter (mm)		600
Berm Side Slopes (H:V)		2:1
Berm Top Width (mm)		500
Ditch and Berm Freeboard Requirement of Sub-Critical Flow (mm)		300

6.8.3 Loading over culverts and pipes shall be in accordance with AASHTO HS 20-44, except for areas of special equipment operation, which shall consider actual vehicle loading. The minimum cover for culverts shall be 600 mm, or as required by the differing specific design vehicle.

6.8.4 Fish-bearing culverts shall be minimum 1,000 mm diameter and only one pipe shall be embedded by 10% of the pipe diameter.

6.8.5 All culverts shall be Corrugated Steel Pipe (CSP).

6.8.6 Apply Manning's n values as per the following:

- n = 0.025 for gravel ditches
- n = 0.040 for rip rap ditches
- n = 0.024 for all CSP pipe. 0

6.9 Drainage Interceptor/Collector Berms

6.9.1 Drainage berms diverting overland flow from the waste rock drainage area to the sedimentation ponds shall detail as per table 6.1 above and 0.5 m top width.

6.9.2 Rip rap and other energy dissipation measures shall be provided to protect against erosion.

Appendix A

Item	Sub-Grade	Sub-Base	Base / Surface	Comments
Rail Embankment	Type 12	Type 22 (-50)	Ballast	Refer to rail design for additional details
	>550 mm	150 mm	*per rail detail*	
Construction Laydown Pad	Type 12*	-	Type 5 (-32)	
	>300 mm	-	100 mm	
General Operations Areas and Pads for Equipment / Structures (unheated)	Type 12*	Type 8 (-150)	Type 5 (-32)	Pads constructed directly on excavated rock do not require sub-base fill
	-	300 mm	100 mm	
Slab-on-Grade Building on Permafrost	Type 12*	Type 8 (-150)	Type 5 (-32)	Styrofoam insulation installalled in the Base fill (400mm below finished

	-	300 mm	500 mm	grade), total thickness with insulation 650mm.
Stacker/Reclaimer Berm	Type 8 (-150)	Type 22 (-50)	Ballast	To be confirmed by Geotechnical based on updated borehole data and final design for S/R equipment
	>1.85m	150 mm	*per S/R rail detail*	
Ore Stockpile Pads (where developed pad required)	Type 12*	-	Iron Ore **	Primary crusher feed area, rail loading stockpile area, fines intermediate pile, and fines stockpile area (existing SL pile)
	-	-	200 mm	
Road - Primary / Secondary	Type 12*	Type 8 (-150)	Type 5 (-32)	
	-	300 mm	100 mm	
Road - Tertiary / Temporary	Type 12*	-	Type 5 (-32)	
	>300 mm	-	100 mm	

HME Operating Roads / Areas	Type 12*	-	-	Sub-base and surface requirements for Mine Haul Road / HME operating areas to be confirmed
	-	-	-	
Heavy Module Transport Road	Type 12	Type 8 (-150)	Type 5 (-32)	Design and requirements to be confirmed based on final module transport equipment and loads
	>600 mm	300 mm	100 mm	

Notes:

1. Sub-Grad fill depth as required to achieve final grad. Use Type 8 instead of Type 12 for depth <600mm.
2. Iron ore used to surface stockpile pads may be on-spec or off-spec as supplied by BIM operations.
3. Material Types:
    a. Type 12 – ROQ nominally, <600mm (maximum permitted 1000mm)
    b. Type 8 – Jaw crushed or similar, <150mm
    c. Typed 5 – Crushed Aggregate, <32mm
    d. Type 22 – Rail sub-ballast, <50mm

Attachment 3

Milne Port Water Management Plan

Water Management Plan

2018-02-16	0	Approved for Use	for F Hugo	for A Grobbelaar	D Stanger	T Atiba
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
HATCH						**Client**

Table of Contents

1. Introduction

This document describes the various earthwork and infrastructure features that are planned to be built in 2018 and the impact these will have on surface drainage. This document covers the design of all surface water infrastructure required to satisfy the latest Civil Design Philosophy for the Milne Port.

This stormwater management plan includes areas where new infrastructure and drainage will be constructed as described in the 2018 workplan.

2. References

2.1 General

2.1.1 All applicable federal, territorial (Nunavut) and local laws and regulations.

- OHSA Occupational Health and Safety Act
- CSA Canadian Standards Association
- MHSA Mine Health and Safety Act (Nunavut – S.N.W.T. 1994)
- OHSR Occupational Health and Safety Regulations
- NBCC National Building Code of Canada (2010)
- ASTM American Society for Testing and Materials
- ASCE American Society of Civil Engineers
- NFPA National Fire Protection Association
- NRC Natural Resources Canada – Explosives Safety and Security Branch

2.2 Reference Documents

Reference will be made to or contents have been used as general guidance from the following documents, articulated during the previous phases of the project.

- H353004-00000-200-210-0001: Civil Design Philosophy (Rev 2)
- H337697-0000-10-122-0001: Stormwater Management and Drainage System Design
- H337697-6170-10-122-0001: Milne Port Drainage System and Stormwater Management Ponds
- H337697-6170-10-122-0002: Mine Site Drainage System, Stormwater and Sediment Management
- Standard Specification S311213: Quarried Fill Materials
- Standard Specification S003120: Site Conditions
- NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012
- Updated Design Peak Flow Assessment. Knight Piesold, 2016
- Final Environmental Impact Statement (FEIS), Mary River Project, February 2012

- H353004-00000-228-066-0001: Mary River – Snowmelt and Rainfall Frequency Analysis.

3. Stormwater Management and Drainage Systems

Stormwater management and drainage systems have been applied in various locations across the site to ensure that surface water runoff will have limited interference with the proposed construction activities.

Care was taken to ensure that where possible, the existing watersheds and streams remained in their original state.

This was done through the use of berms, ditches, swales and culverts.

The overall layout can be seen in Appendix A.

3.1 Eastern Diversions

On the eastern side of the lease area in the vicinity of the existing quarry surface water runoff will be diverted to the North (P-SWD-6) and the South (P-SWD-5) by two drainage ditches/berms. The reason for this is to redirect surface water flows away from project infrastructure. Refer to Figure 3-1. The sizing of the infrastructure is presented in Section 4.1.

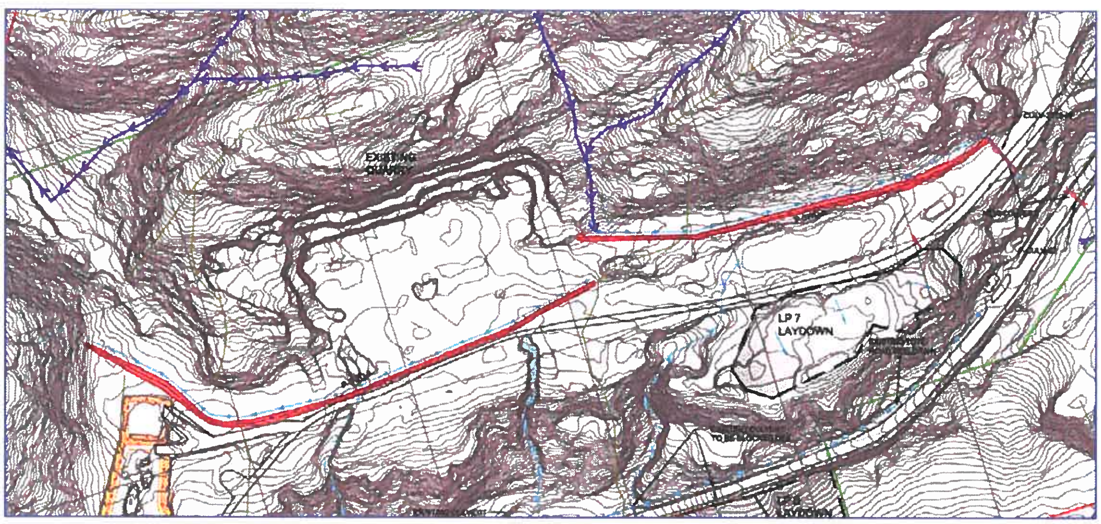


Figure 3-1: Eastern Diversion

P-SWD-6 also contains a culvert crossing (Culv-2018-H) that will have to be constructed through an existing road. The design of this culvert is discussed in Section 4.1.

3.2 Laydown Areas

3.2.1 LP2 Laydown

Laydown LP2 will be constructed South of the existing port infrastructure. This area will be used for laydown as well as serve as the location for relocated buildings as per Figure 3-2.

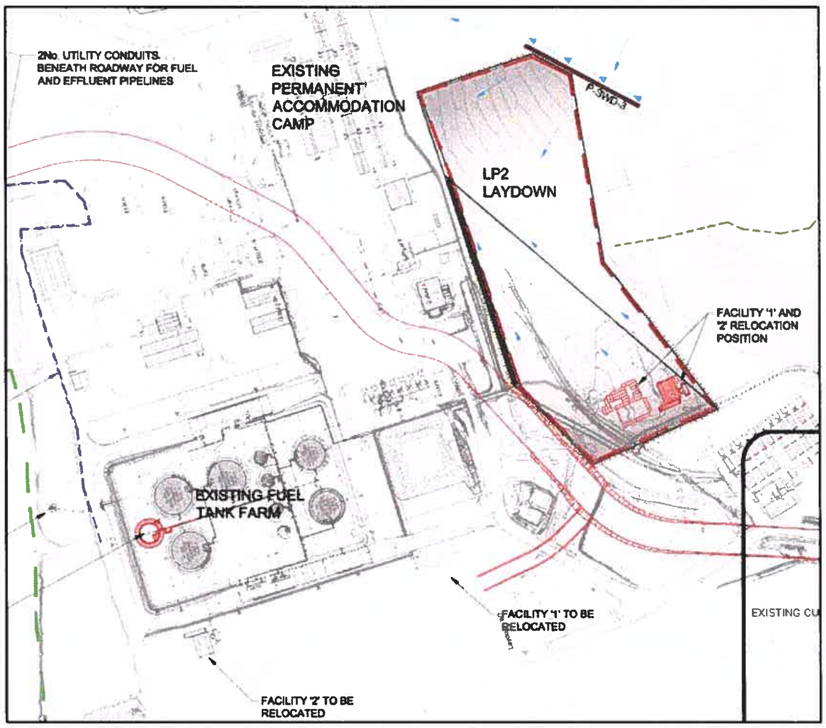


Figure 3-2: Facility Relocation

Figure 3-3 shows the proposed LP2 laydown area in more detail.

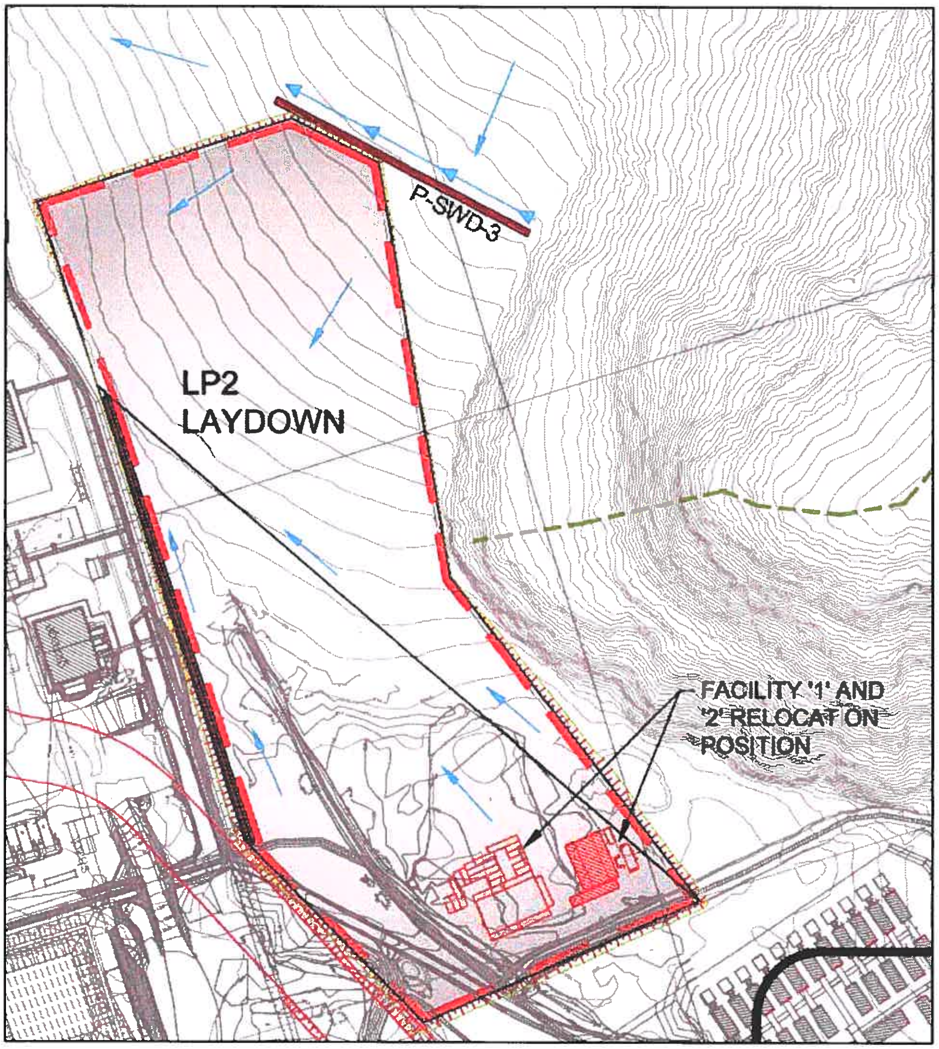


Figure 3-3: Laydown LP2

The laydown will be constructed with a swale sloping towards the Northeast where it will discharge any precipitation falling onto the laydown into the existing drainage ditch. The discharge location was determined to be the highest point in the existing drainage ditch so that water will flow to the East. A berm will be constructed on top of the laydown to ensure no water runs off the laydown area before this point. This ditch links up with the natural drainage path that will convey the water to the North.

A stormwater diversion berm will be constructed upstream of the laydown area to ensure water is adequately diverted away. This berm will be referred to as P-SWD-3. The sizing of this berm is discussed in Section 4.2.1.

3.2.2 LP3 Laydown

Laydown LP3 will be designed to allow water to drain primarily towards the Western edge. It will allow for surface water from the east to run onto the laydown area and will then be conveyed to the West through swales and culverts where it crosses the delivery road. Figure 3-4 shows the drainage plan for the area.

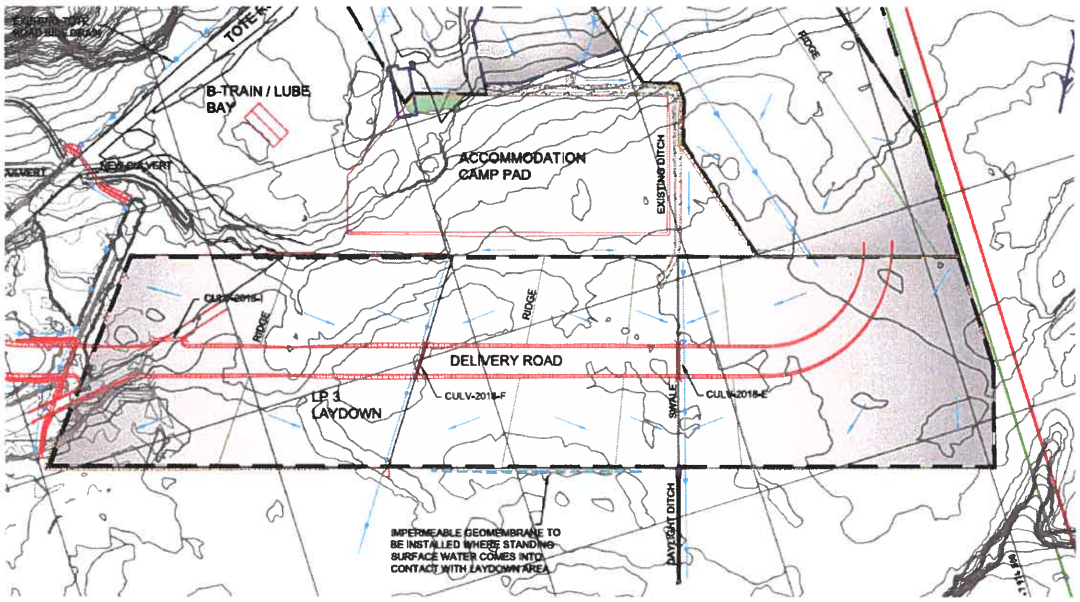


Figure 3-4: Laydown LP3 Drainage

There is an existing pad to the East of the proposed laydown area with a diversion ditch around it. The current outlet point for the ditch is within the proposed area of LP3. The level of LP3 will be lowered to connect to the ditch invert level. Water will then discharge onto LP3 and flow in a swale, through a culvert (Culv-2018-E) crossing the delivery road and into a daylight channel on the other side.

Two more culverts will be placed on the final grade of the laydown area. These are:

- Culv-2018-H will cross the delivery road running from East to West
- Culv-2018-I will cross the eastern ramp connecting the existing haul road with the delivery road and the will discharge to the North.

The calculations for the above will be discussed in Section 4.3.

An impermeable geomembrane liner will be installed on the side of the laydown area where there is a possibility of standing water ponding against the earthworks.

3.2.3 W10A Laydown

Precipitation that falls onto laydown W10A will be directed to the West by designing the levels on the laydown to ensure adequate slope and flow will be achieved. No swales will be constructed for the laydown area and all the runoff will be considered as sheet flow. W10A is shown in Figure 3-5.

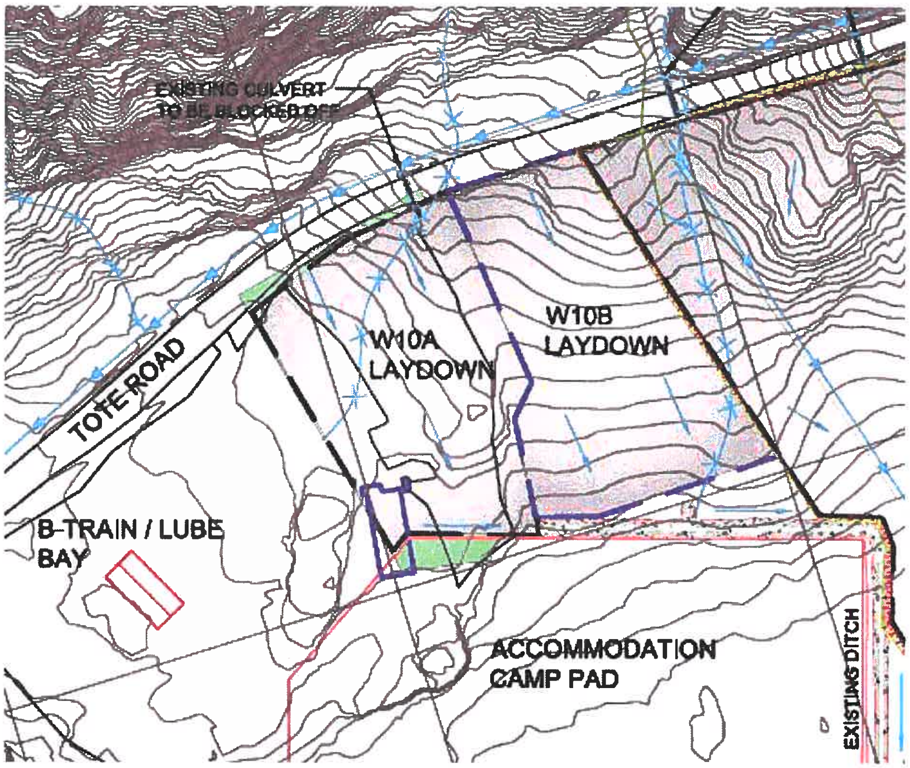


Figure 3-5: Laydown W10A

Runoff from the upstream area will not be allowed to reach Laydown W10A since the culverts on the Tote Road will be blocked off. The blocked culverts will ensure water is diverted to the North in an existing ditch on the east side of the Tote Road. The details of the Tote Road drainage is discussed in Section 3.3.

3.2.4 W10B Laydown

Laydown W10B will be handled in a similar way as Laydown W10A. Runoff will be dealt with as sheet flow by designing the levels of the laydown area to ensure adequate slope and drainage are provided. This laydown will drain into the existing ditch on the Western side. Laydown W10B can be seen in Figure 3-6.

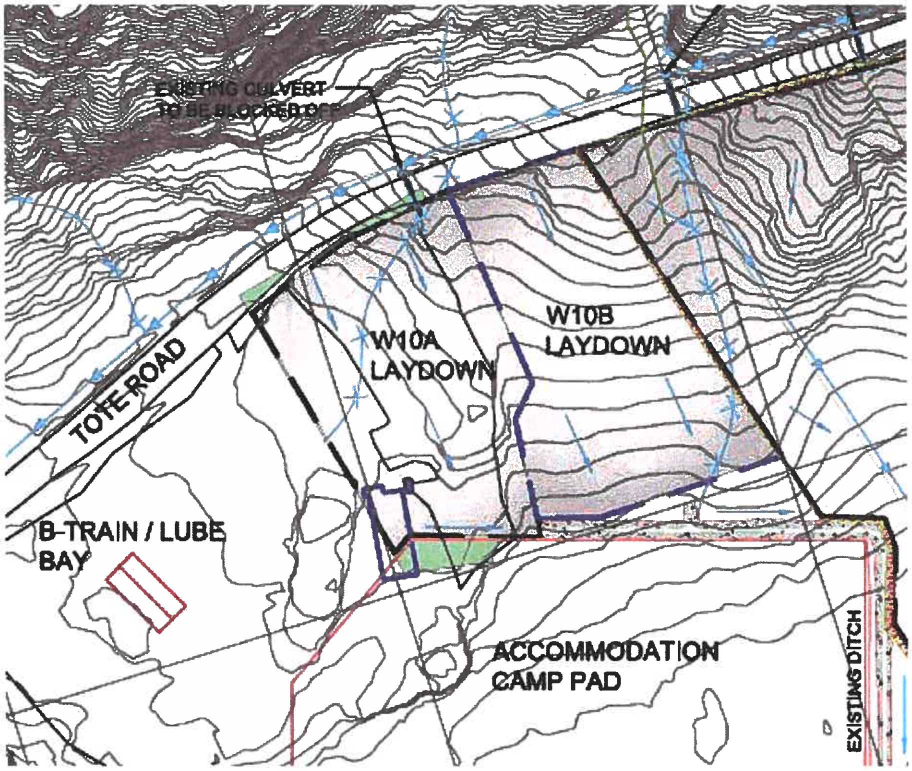


Figure 3-6: Laydown W10B

Runoff from the upstream area will not be allowed to reach Laydown W10B since the culverts on the Tote Road will be blocked off to ensure water is diverted to the North where it will tie into the existing drainage ditch on the eastern side of the Tote Road. The details of the Tote Road drainage is discussed in Section 3.3.

3.2.5 LP5 Laydown

Laydown LP5 will drain towards the Southwest through a combination of swales and sheet flow as per Figure 3-7.

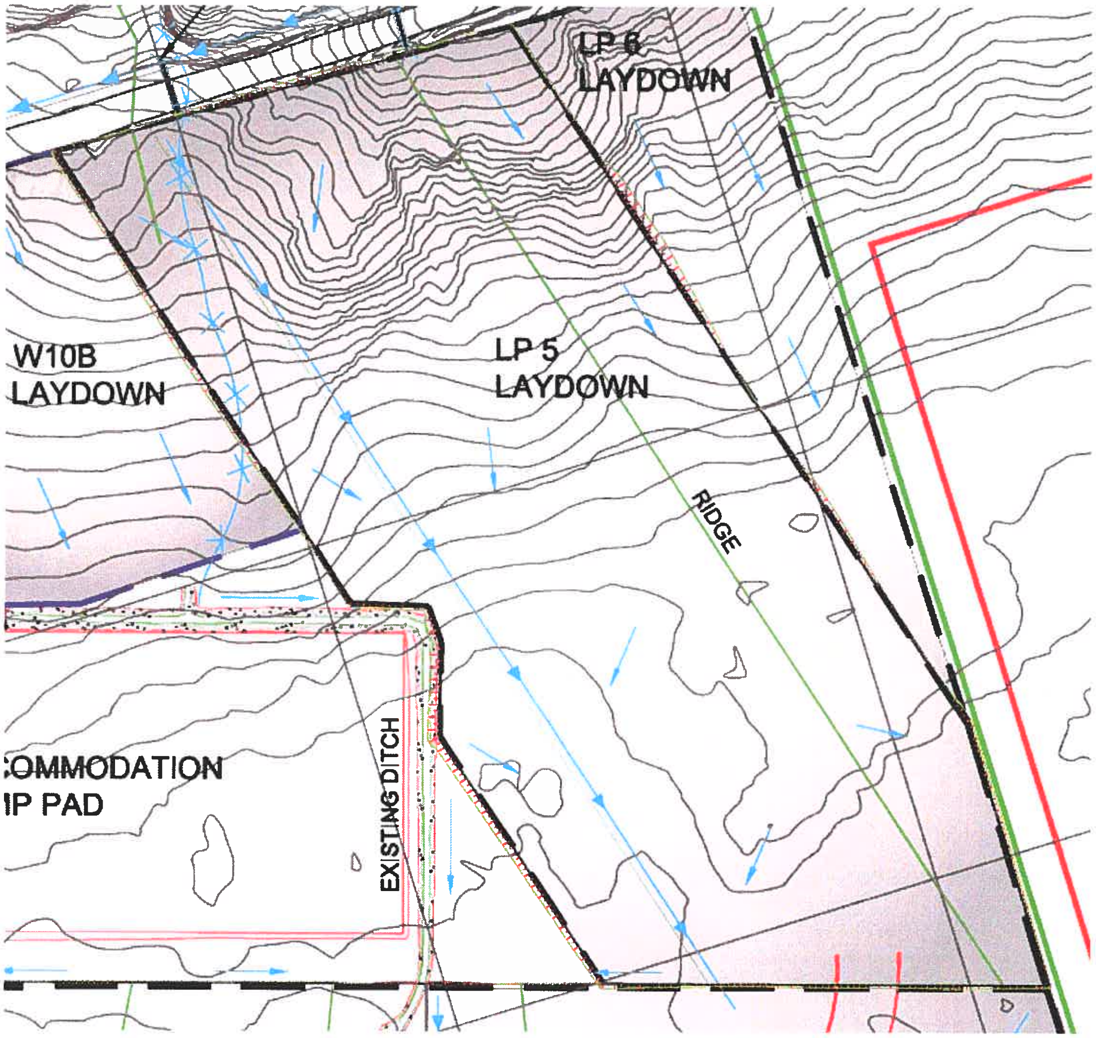


Figure 3-7: Laydown LP5

As per W10A and W10B, runoff from the east onto this Laydown LP5 will not be allowed since the Tote road ditch will divert runoff to the North. See Section 3.3.

3.2.6 *LP6 Laydown*

This laydown area will drain towards the West as sheet flow that will be achieved by designing the levels to ensure adequate slope. The LP6 laydown area will discharge into the natural environment as can be seen in Figure 3-8.

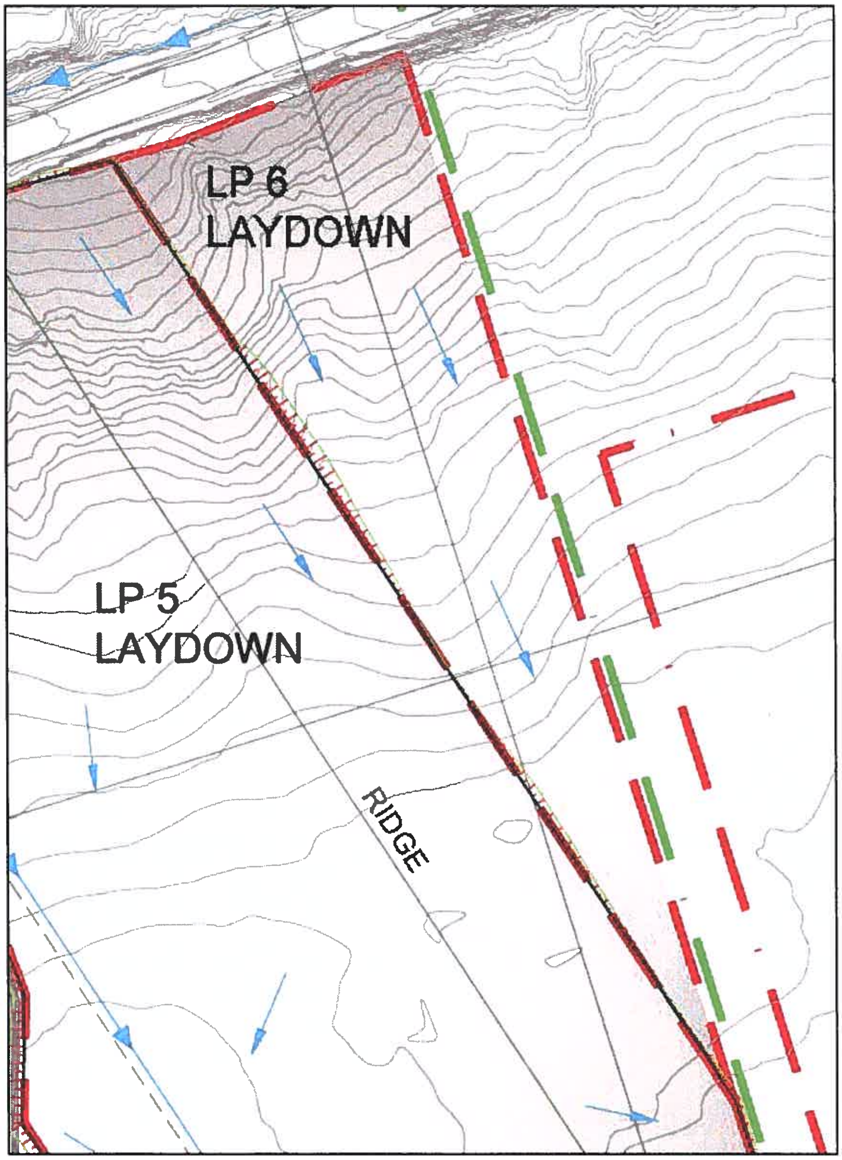


Figure 3-8: Laydown LP6

Water on the East of laydown LP6 will be diverted to the North by the Tote Road as will be discussed in Section 3.3.

3.2.7 *LP7 Laydown*

Laydown LP7 will be constructed further East than the other laydown areas and can be seen in Figure 3-9.

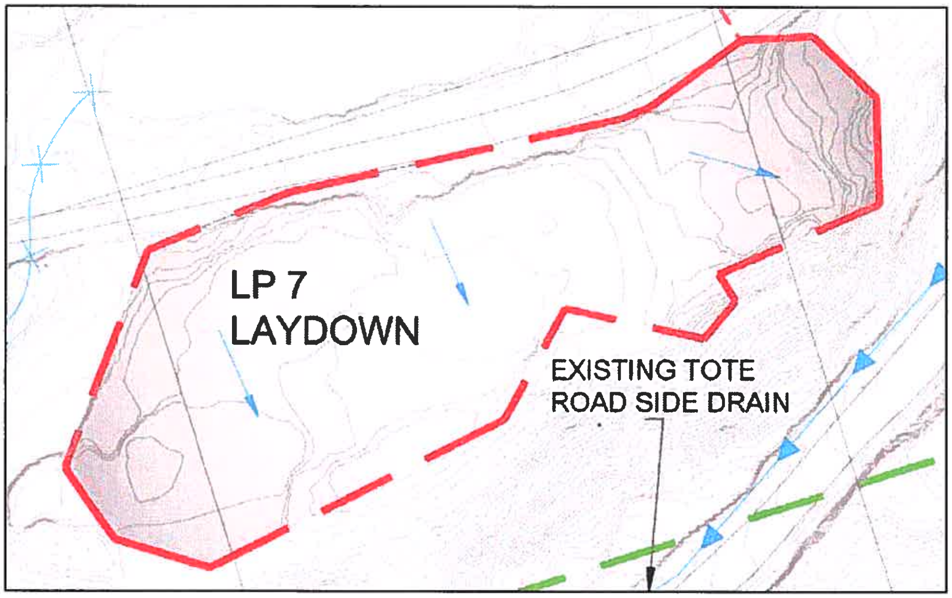


Figure 3-9: Laydown LP7

From Figure 3-9 it can be seen that this laydown area will be drained as sheet flow to the West where it will be picked up further downstream by the Tote Road drainage and then diverted to the North.

3.3 Tote Road

The existing Tote Road is currently used to deliver iron ore from the mine to the stockpiles at the port. For 2018 , three existing culverts will be temporarily blocked off to ensure that no runoff interferes with the proposed laydown areas W10A, W10B, LP5 and LP6 as Figure 3-10.

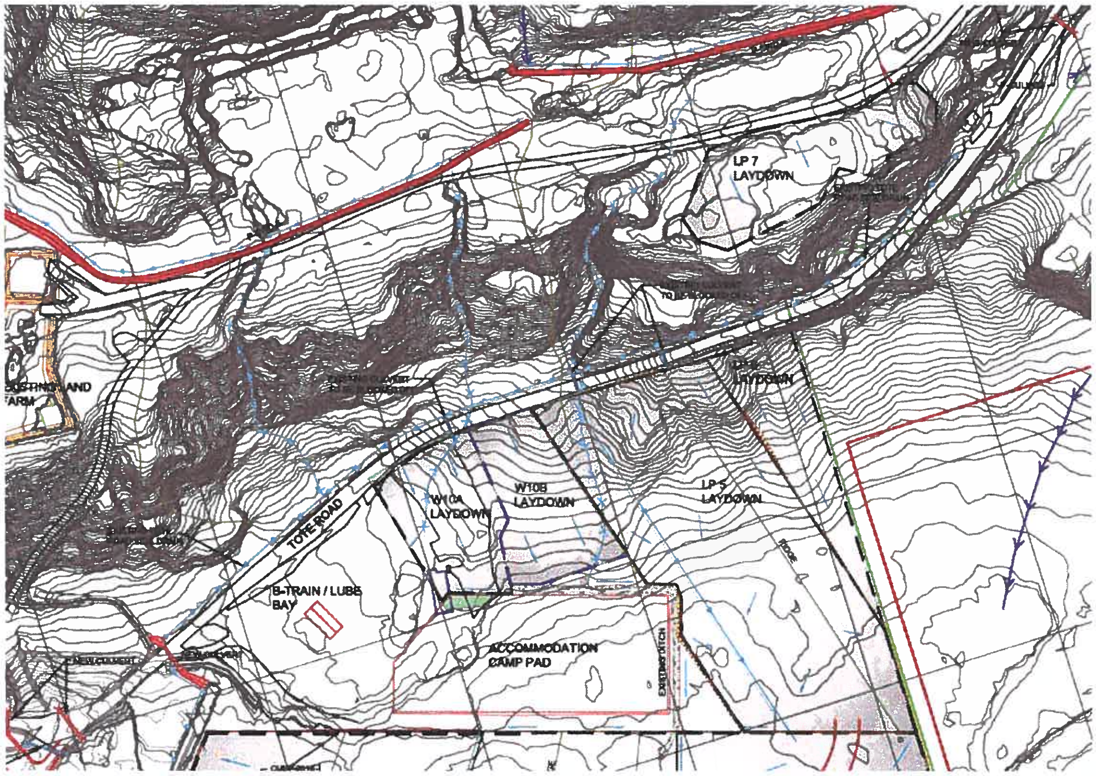


Figure 3-10: Tote Road

The water will be diverted to the North along the existing roadside ditch towards a new culvert (P-Culv-22) that can also be seen in Figure 3-10. This culvert will discharge water to the West. The sizing of the culvert and analysis of the existing ditch is discussed in Section 4.4. The infrastructure downstream of this culvert is discussed in Section 3.4.

A new culvert (P-Culv-32) will be added to cater for flow that comes from P-SWD-6. This culvert will take the water through the Tote Road to the West where it will join the natural water course.

3.4 Delivery Road

This section discusses all the drainage North of laydown LP3 that will come into contact with the proposed delivery road.

Figure 3-11 shows the drainage for the area. It consists of existing ditches, new ditches, existing culverts and proposed culverts.

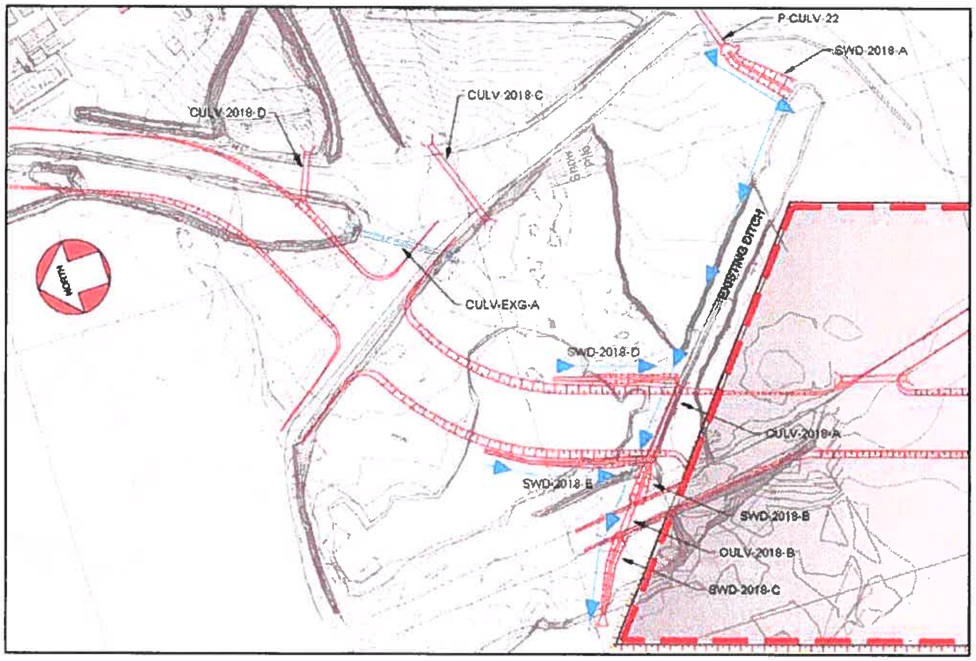


Figure 3-11: Delivery Road

As per Figure 3-11 it can be seen that water will cross the Tote road though the culvert as described in Section 3.3. From the culvert it will enter SWD-2018-A which discharges into the existing ditch. From the existing ditch, water will cross the delivery road through Culv-2018-A that will discharge into SWD-2018-B. The water will then cross the existing haul road through Culv-2018-B and into SWD-2018-C from where it will daylight.

The delivery road crosses a low lying area which will be drained by ditches SWD-2018-D and SWD-2018-E which will, in turn, connect with the existing ditch and SWD-2018-B respectively.

The following culverts will either have to be designed as new culverts or analysed as existing culverts to ensure that they have enough capacity:

- Culv-2018-C - New Culvert Crossing Existing Tote Road and Haul Road
- Culv-Exg-A - Existing 500mm CSP culvert to be analysed
- Culv-2018-D - New Culvert through existing road.

The design and analyses of the culverts and ditches is discussed in Section 4.5.

Any culvert crossings beneath the road that occurs on laydown LP3 have already been covered in Section 3.2.2.

3.5 Existing Barge Offloading Dock

At the existing barge offloading dock, there is an existing culvert that shall be referred to as Culv-Exg-B. This culvert takes up runoff from the South and discharges to the West where water will be directed via a berm (P-SWD-7) and discharged into the sea. Refer to Figure 3-12.

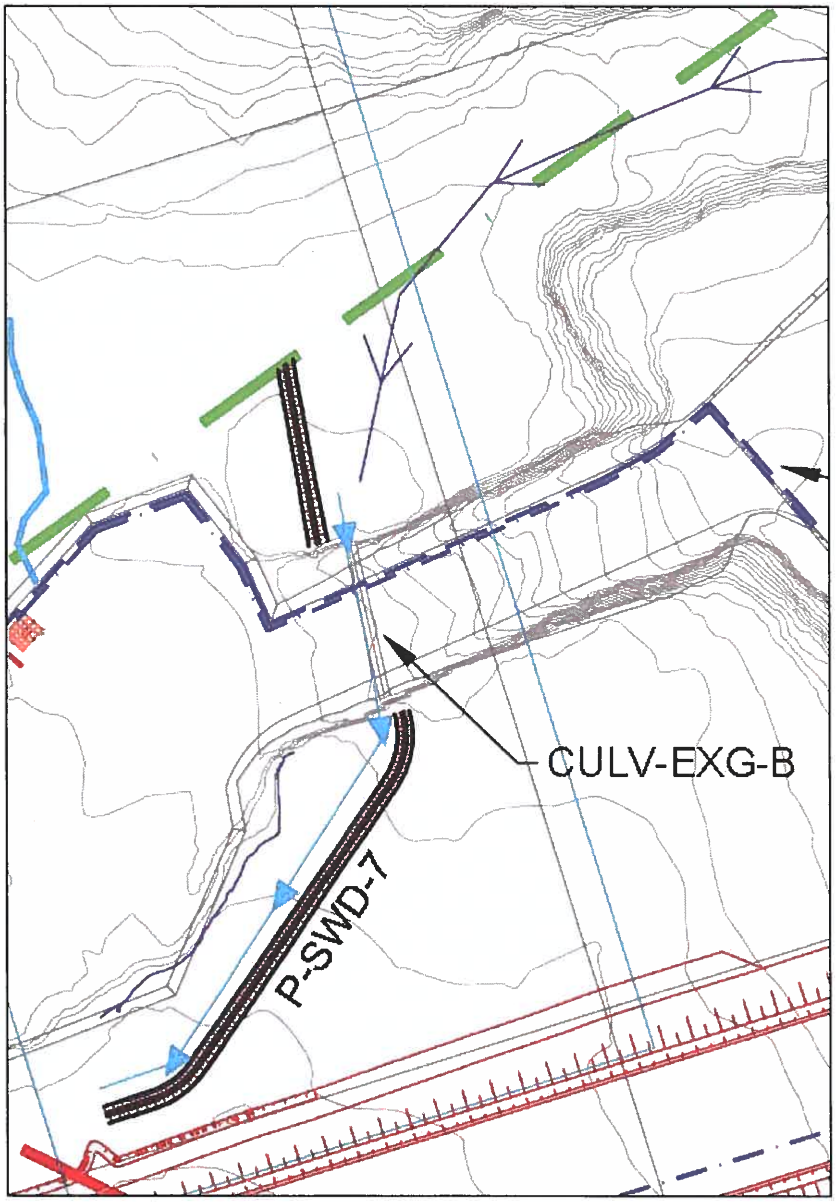


Figure 3-12: Existing Barge Offloading Dock

The existing culvert will be modified to ensure that no water for any flood event up to and including the 1:100 year event will discharge towards the North. The berm will be designed so that runoff will not interfere with the construction of the proposed new temporary barge offloading dock. The design calculation and results for the culvert modification as well as the proposed berm can be seen in Section 4.6.

3.6 Fuel Pipeline

The fuel import pipeline is used for connecting the floating pipeline from fuel tankers anchored in the bay to pump fuel into the fuel storage tanks. The floating pipeline connects at the marine manifold that is currently located to the north of the fuel tank farm. The marine manifold is to be moved in 2018 to a new location on the barge offloading dock in order to avoid operational clashes with the proposed temporary offloading dock to be constructed in 2018. The fuel pipe will be extended from its current location to run along the northern edge of the port infrastructure pad. Utility culverts will be provided where the pipe crosses roadways.

The fuel pipe will be supported by pipe supports mounted on an earth berm or existing earth platform.

The new location of the marine manifold and fuel pipeline is shown in Figure 3-13 below.

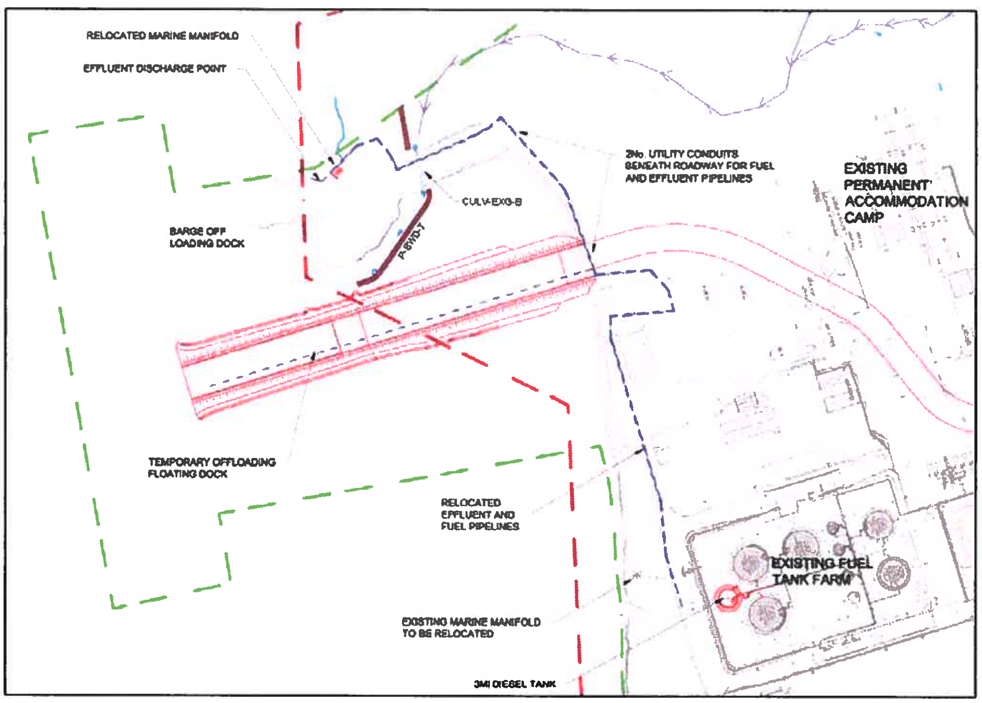


Figure 3-13: Fuel and Sewage Discharge Pipelines

3.7 Sewage Discharge Pipeline Relocations

Effluent treated at the port sewage treatment plant is currently discharged via a 2 inch insulated and heated pipe at a position to the north of the fuel tank farm.

The discharge point will be moved to a position on the existing barge offloading dock as shown in Figure 3-13.

The treated effluent pipe will follow the same alignment as the fuel pipeline and will run on an earth berm or existing earth platform.

4. Sizing of Drainage Ditches and Culverts

This section covers basic input and important results from the completed design and analysis with regards to surface water infrastructure.

4.1 Eastern Diversions

4.1.1 P-SWD-5

The diversion was modelled and analysed as a combination of berm and channel taking into account the surrounding existing ground and the results were as follows:

- Berm Height Required = 1 m
- Channel bottom width = 0.5 m
- Maximum Velocity = 1.40 m/s

Based on the results no rip rap will be required for P-SWD-6.

4.1.2 P-SWD-6

The diversion was modelled and analysed as a combination of berm and channel taking into account the surrounding existing ground and the results were as follows:

- Berm Height Required = 1 m
- Channel bottom width = 0.5 m
- Maximum Velocity = 1.28 m/s

Based on the results no rip rap will be required for P-SWD-6.

4.1.3 P-Culv-5

The culvert was analysed using Bentley Culvert Master and the analyses showed that 2 x 900mm diameter CSP culverts will be required. The velocity in the culvert will be 1.96 m/s and therefore rip rap will be placed at both the inlet and outlet to prevent scouring.

4.2 Laydown LP2

4.2.1 P-SWD-3

The diversion was modelled and analysed as a berm taking into account the surrounding existing ground and the results were as follows:

- Berm Height Required = 0.6 m
- Maximum Velocity = 1.49 m/s

Based on the results no rip rap will be required for P-SWD-3.

4.3 Laydown LP3

4.3.1 Culv-2018-E

The culvert was analysed using Bentley Culvert Master and the analyses showed that 1 x 900mm diameter CSP culverts will be required. The velocity in the culvert will be 1.63 m/s and therefore rip rap will be placed at both the inlet and outlet to prevent scouring.

4.3.2 Daylight Ditch

The flow calculated for Culv-2018-E also applies to the daylight ditch under consideration. The ditch was analysed using Bentley Flow Master and some of the results from the analyses can be seen below:

- Bottom Width = 1 m
- Side Slopes = 1V:2H
- Normal Depth = 0.35 m
- Manning N = 0.025
- Slope = 0.2%
- Discharge = 0.39 m^3/s
- Velocity = 0.67 m/s
- Froude No. = 0.42 (Sub-Critical Flow)

The channel will be flared at the end where it daylights to ensure adequate energy dissipation is achieved and to minimise any potential erosion in the area.

4.3.3 Culv-2018-F

The culvert was analysed using Bentley Culvert Master and the analyses showed that a 1 x 600mm diameter CSP culvert will be required. The velocity in the culvert will be 1.48 m/s and therefore no rip rap will be placed.

4.3.4 Culv-2018-I

Due to the small catchment area for this culvert it will be a nominal diameter pipe. Thus a 1 x 600mm diameter CSP culvert will be required and no rip rap will be placed.

4.4 Tote Road

4.4.1 Tote Road Side Drain

The Tote Road has an existing side drain of which the exact size was unknown at the time this report was compiled. This section will cover the runoff determination and the sizing of the drain. The existing drain size will be confirmed on site prior to construction and if deemed too small will be upgraded as per the recommendation in this section.

The drain was sized and analysed using Bentley Flow Master and some of the results from the analyses can be seen below:

- Bottom Width = 2 m
- Side Slopes = 1V:2H
- Normal Depth = 0.18 m
- Manning N = 0.025
- Slope = 2.6% (average slope taken; this will be optimized in detail design)
- Discharge = 0.87 m^3/s
- Velocity = 1.82 m/s
- Froude No. = 1.48 (Supercritical Flow)

Rip rap will be provided to protect against erosion since the velocity exceeds 1.5 m/s.

4.4.2 P-Culv-22

The Tote Road side drain discharges into Culv-2018-J and therefore the flow calculated in Section 4.4.1 can be applied in the sizing of the culvert.

The culvert was analysed using Bentley Culvert Master and the analyses showed that a 1 x 900mm diameter CSP culverts will be required. The velocity in the culvert will be 2.8 m/s and therefore rip rap will be provided at the inlet and outlet to protect against erosion.

4.4.3 P-Culv-32

The culvert was analysed using Bentley Culvert Master and the analyses showed that 2 x 900mm diameter CSP culverts will be required. The velocity in the culvert will be 1.99 m/s and therefore rip rap will be provided at the inlet and outlet to protect against erosion.

4.5 Delivery Road

4.5.1 SWD-2018-A

The diversion was modelled and analysed as a trapezoidal channel taking into account the surrounding existing ground and the results were as follows:

- Bottom Width = 0.5 m
- Side Slopes = 1V:2H
- Normal Depth = 0.18 m
- Manning N = 0.025
- Slope = 0.83% (average slope taken; this will be optimized in detail design)
- Discharge = 0.87 m^3/s
- Velocity = 1.28 m/s

- Froude No. = 0.86 (Subcritical Flow)

4.5.2 Culv-2018-A

The culvert was analysed using Bentley Culvert Master and the analyses showed that a 1 x 1200mm diameter CSP culvert will be required. The velocity in the culvert will be 2.09 m/s and therefore rip rap will be provided at the inlet and outlet to protect against erosion.

4.5.3 SWD-2018-B

The same flow as calculated for Culv-2018-A was used in the design and analysis of this diversion.

The diversion was modelled and analysed as a trapezoidal channel taking into account the surrounding existing ground and the results were as follows:

- Bottom Width = 1.5 m
- Side Slopes = 1V:2H
- Normal Depth = 0.46 m
- Manning N = 0.025
- Slope = 0.3% (average slope taken; this will be optimized in detail design)
- Discharge = 1.14 m^3/s
- Velocity = 1.01 m/s
- Froude No. = 0.56 (Subcritical Flow)

4.5.4 Culv-2018-B

The culvert was analysed using Bentley Culvert Master and the analyses showed that a 1 x 1200mm diameter CSP culvert will be required. The velocity in the culvert will be 2.11 m/s and therefore rip rap will be provided at the inlet and outlet to protect against erosion.

4.5.5 SWD-2018-C

The same flow as calculated for Culv-2018-B was used in the design and analysis of this diversion.

The diversion was modelled and analysed as a trapezoidal channel taking into account the surrounding existing ground and the results were as follows:

- Bottom Width = 1.5 m
- Side Slopes = 1V:2H
- Normal Depth = 0.47 m
- Manning N = 0.025
- Slope = 0.3% (average slope taken; this will be optimized in detail design)
- Discharge = 1.16 m^3/s
- Velocity = 1.02 m/s

- Froude No. = 0.56 (Subcritical Flow)

4.5.6 SWD-2018-D and SWD-2018-E

No design and analysis will be required for SWD-2018-D and SWD-2018-E since they are only required to drain local low points and do not have a significant catchment area. They will be constructed as follows:

- Trapezoidal in shape
- Bottom Width = 0.5m
- Side Slopes = 1V:2H

4.5.7 Culv-2018-C

The culvert was analysed using Bentley Culvert Master and the analyses showed that a 1 x 600mm diameter CSP culverts will be required. The velocity in the culvert will be 0.98 m/s and therefore no rip rap will be placed.

4.5.8 Culv-Exg-A

The culvert was analysed using Bentley Culvert Master with input values such as slope and length obtained from the received survey. The survey received also indicated that this is a 500mm diameter CSP pipe. This is not a standard size and it was assumed that it was a 525mm diameter pipe. The culvert was analysed and it was found that it had sufficient capacity to handle the calculated peak flow.

4.5.9 Culv-2018-D

It was determined that this culvert has no catchment area except for the localised low point that exists at the inlet to the proposed culvert. It was therefore decided that a nominal diameter culvert would suffice and that a 600mm diameter culvert would be installed.

4.6 Barge offloading Dock

4.6.1 Culv-Exg-B

The existing culvert has two barrels of 1200mm diameter each. These will be modified by dropping the inlet invert elevations and adding two additional 1200mm diameter barrels to the culvert. The tail water was determined from the high water elevation and the backwater effects that will occur due to the calculated flow. A Hec-RAS model was used to compute this and a profile of the analysis can be seen in Figure 4-1.

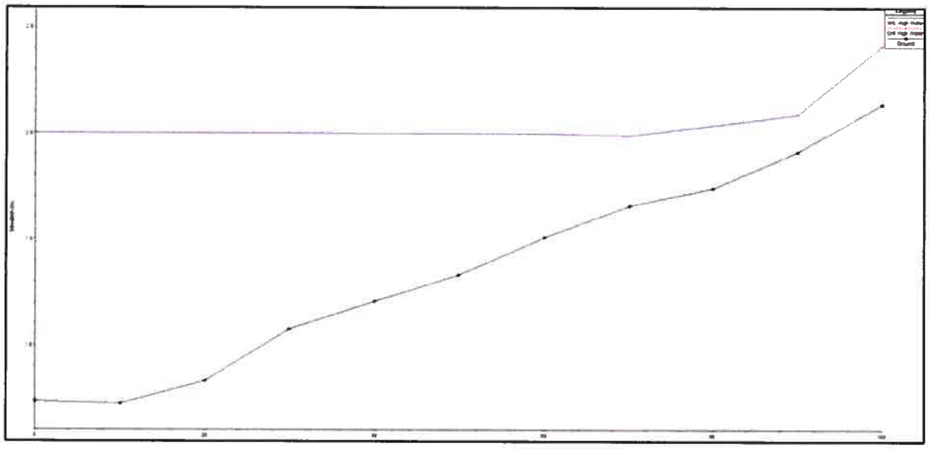


Figure 4-1: Downstream of Culv-Exg-B

The culvert designed and analysed is Bentley Culvert Master and the key output from the analysis can be seen below:

- Computed headwater elevation is equal to 3.20 m which is less than the requirement of 3.24m which was determined using the existing ground information (obtained for Lidar data) to be the maximum level water can rise before discharging to the North
- Velocity is equal to 1.83 m/s and rip rap will be placed at the inlet and outlet of the culvert to protect against erosion.

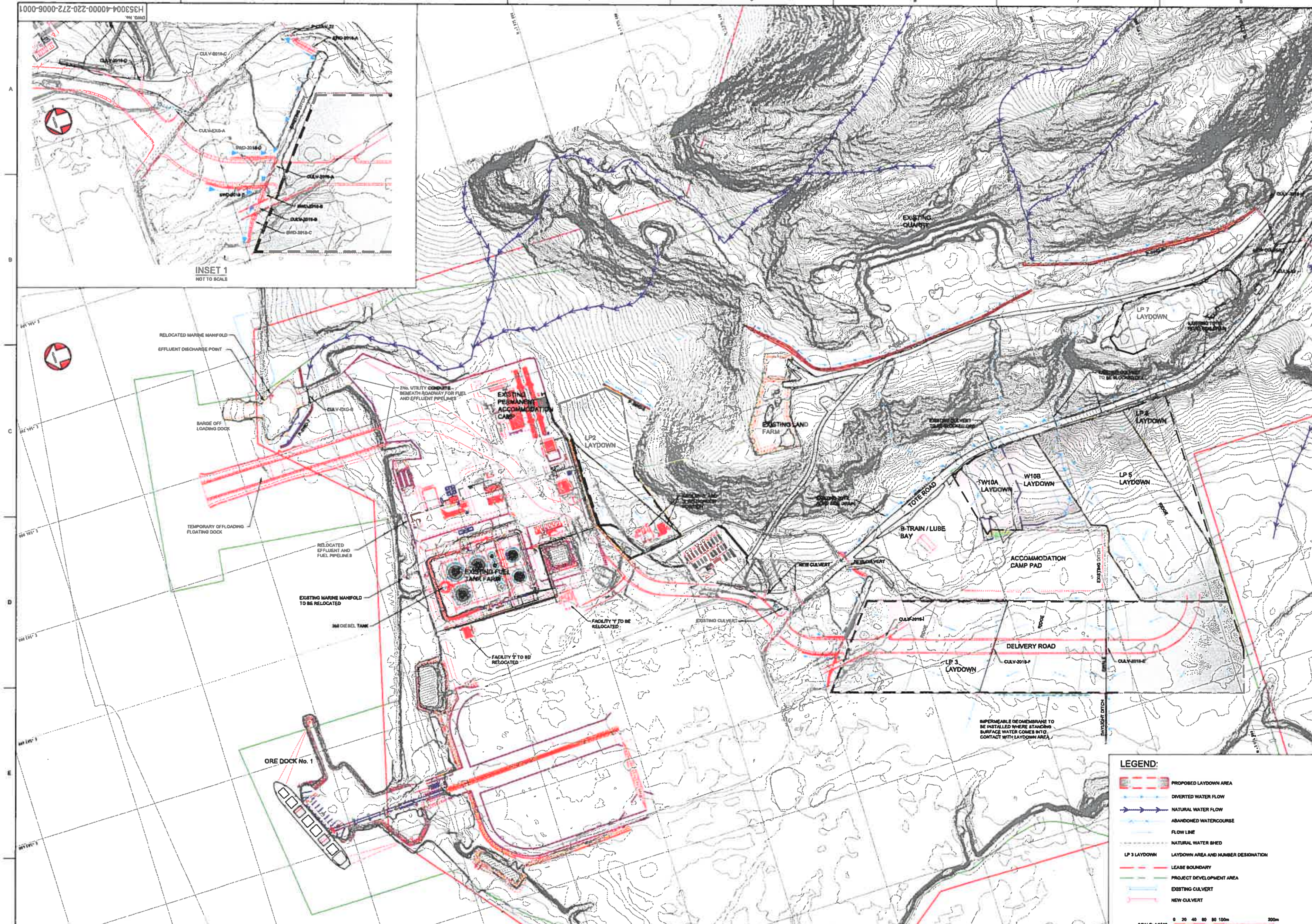
4.6.2 P-SWD-7

The diversion was modelled and analysed as a berm taking into account the surrounding existing ground and the results were as follows:

- Berm Height Required = 1.2 m
- Maximum Velocity = 1.53 m/s

Based on the results adequate rip rap shall be provided to protect against erosion.

Appendix A
Drawing H353004-40000-220-272-0006-0001 - 2018 Surface Water Management Plan - Milne Port



NOT FOR CONSTRUCTION

HATCH

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER PROJECT

MILNE PORT
2018 SURFACE WATER
MANAGEMENT PLAN

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	I BARNARD	NR	
DESIGNER	I BARNARD	NR	
CHECKER	F HUGO		
DESIGN COORD	B GODEEN		
RESP. ENG.	R HALIM		
LEAD DISC. ENG.	A GROBBELAAR		
AREA MANAGER	V LARREC		
PROJ. MANAGER	D STANGER		
CLIENT			

DRAWING APPROVAL STATUS: Approved for Use

No.	DESCRIPTION	BY	CHK'D	DATE
A	APPROVED FOR PERMITTING	IHB	FH	15/02/2018

REVISIONS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG PROFESSIONAL

DRAWING No	DRAWING TITLE

REFERENCE DRAWINGS

SCALE 1:2500

DWG. No. H353004-40000-220-272-0006-0001

REV B

SHEET SIZE: E