TETRA TECH EBA

April 4, 2014

ISSUED FOR USE
FILE: E14103075-01

Baffinland Iron Mines Inc.
120 Adelaide Street West, Suite 1016
Toronto, ON M5H 1T1

Attention: Jim Millard
Environmental Manager

Subject: Design Brief for Milne Inlet Landfarm and Contaminated Snow Containment Facility
Milne Inlet, NU

1.0 INTRODUCTION

1.1 General

Tetra Tech EBA Inc. (Tetra Tech EBA) was retained by Baffinland Iron Mines Corp. (Baffinland) to update the Milne Inlet landfarm design previously completed for the Mary River Project. The update was requested by Baffinland to accommodate increased contaminated soil volumes and provide a secondary containment cell for hydrocarbon contaminated snow.

This document provides a summary of the updated design. Construction drawings and specifications for the updated landfarm and contaminated snow containment facility have been prepared and are attached. In the case of discrepancies, the construction drawings and specifications supersede the design brief.

1.2 Project Details

Tetra Tech EBA completed a design for the landfarm in 2012 (Tetra Tech EBA, 2012). The landfarm facility was sized to accommodate staged remediation of an estimated 1,700 m^3 of contaminated soil from a bladder fuel farm. Subsequent contaminated soil excavation generated approximately 9,000 m^3 of contaminated soil.

To accommodate this increased contaminated soil volume, Baffinland requested that the landfarm footprint be approximately doubled in size. Successive treatments will still be required to remediate the contaminated soil volume; however, increasing the landfarm footprint beyond what is shown on the drawings is not possible due to space constraints at the site, and the increased material volumes required to construct an even larger facility.

In addition to increasing the landfarm footprint, Baffinland requested that a second containment cell be constructed adjacent to the landfarm to contain hydrocarbon contaminated snow. A minimum containment volume of 1,000 m^3 was requested.

2.0 DESIGN SUMMARY

The landfarm and contaminated snow containment facility (facility) location and general site layout is shown on Drawing C01. Design details for the facility are provided on Drawings C02 and C03, and in the construction specifications.

The facility consists of two geomembrane lined containment cells. The larger west cell will be used as a landfarm for the biotreatment of contaminated soil from the bulk fuel storage facility. The smaller east cell will be used for the containment of hydrocarbon contaminated snow collected during winter operations.

Tetra Tech EBA Inc.
14940 - 123 Avenue
Edmonton, AB T5V 1B4 CANADA
Tel 780.451.2121 Fax 780.454.5688

2.1 Landfarm Area

The landfarm cell is an irregularly shaped, lined containment area, measuring approximately 136 m x 63 m with a floor area of 7,620 m^2 (excluding sump). The landfarm is bounded on its south side by water features (channel and pond), and on its north side steep, unstable slopes. The landfarm was sized to maximize the footprint while not encroaching on either of these features.

The cross section design is consistent with Tetra Tech EBA (2012) and consists of a granular containment area utilizing fill materials available on site. The cell is lined with a HDPE geomembrane liner, protected with a top and bottom nonwoven geotextile, and keyed into the perimeter berms. The liner system will be covered with 0.3 m aggregate fill to protect the liner. Liner system and cross section details are provided on Drawing C03.

The landfarm has been designed to contain seasonal water accumulation due to snow melt and precipitation events. The total capacity in the landfarm, assuming a 0.3 m freeboard, is 3,383 m^3. The expected seasonal inputs are summarized in Table 1.

Table 1 – Estimated Seasonal Water Accumulation

Average Snow Accumulation on Base, SWE (m^3)	Snow Drift Accumulation, SWE (m^3)	Extreme Seasonal Precipitation (m^3)	Total Annual Accumulation (m^3)
956	370	2,000	3,307

The average base snow accumulation was calculated using a snow water equivalent of 105 mm applied over the landfarm area, as documented in Tetra Tech EBA (2012). The snow drift volume was based on snow accumulation at a 6:1 slope around the perimeter berms with a density of 325 kg/m^3. The extreme precipitation volume was evaluated by a frequency analysis of recorded summer rainfall events at Igloolik and Pond Inlet. This provided an annual 1:100 year precipitation value of 260 mm.

The total annual accumulation of 3,307 m^3 represents the average snowfall accumulation combined with a 1:100 year annual seasonal rainfall. This volume is considered to be a conservative estimate of the annual precipitation in the landfarm as it represents an extreme annual summer volume and does consider evaporation (estimated at 190 mm per year), and any water treatment and extraction completed by Baffinland.

The landfarm design includes a small sump in the southwest corner of the landfarm to accommodate small seasonal rainfall events. The capacity of the sump area is of 325 m^2.

2.2 Contaminated Snow Containment Facility

The contaminated snow containment facility is located east of the landfarm and shares a common berm with the landfarm. The cross section design is consistent with the landfarm design, with the exception that the cover thickness over the liner system has been increased to 0.6 m. For the landfarm, placement of contaminated soil contributes to the overall cover thickness over the liner system. In the contaminated snow containment facility no contaminated soil was placed so the cover thickness was increased to compensate. Along the crest of the berm, the thickness of the cover over the key trench is only 0.3 m.

The contaminated snow containment facility is a rectangular, lined containment area, measuring approximately 47 m x 43 m. The facility is graded to the south side of cell, to a point, 12 m east of the southwest corner. This will permit the facility to be accessed from either the southwest or southeast corners. The contaminated snow containment facility is shown on Drawing C02.

The contaminated snow containment facility has a containment volume of 929 m^3, with 0.3 m of freeboard. The water capacity at the liner crest is 1,428 m^3. The containment volume was developed in dialogue with Baffinland based on estimated contaminated snow volumes.

2.3 Access Road

The landfarm and contaminated snow containment facility will be accessed from the road located southwest of the facility. A detailed access road design has not been completed as part of this design; however, two possible access configurations are shown on Drawing C01. These configurations can be adjusted based on Baffinland's specific requirements and actual site conditions.

All access roads will be required to cross the small watercourse on the south side of the facility.

3.0 CONSTRUCTION MATERIALS

3.1 Pad and Berm Materials

The pad and berms of both the landfarm and the contaminated snow containment area will be constructed with Type 2 material, while Type 5 material is used adjacent to the liner. Specified particle size distributions for each material are included in construction specifications.

3.2 Geomembrane Liner System

Both the landfarm and contaminated snow containment areas will be lined with an HDPE liner system. The liner system comprises a 60 mil HDPE geomembrane sandwiched between layers of 12-oz non-woven geotextile. The properties and characteristics of the geomembrane are outlined in the construction specifications.

The liner system bedding consists of a 150 mm layer of Type 5 granular fill. The liner system cover in the landfarm area consists of 300 mm of Type 5 granular fill, the contaminated snow containment area cover is 600 mm of the Type 5 granular fill, as discussed above. Soil from the bladder farm that has contaminants below the Government of Nunavut PHC industrial guidelines can be used for Type 5 granular fill on top of the geomembrane liners.

3.3 Quantities

Material quantities for the landfarm and contaminated snow containment facility are summarized in Table 2. The Type 2 and Type 5 quantities represent in place volumes and do not include any allowances for overbreak, wastage, or overbuild.

Table 2 – Estimate Material Quantities

Area	Type 2 Granular Fill (m^3)	Type 5 Granular Fill (m^3)	Geotextile (m^2)*	60 mil HDPE Geomembrane (m^2)*
Landfarm	14,953	4,099	22,733	11,367
Contaminated Snow Containment Facility	2,306	1,745	5,352	2,716
Total	**17,259**	**5,844**	**28,085**	**14,083**

* Geotextile and geomembrane quantities provide a 15 percent allowance for overlap and waste

4.0 CONSTRUCTION CONSIDERATIONS

The following sections provide construction considerations and recommendations for construction of the landfarm and contaminated snow containment facility. Additional construction requirements are available in the construction specifications.

4.1 Foundation Preparation

The landfarm and contaminated snow containment facility will be constructed over the existing ground surface. Any ground disturbance should be minimized. Large boulders which may protrude into the liner system should be removed; however, no excavation of the foundation soils should occur.

Construction over undisturbed natural ground may create a thermal barrier, causing the permafrost table to aggrade upwards towards the base of the fill. Although construction of the landfarm overtop the ice-rich areas is not expected to cause significant permafrost degradation, the naturally-occurring patterns in the ground may eventually translate to the top and side surfaces of the berms, which may require periodic maintenance.

4.2 Material Placement

4.2.1 Granular Materials

All granular materials should be placed in lifts not exceeding 300 mm in thickness and compacted as specified in the construction specifications. Moisture conditioning may be required to achieve the compaction requirements.

4.2.2 Geomembrane Liner

The installation of the non-woven geotextile and geomembrane will commence after the 300 mm layer of Type 5 material has been placed and compacted. The bedding material must be made smooth and must be placed in a manner that will prevent damage to the liner.

The edges of the liners will be terminated in key trenches around the perimeter of the containment areas. Bedding cover material should be placed on the edges of the liner to secure the liner in place within the key trench. Low ground pressure equipment should push cover material ahead of itself, and never travel directly on the geomembrane.

4.3 Quality Assurance / Control

The construction quality assurance program must be structured to ensure that construction sensitive features of the design are achieved. The elements of the program will include:

- Careful surveying to establish material quantities and allow preparation of as-built construction drawings;
- Specific engineering approvals at critical times such as foundation preparation, and key trench excavation and cleaning;
- Monitoring field and laboratory testing of fill materials;
- Specific approval of construction procedures for moisture condition and placement of embankment materials, and liner installation;
- Observation and approval of contractor's proposed material placement sequences and preparation of each surface prior to the placement of the next lift; and

- Defined procedures for reporting with identified responsibilities for decision making during construction.

Specific testing requirements and frequencies for granular fill and liner installation are outlined in the construction specifications.

5.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Baffinland Iron Mines Corporation and their agents. Tetra Tech EBA Inc. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Baffinland Iron Mines Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are attached to this memo.

6.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.

Prepared by:
Elizabeth A. Garven, M.A.Sc., P.Eng.
Geotechnical Engineer – Arctic Region
Direct Line: 780.451.2130 x257
Elizabeth.Garven@tetratech.com

Reviewed by:
Gary Koop, P.Eng
Project Director – Arctic Engineering
Direct Line: 780.451.2130 x509
Gary.Koop@tetratech.com

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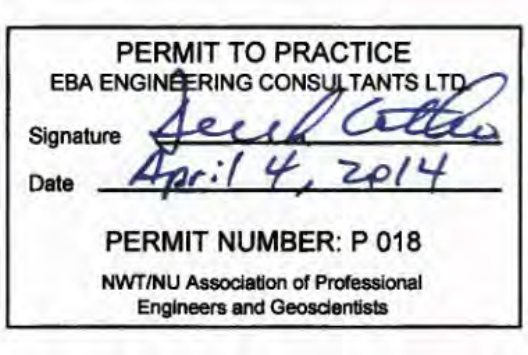
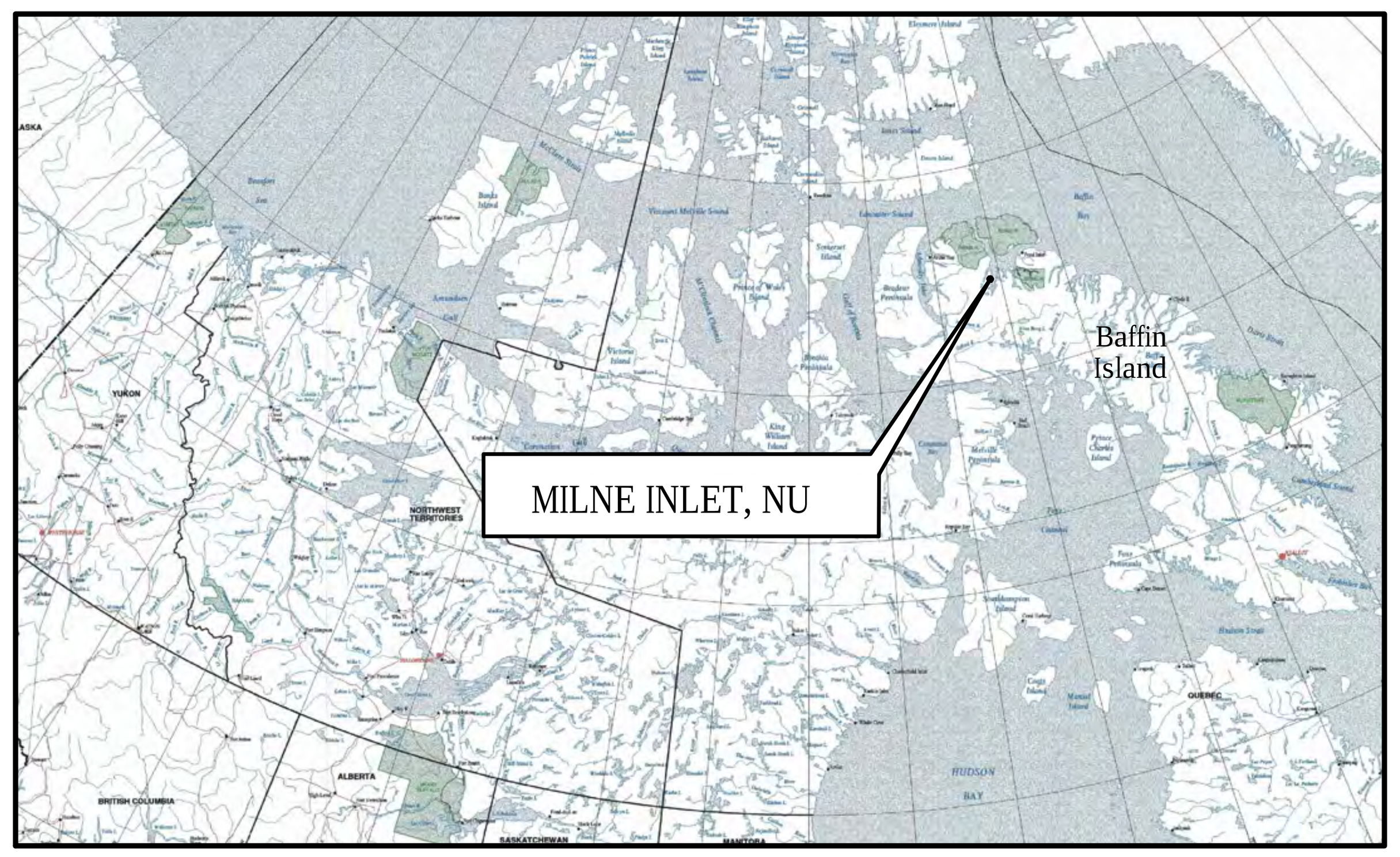


FIGURES

DRAWING INDEX

GENERAL ARRANGEMENTS

DRWG #	TITLE
C101	(GENERAL SITE) SITE LOCATION AND IDENTIFICATION OF MAJOR FEATURES
C102	PLAN AND LAYOUT
C103	CROSS-SECTIONS AND DETAILS



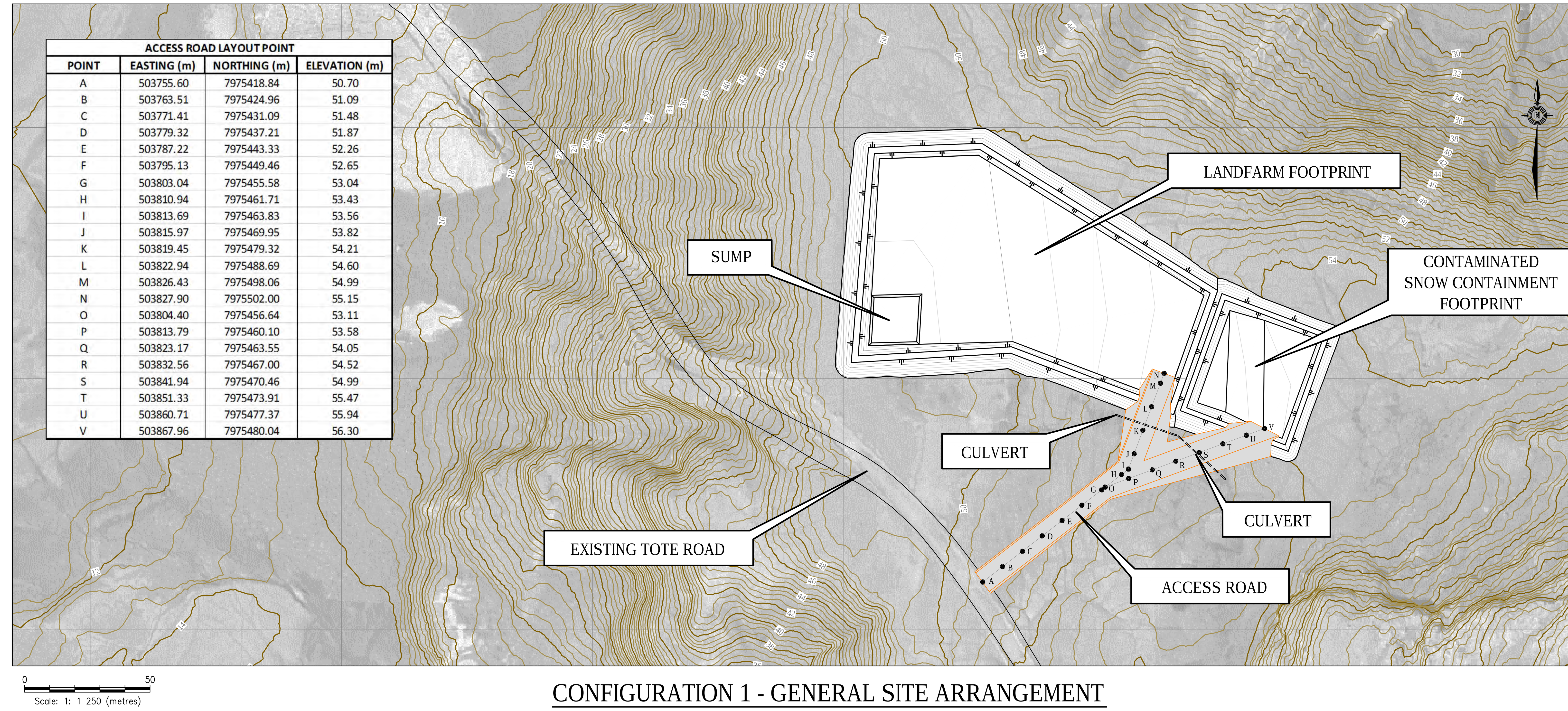
KEY MAP

SCALE: NTS

GENERAL LOCATION MAP

SCALE: NTS

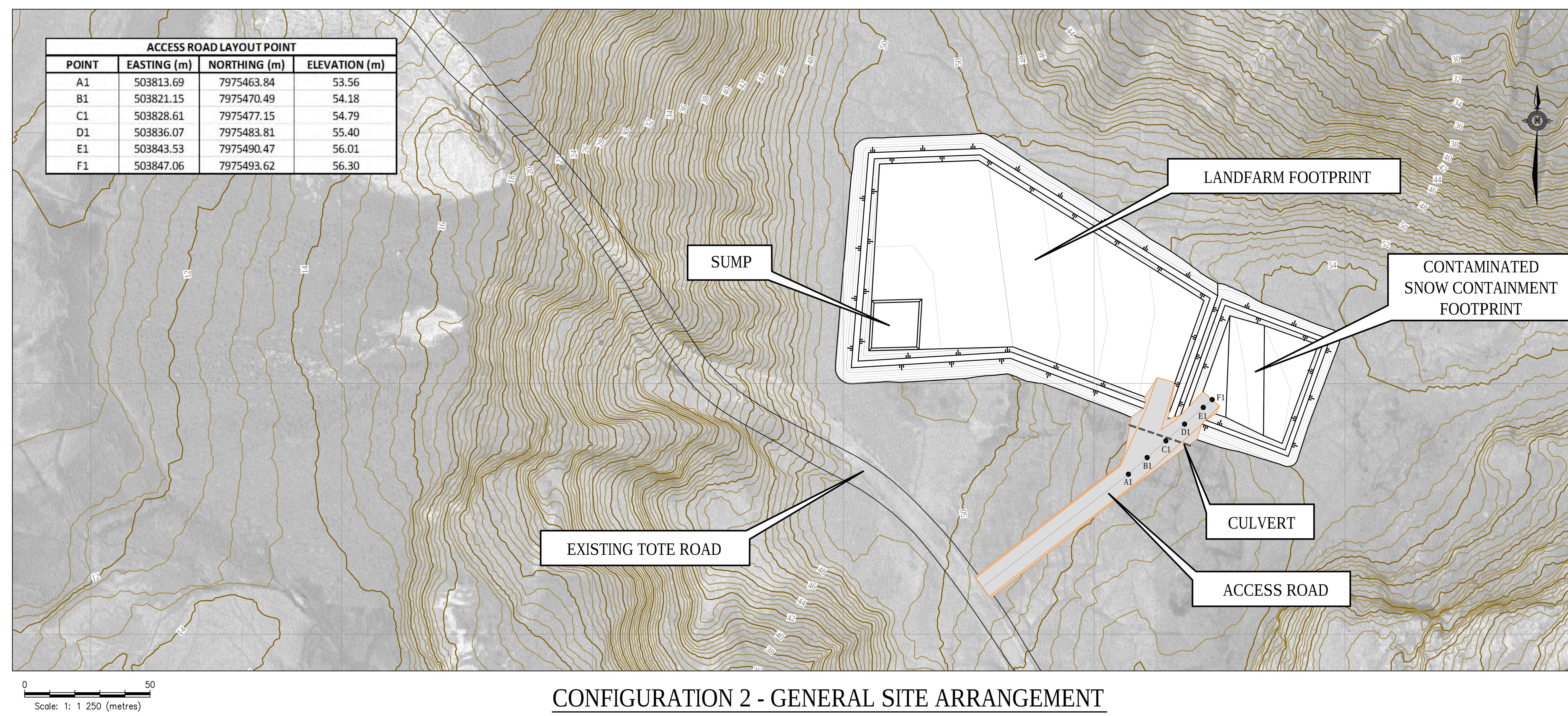
ACCESS ROAD LAYOUT POINT			
POINT	EASTING (m)	NORTHING (m)	ELEVATION (m)
A	503755.60	7975418.84	50.70
B	503763.51	7975424.96	51.09
C	503771.41	7975431.09	51.48
D	503779.32	7975437.21	51.87
E	503787.22	7975443.33	52.26
F	503795.13	7975449.46	52.65
G	503803.04	7975455.58	53.04
H	503810.94	7975461.71	53.43
I	503813.69	7975463.83	53.56
J	503815.97	7975469.95	53.82
K	503819.45	7975479.32	54.21
L	503822.94	7975488.69	54.60
M	503826.43	7975498.06	54.99
N	503827.90	7975502.00	55.15
O	503804.40	7975456.64	53.11
P	503813.79	7975460.10	53.58
Q	503823.17	7975463.55	54.05
R	503832.56	7975467.00	54.52
S	503841.94	7975470.46	54.99
T	503851.33	7975473.91	55.47
U	503860.71	7975477.37	55.94
V	503867.96	7975480.04	56.30



CONFIGURATION 1 - GENERAL SITE ARRANGEMENT

SCALE: 1: 1,250

ACCESS ROAD LAYOUT POINT			
POINT	EASTING (m)	NORTHING (m)	ELEVATION (m)
A1	503813.69	7975463.84	53.56
B1	503821.15	7975470.49	54.18
C1	503828.61	7975477.15	54.79
D1	503836.07	7975483.81	55.40
E1	503843.53	7975490.47	56.01
F1	503847.06	7975493.62	56.30



CONFIGURATION 2 - GENERAL SITE ARRANGEMENT

SCALE: 1: 1,250

NOTE:
ELEVATIONS FOR ACCESS ROAD ARE ESTIMATED BASED ON LIDAR ELEVATIONS.
THE ACCESS ROAD WAS NOT DESIGNED.

REVISIONS

NUM	DATE	DWN	CKD	APR	DESCRIPTION
0	APR. 04/14	DBD	EG	GDK	ISSUED FOR USE (CONSTRUCTION)

DRAWING STATUS

NUM	DATE	APR	DESCRIPTION
B	Mar. 20/2014	GDK	ISSUED FOR REVIEW
A	Mar. 18/2014	GDK	ISSUED FOR REVIEW

PERMIT TO PRACTICE
EBA ENGINEERING CONSULTANTS LTD.
Signature [signature]
Date April 4, 2014
PERMIT NUMBER: P 018
NWT/NU Association of Professional Engineers and Geoscientists

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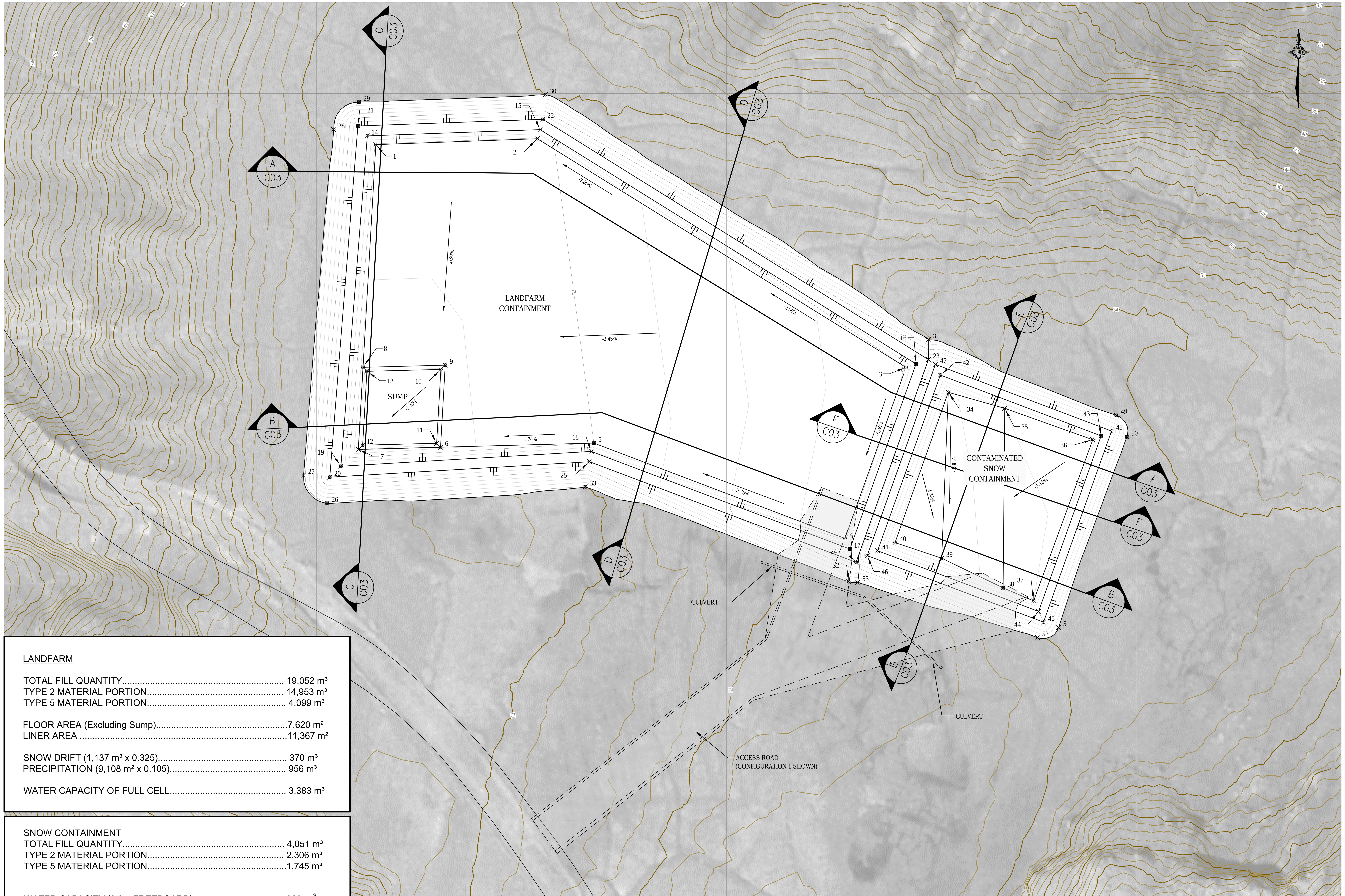
TETRA TECH EBA

MILINE INLET LANDFARM DESIGN
MILINE INLET, NU

SITE LOCATION AND IDENTIFICATION OF MAJOR FEATURES

PROJECT No.	OFFICE	DES	CKD	REV	DRAWING
E14103075-01	EDM	DRG	EG	0	C01
DATE: April 04, 2014	SHEET No. 1 of 3	DWN DRG/DBD	APP GDK	STATUS -	



LANDFARM

TOTAL FILL QUANTITY....... 19,052 m³
TYPE 2 MATERIAL PORTION....... 14,953 m³
TYPE 5 MATERIAL PORTION....... 4,099 m³

FLOOR AREA (Excluding Sump)....... 7,620 m²
LINER AREA .... 11,367 m²

SNOW DRIFT (1,137 m³ x 0.325)....... 370 m³
PRECIPITATION (9,108 m² x 0.105)....... 956 m³

WATER CAPACITY OF FULL CELL....... 3,383 m³

SNOW CONTAINMENT

TOTAL FILL QUANTITY....... 4,051 m³
TYPE 2 MATERIAL PORTION....... 2,306 m³
TYPE 5 MATERIAL PORTION....... 1,745 m³

WATER CAPACITY (0.3m FREEBOARD)....... 929 m³

LINER AREA .... 2,716 m²

LANDFARM LAYOUT POINTS			
POINT #	NORTHING	EASTING	ELEVATION
1	7975587.511	503714.454	51.900
2	7975588.943	503753.860	51.900
3	7975533.109	503843.833	54.017
4	7975491.339	503828.939	53.826
5	7975514.617	503767.660	52.000
6	7975513.616	503730.232	51.349
7	7975513.079	503710.168	51.000
8	7975533.117	503711.322	51.242
9	7975533.654	503731.386	51.405
10	7975532.625	503730.325	50.905
11	7975514.591	503729.286	50.849
12	7975514.108	503711.228	50.500
13	7975532.142	503712.267	50.742
14	7975589.637	503712.373	53.001
15	7975591.169	503754.535	53.001
16	7975533.954	503846.258	55.035
17	7975488.747	503830.139	54.850
18	7975512.598	503767.006	53.001
19	7975508.964	503705.924	53.001
20	7975506.298	503703.203	53.001
21	7975592.054	503710.058	53.001
22	7975593.695	503755.209	53.001
23	7975535.010	503849.289	55.035
24	7975485.508	503831.638	54.850
25	7975510.071	503766.622	53.001
26	7975499.931	503702.536	49.800
27	7975506.808	503696.821	49.800
28	7975591.157	503704.166	50.100
29	7975597.870	503710.330	50.100
30	7975599.676	503755.799	49.996
31	7975539.868	503849.301	52.924
32	7975480.761	503829.844	52.313
33	7975503.940	503765.540	49.973

SNOW CONTAINMENT LAYOUT POINTS			
POINT #	NORTHING	EASTING	ELEVATION
34	7975527.021	503854.129	54.400
35	7975523.112	503867.909	55.000
36	7975515.446	503889.390	55.200
37	7975476.097	503874.955	55.000
38	7975479.275	503867.509	54.800
39	7975486.515	503852.529	54.000
40	7975490.322	503841.148	54.200
41	7975488.331	503836.891	55.858
42	7975531.243	503852.192	56.034
43	7975516.390	503891.423	56.000
44	7975473.512	503876.182	56.000
45	7975470.921	503877.383	56.000
46	7975487.153	503834.348	55.858
47	7975533.835	503850.993	56.034
48	7975517.567	503893.964	56.000
49	7975521.416	503895.096	54.000
50	7975516.128	503897.698	54.000
51	7975469.610	503881.071	54.043
52	7975467.106	503875.944	53.961
53	7975480.601	503832.038	52.386

NOTE:

WATER CAPACITY OF THE LANDFARM AND CONTAINMENT AREA ASSUMES 0.3 m FREEBOARD

0 — 25
Scale: 1: 500 (metres)

NUM	DATE	DWN	CKD	APR	DESCRIPTION
0	APR. 04/14	DBD	EG	GDK	ISSUED FOR REVIEW (CONSTRUCTION)

REVISIONS

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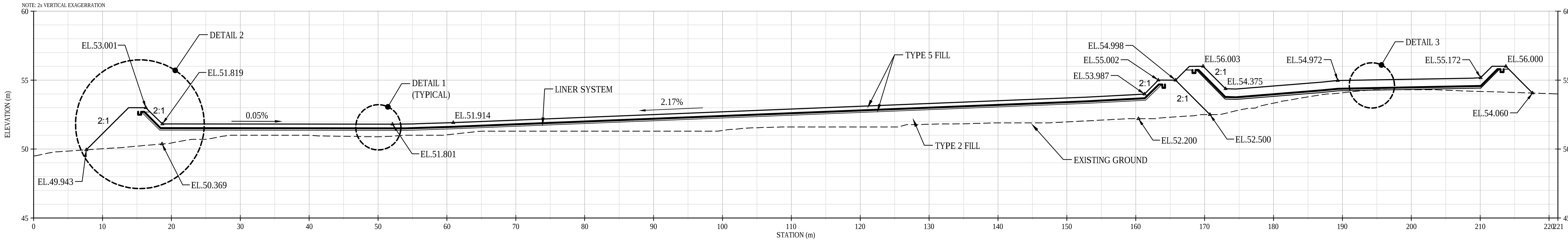
TETRA TECH EBA

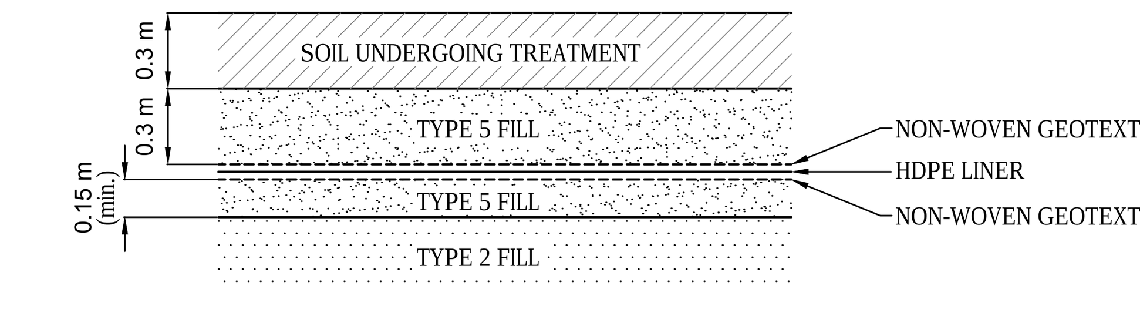
MILNE INLET LANDFARM DESIGN
MILNE INLET, NU

PLAN AND LAYOUT

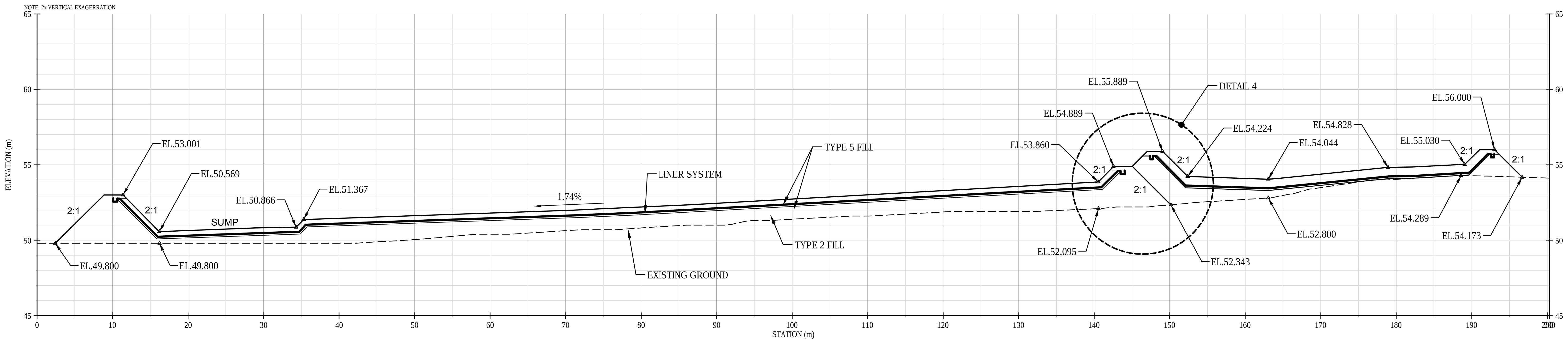
PROJECT No.	OFFICE	DES	CKD	REV	DRAWING
E14103075-01	EDM	DRG	EG	0	C02
DATE:	SHEET No.	DWN	APP	STATUS	
April 04, 2014	2 of 3	DRG/DBD	GDK	-	



SECTION A



DETAIL - LINER SYSTEM (1 / C03) N.T.S.



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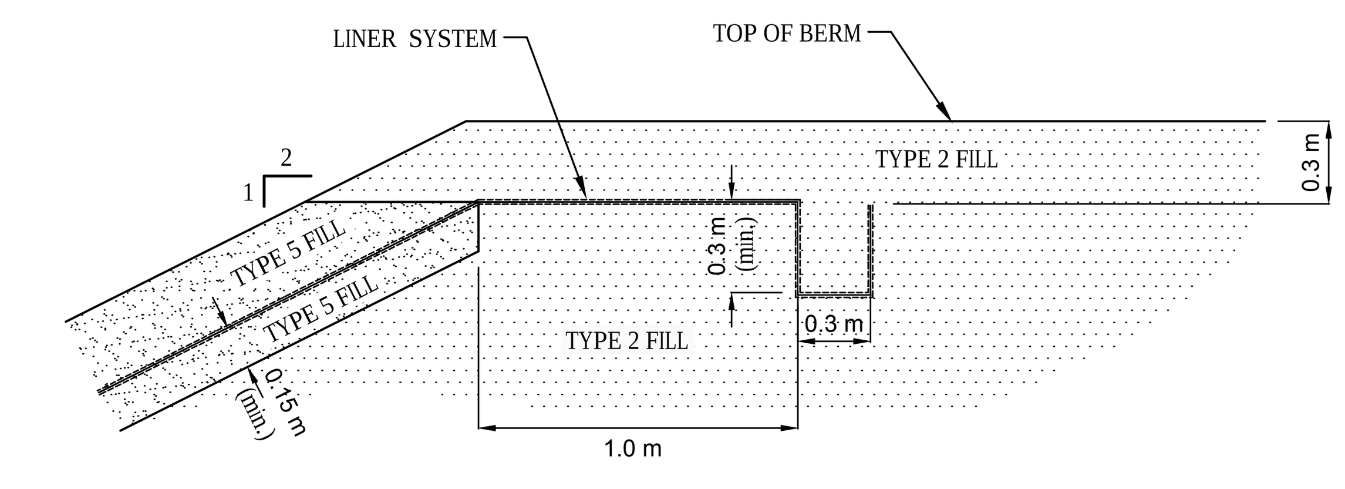

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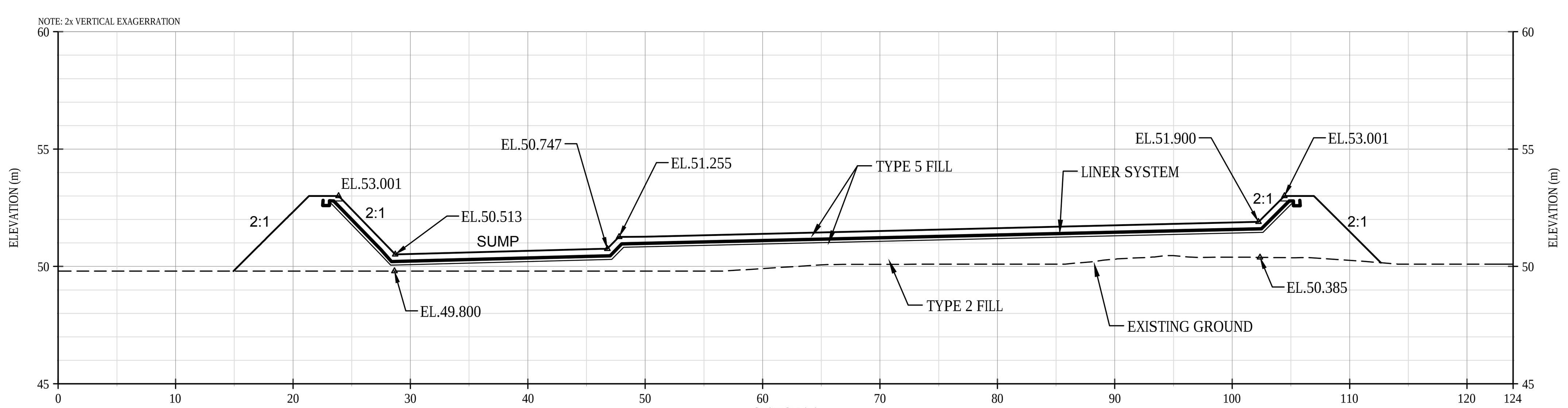

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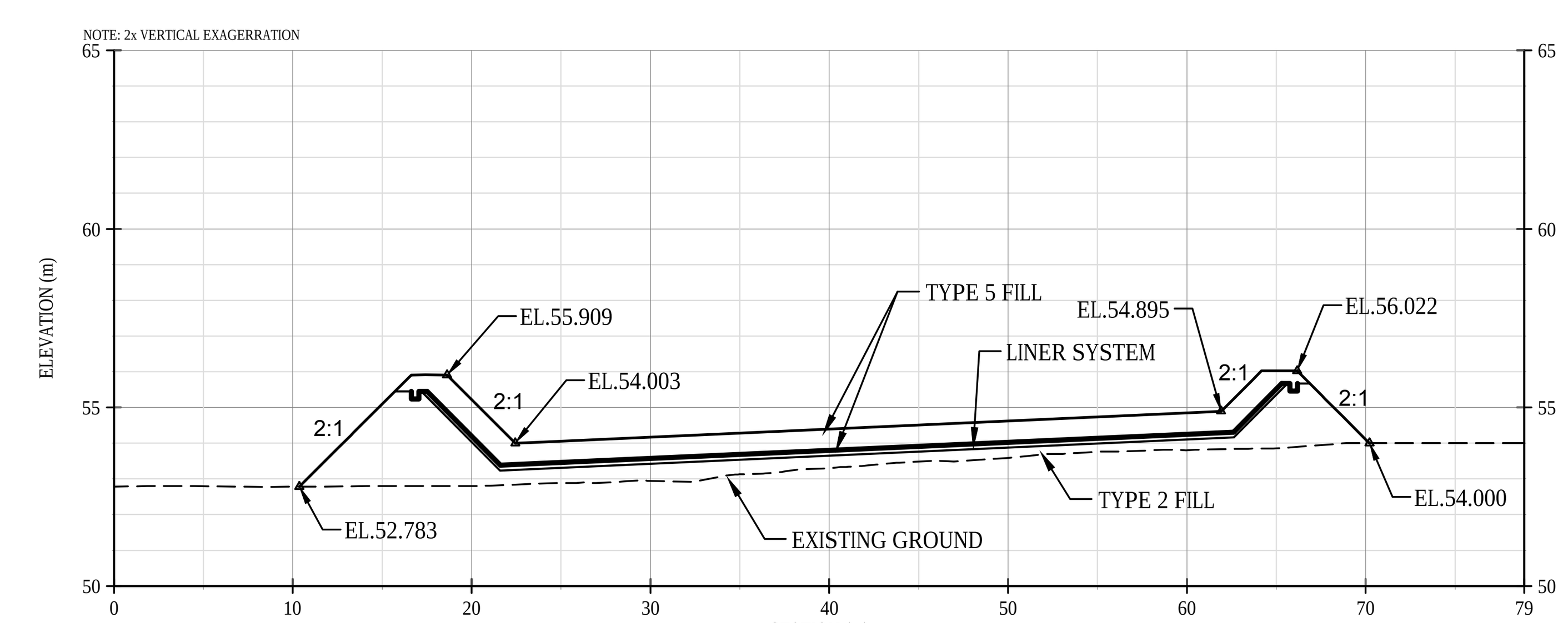

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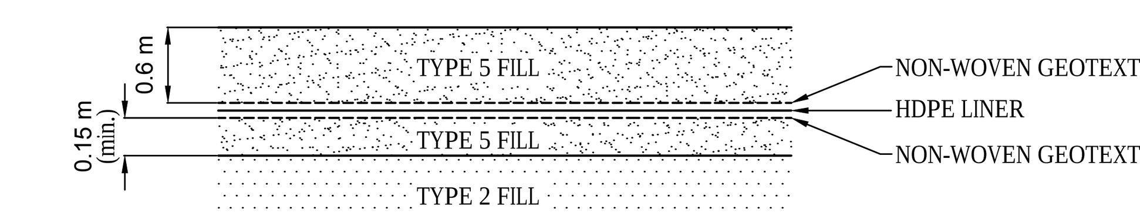
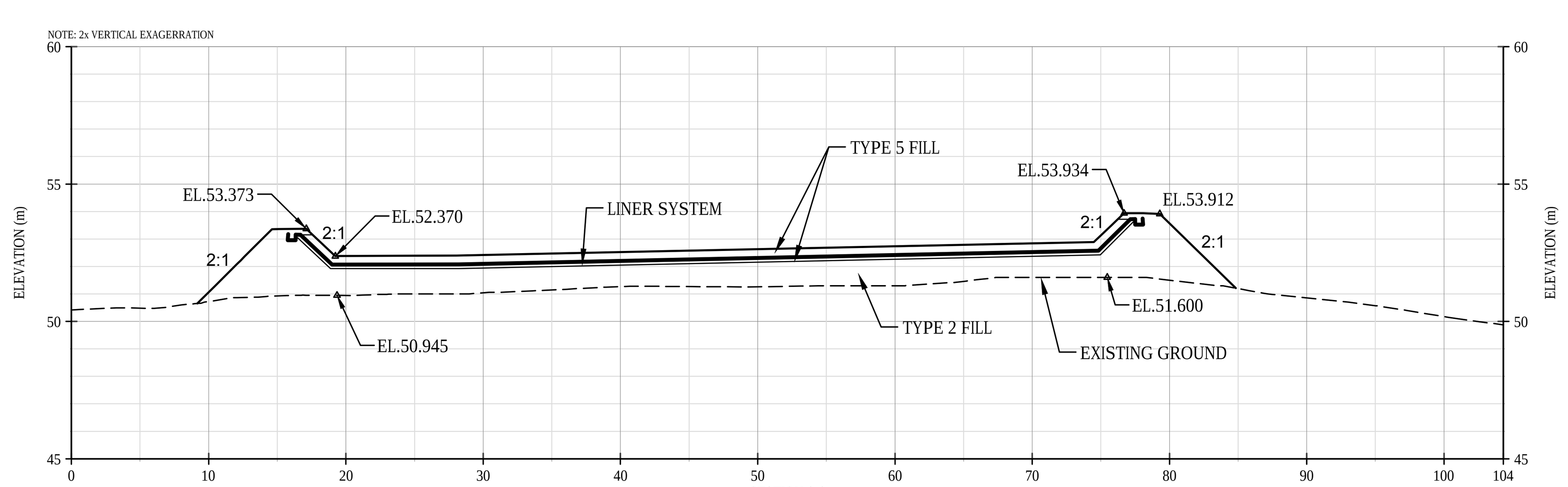


DETAIL - LINER SYSTEM (3 / C03) N.T.S.



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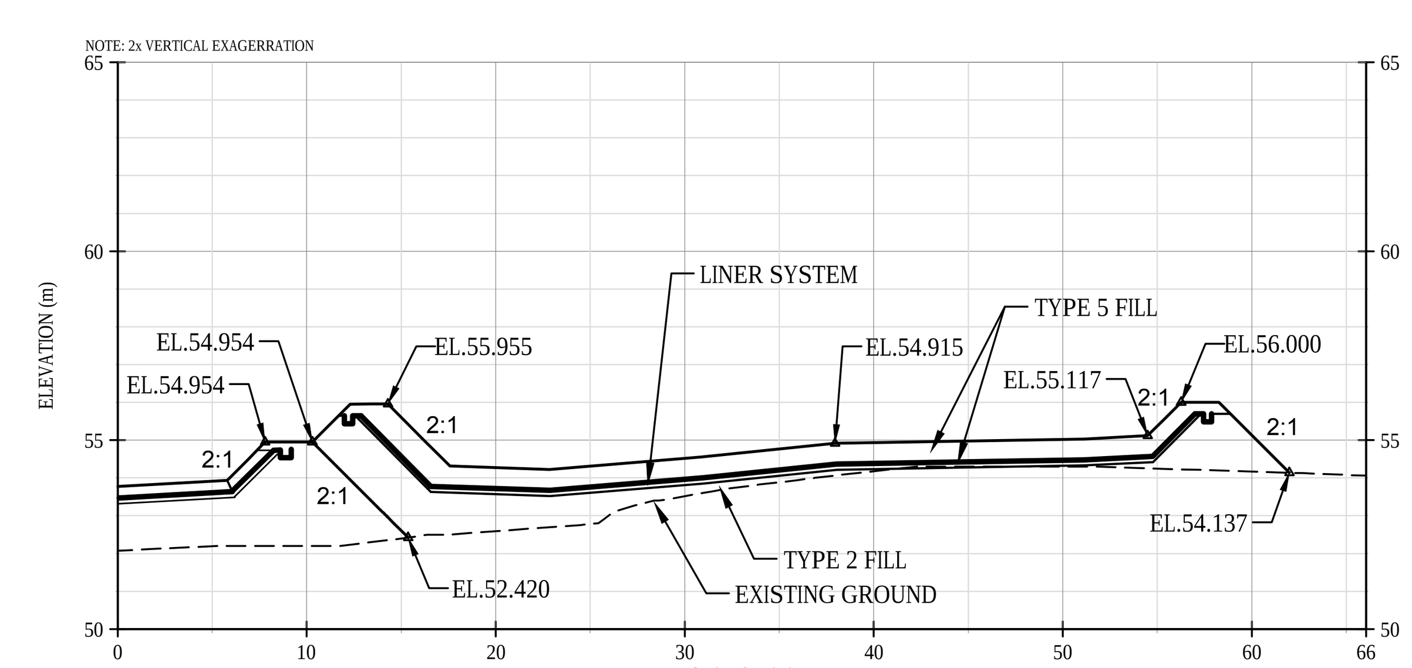
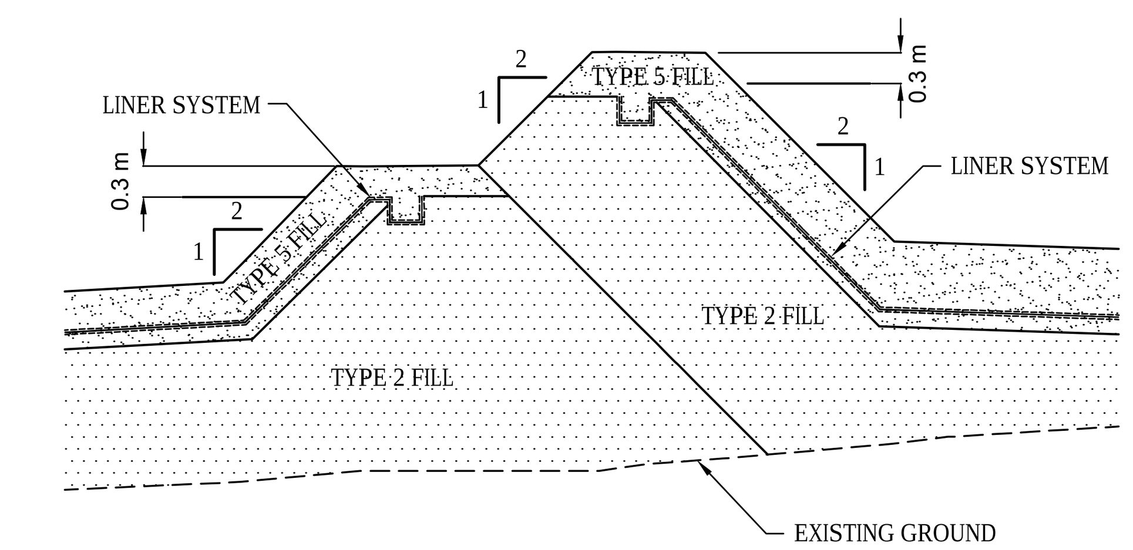


SECTION F



DETAIL - LINER ANCHORING (4 / C03) N.T.S.

NOTES:

1. DIMENSIONS AND ELEVATIONS ARE IN METRES.
2. COVER OVER LINER ALONG CREST OF SNOW CONTAINMENT FACILITY BERM IS 0.3 m

Scale: 1: 400 (metres)

REVISIONS

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TETRA TECH EBA

MILNE INLET LANDFARM DESIGN
MILNE INLET, NU

SECTIONS

PROJECT No.	OFFICE	DES	CKD	REV	DRAWING
E14103075-01	EDM	DRG	EG	0	C03
DATE: April 04, 2014	SHEET No. 3 of 3	DWN DRG/DBD	APP GDK	STATUS -	

APPENDIX A
TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

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2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, Tetra Tech EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. Tetra Tech EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. Tetra Tech EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

Tetra Tech EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B
SPECIFICATIONS

TETRA TECH EBA

CONSTRUCTION SPECIFICATIONS FOR THE MILNE INLET LANDFARM AND CONTAMINATED SNOW CONTAINMENT FACILITY

PRESENTED TO

Baffinland Iron Mines Corporation

APRIL 2014
ISSUED FOR USE
FILE: E14103075-01

CONSULTING ENGINEERS & SCIENTISTS · www.eba.ca

Tetra Tech EBA Inc.
14940 - 123 Avenue
Edmonton, AB T5V 1B4 CANADA
Tel 780.451.2121 Fax 780.454.5688

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CONFIDENTIALITY STATEMENT

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Baffinland Iron Mines Corporation and their agents. Tetra Tech EBA Inc. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Baffinland Iron Mines Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

SECTION 1001: EARTHWORKS

1.0 GENERAL

1.1 References

Where material properties are specified, the following standards are applicable:

Materials International

.1 ASTM D698 [07e1], Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft lbf/ft) (600kN m/m^3).

.2 ASTM D422 Test Method for Particle-Size Analysis of Soils.

.3 ASTM D1140 Test Method for Amount of Material in Soils Finer than the No. 200 (75 µm) Sieve.

.4 ASTM C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates.

.5 ASTM D2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

.6 ASTM D1556 Test Method for Density of Soil in Place by the Sand-Cone Method.

.7 ASTM D2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (shallow depths).

Canadian General Standards Board (CGSB)

.1 CAN/CGSB-8.1-88, Sieves, Testing, Woven Wire, Inch Series.

.2 CAN/CGSB-8.2-M88, Sieves, Testing, Woven Wire, Metric.

1.2 Scope

.1 This Specification defines the requirements for furnishing of all labour, equipment, and materials for earthworks required for site preparation as indicated on the Drawings and as specified herein for Baffinland Iron Mines Milne Inlet Landfarm, in Nunavut, Canada.

.2 All work shall conform to the lines, grades, and cross sections indicated on the Drawings. Included is all site preparation, excavation, processing as necessary, stockpiling, loading, hauling, placing, compacting, and finishing of all material classified as acceptable for fill material. Excavation and processing of this material shall include sorting or screening that may be necessary to produce the required gradations.

1.3 Protection of Existing Utilities

.1 If relevant, location, isolation, and/or relocation of buried utilities shall be completed before any excavation commences.

1.4 Drawing Discrepancies

.1 Any discrepancies found on the drawings shall be brought to the immediate attention of the Owner's Representative.

.2 No deviations shall be permitted from the design drawings without written approval from the Owner's Representative.

.3 Contractor shall immediately submit in writing to the Owner's Representative any conflicts discovered within this Specification or between this Specification, the purchase order, the accompanying data sheets and drawings, and any other supplemental information or Specifications. The Owner's Representative will then make a ruling and clarify the matter in writing.

1.5 Product Delivery and Storage

.1 Store separate from other materials, stockpile, and protect all materials from contamination prior to their use.

.2 Deliver, stockpile, and handle materials using proper equipment. Reject and remove from site all materials contaminated with foreign matter, or in any way damaged or defective.

.3 Should any materials become segregated, remix the material to provide uniform gradation. Alternatively, remove and replace the segregated material.

1.6 Material Sources

.1 Use material sources and borrow pits shown on the Drawings or alternate borrow pits as designated by the Owner's Representative. Contractor shall use these sources, subject to the conditions of the Owner's quarry permits. Maintain haul and access roads to provide safe passage and control for traffic at all times.

.2 Before development of borrow pits, excavate test pits as and where necessary to assess the quality composition and extent of the deposits as directed by the Owner's Representative.

.3 The Contractor shall refer to the Borrow Site Reclamation Overview Milne Inlet Access Road, Mary River Project, Baffin Island, NU, file E14101074 (EBA 2009) for site-specific guidelines related to borrow pit development and reclamation.

.4 Leave unsuitable material in the borrow pit unless its removal is required for continued operation of the pit. Dispose of such material to areas designated by the Owner's Representative

1.7 Survey Control

.1 The Contractor shall furnish all stakes, markers, tools, and equipment required to lay out the work, and to lay out the work from the benchmarks. Markers that are lost or disturbed by the Contractor's operations shall be replaced at their expense.

1.8 Drainage

.1 Excavation, fill, and backfill work areas shall be continually and effectively drained. Water shall not be permitted to accumulate in excavations or foundation areas for compacted fill. The Contractor shall provide pumping equipment to divert water flows away from work areas. The proposed point of discharge shall be approved by the Owner. The Contractor must also ensure that sediments contained in diverted water will not enter a natural watercourse.

.2 Backfill may not commence until all water has been drained or otherwise removed from the excavation, and the Owner's Representative approves the commencement of backfilling operations.

1.9 Inspection and Testing

.1 The Owner's Representative will witness excavation and backfilling operations, take samples, and perform nuclear densometer testing to ensure compliance with contract and specification requirements.

1.10 Environmental Protection Plan

.1 The Contractor is to comply with all requirements of Baffinland's Environmental Protection Plan (2007 to 2009) or most recent version.

2.0 PRODUCTS

2.1 General

.1 All backfill shall be free from clay lumps, organic matter, frozen material, refuse, or other deleterious material.

.2 Gradations shall be within the limits specified when materials are tested to ASTM C136 and ASTM C117. Sieve sizes shall conform to CAN/CGSB-8.1-88.

2.2 Materials

.1 Representative bulk samples of any materials proposed shall be submitted to the Owner's Representative for particle size analysis, laboratory compaction testing, and evaluation prior to a final decision on the use of such materials.

.2 Rock Rip-rap: Hand-laid rock rip-rap material shall consist of sound, durable stones having at least a minimum dimension of 200 mm.

.3 Type 2 and Type 5 granular fill properties for the following requirements:

.a Crushed, pit run, or screened stone, gravel or sand.

.b Gradations to be within limits specified when tested to ASTM C136 and ASTM C117. Sieve sizes to CAN/CGSB-8.1, CAN/CGSB-8.2.

.c Oversize rocks in the pit run material shall be removed from the Work.

.d Table:

Table 1001-1: Aggregate Particle Size Distribution Limits

ASTM Sieve Size (mm)	Type 2 Aggregate (Berms, Pad)	Type 5 Aggregate (Embedment of Geomembranes)
100	100	
50	60 -100	
25	40 – 100	100
12.5		75 – 100
4.75	20 – 70	50 – 100
2.0	10 – 60	30 - 100
0.63		10 – 95
0.075	0 -5	0 - 5

3.0 EXECUTION

3.1 General

.1 Construction shall be performed in accordance with the best industry practices and with equipment best adapted to the work being performed. Material shall be placed so that each zone is homogenous, free of stratifications, ice chunks, lenses, pockets, ruts, and layers of material of different texture, and grading not conforming to the requirements specified herein.

.2 No fill material shall be placed on any part of the foundation until it has been prepared as specified herein and approved by the Owner's Representative. Placement of material shall conform to the lines, grades, and elevations shown on the Construction Drawings or as specified herein and shall be performed in such a manner as to avoid mixing of materials in adjacent zones.

.3 Fill placement shall not proceed when the work cannot be performed in accordance with the requirements of the Specifications. Any part of the Project, which has been damaged by the action of rain and snow, or any other cause, shall be removed and replaced with material conforming to the requirements specified herein before succeeding layers are placed.

.4 Stockpiling, loading, transporting, dumping, and spreading of all materials must be carried out in such a manner to avoid segregation or any other condition that does not meet the requirements stated herein. Segregated materials shall be removed and replaced with the materials meeting the requirements stated herein and receiving the Owner's Representative's approval.

.5 The Contractor shall remove all snow, debris, vegetation, or any other material not conforming to the requirements stated herein prior to placing fill. The Contractor shall dispose of these materials in an area approved by the Owner.

.6 The Owner's Representative may, at their discretion, adjust the berm top width to account for site specific foundation conditions and construction equipment. The minimum top of berm width shall be 2.5 m.

3.2 Preparation

3.2.1 Protection of Permafrost

.1 In permafrost areas, permafrost degradation by excavating trenches or ditches may be initiated if adequate thermal and erosion protection is not present.

.2 Ice-rich permafrost has been identified in the area of the landfarm, and surface disturbance of these areas should be avoided or minimized.

.3 Avoid open excavations and areas of standing water near the project footprint. Promptly remove melt water accumulations in excavations.

.4 Access road is to be constructed on original ground to protect the permafrost.

3.2.2 Temporary Erosion and Sedimentation Control

.1 Use temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust.

.2 Inspect, repair, and maintain erosion and sedimentation control measures during construction.

.3 Remove erosion and sedimentation controls and restore and stabilize areas disturbed during construction works.

3.2.3 Landfarm Footprint Preparation

.1 Remove open graded boulders and deleterious materials from the landfarm footprint area.

.2 Excavate to lines, grades, elevations, and dimensions as indicated on the Drawings.

.3 Landfarm footprint must be approved by the Owner's Representative before fill is placed.

3.2.4 Fill Placement and Compaction

.1 Use types of fill as indicated on the Drawings. Compaction densities are percentages of maximum densities obtained from ASTM D698.

.a Place Type 2 fill in lifts not exceeding 300 mm thickness using techniques to avoid segregation.

.b Compact Type 2 fill to 95 % of corrected maximum dry density.

.c Beneath the liner system, place 150 mm lift of Type 5 material and roll smooth. Angular particles larger than 75 mm must be removed. Only clean materials originating from designated borrow pits may be used beneath the liner.

3.2.5 Protective Layer over HDPE Geomembrane

.1 Place Type 5 materials over the HDPE geomembrane liner in a minimum lift thickness in accordance with the manufacturer's recommendations, depending on the type of equipment used to place the fill.

.2 Prevent damage to the liner during granular fill placement using the following guidelines:

Table 1001-2: Fill Placement Guidelines

Backfill Thickness Over Liner	Allowable Ground Pressure
No backfill	Foot traffic or ATV only
150 mm or less	Hand placement
200 mm to 300 mm	28.7 kPa to 29.0 kPa (D3-D4 CAT Track Loaders B Low Ground Pressure)
300 mm to 600 mm	29.0 kPa to 59.9 kPa (D4 to D6 Style CAT or Equivalent)
600 mm to 900 mm	72.8 kPa to 109 kPa (D7 to D9 CAT or Equivalent)

.3 Type 5 soils originating from the protective layer of the Milne Inlet bulk fuel storage facility (bladderfarm) may be recycled within the contained area at the landfarm provided that the soils meet the particle size gradation requirements and also meet the Government of Nunavut Environmental Guideline for Contaminated Site Remediation (2009), for coarse-grained soils and industrial land use.

.4 If soils from the Milne Inlet bulk fuel facility are to be recycled in the landfarm protective layer, refer to the Summary Report on Assessment of Hydrocarbon-impacted Soils within the Bulk Fuel Storage Facility at Milne Inlet, NU, Tetra Tech EBA letter-report dated November 2, 2011 (draft) for a plan view and delineation of sandy soils within the fuel storage facility petroleum hydrocarbon soil results suitable for recycling at the time of soil sampling (September 2011).

.5 If used in the landfarm protective layer, soils originating from the Milne Inlet bulk fuel facility must be tested for benzene, toluene, ethylbenzene, and xylenes (BTEX), CCME hydrocarbon fractions F1-F4, and lead at a minimum frequency of one (1) set of samples per stockpile or per 200 m^3 of soil.

3.2.6 Quality Assurance

.1 General

.a This section describes the required quality assurance testing that shall be carried out for fill materials.

.b The testing will be carried out by the Owner's Representative or an independent testing firm engaged by the Owner.

.2 Testing Requirements

.a Samples of Type 2 and Type 5 material shall be tested as follows to verify that they meet the specified requirements. Additional testing shall be carried out as requested by the Owner's Representative.

.b Table:

Table 1001-3: Testing Requirements

Test	ASTM Standard	Minimum Test Frequency of Placed Material
Moisture-density Relationship	D698	One per 50 m^3
In-Situ Density	D5195	One per 300 m^3
Grain Size Distribution	D422	One per 500 m^3

END OF SECTION

SECTION 1002: HDPE GEOMEMBRANE

1.0 GENERAL

1.1 Summary

.1 This specification includes furnishing and installing HDPE geomembranes with a formulated sheet density of 0.940 g/cc or greater associated with HDPE geomembranes.

1.2 References

Where material properties are specified, the following standards are applicable:

.1 American Society for Testing and Materials (ASTM):

.a D 413, Standard Test Methods for Rubber Property—Adhesion to Flexible Substrate

.b D 638, Standard Test Method for Tensile Properties of Plastics.

.c D 751, Standard Test Methods for Coated Fabrics.

.d D 792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

.e D 1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

.f D 1204, Standard Test Method for Linear Dimensional Changes of Non Rigid Thermoplastic Sheeting or Film at Elevated Temperature.

.g D 1238, Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.

.h D 1505, Standard Test Method for Density of Plastics by Density-Gradient Technique.

.i D 1603, Standard Test Method for Carbon Black in Olefin Plastics.

.j D 3895, Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.

.k D 4218, Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.

.l D 4437, Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.

.m D 4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

.n D 5199, Standard Test Method for Measuring Nominal Thickness of Smooth Geomembranes.

.o D 5397, Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefins using Notched Constant Tensile Load Test.

.p D 5596, Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.

.q D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.

.r D 5820, Test Method for Air Testing.

.s D 5994, Standard Test Method for Measuring Nominal Thickness of Textured Geomembranes.

.t D 6365, Standard Practice for the Non-destructive Testing of Geomembrane Seams using The Spark Test.

.u D 6392 Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

.v D 5820-95, Pressurized Air Channel Test for Dual Seamed Geomembranes.

.2 Geosynthetic Research Institute (GRI)

.a GRI GM 9, Cold Weather Seaming of Geomembranes

.b GRI GM 10, The Stress Crack Resistance of HDPE Geomembrane Sheet

.c GRI GM 12, Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage

.d GRI GM 13, Test Properties, Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

.e GRI GM 14, Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes

.f GRI GM 19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.3 Submittals

.1 Submit the following to the Engineer or Owner for review and approval, within a reasonable time so as to expedite shipment or installation of the Geomembrane:

.a Documentation of manufacturer's qualifications as specified in subsection 1.4 of this Section.

.b Manufacturer's Quality Control program manual or descriptive documentation.

.c A material properties sheet, including at a minimum all properties specified in GRI GM 13, including test methods used.

.d Sample of the material.

.e Documentation of Installer's qualifications, as specified below and in Subsection 1.4 of this Section:

i. Submit a list of at least ten completed facilities. For each installation, provide: name and type of facility; its location; the date of installation; name and telephone number of contact at the facility; type and thickness of geomembrane and; surface area of the installed geomembrane.

ii. Submit resumes or qualifications of the Installation Supervisor, Master Seamer and Technicians to be assigned to this project.

iii. Submit written Welding Procedures for each type of weld to be used, describing the following minimum parameters. The Welding Procedure shall incorporate:

- Joint geometry.
- Specific base resins or range of resin properties for sheet and filler material to which the procedure applies (identify by manufacturer and resin name).
- Limitations with respect to positions or locations, such as slopes, vertical, overhead, etc.
- Type and extent of surface preparation required.
- Temperature settings for equipment, including descriptions for method and frequency of monitoring.

- Ambient conditions at which the procedure is applicable. Indicate method of measurement for each parameter.

.f Submit all information pertaining to the type of welding equipment to be used and provide the Owner with the opportunity to inspect a log record of maintenance and overhaul history of the seaming equipment and accessories (generator, power cords, volt meter, etc.).

.g Quality Control Program.

.2 Example Material Warranty and Liner Installation Warranty

.3 Shop Drawings

.a Submit copies of shop drawings for Engineer's approval within a reasonable time so as not to delay the start of geomembrane installation. Shop drawings shall show the proposed panel layout identifying seams and details. Seams should generally follow the direction of the slope. Butt seams or roll-end seams should not occur on a slope unless approved by the Owner or Engineer. Butt seams on a slope, if allowed, should be staggered.

.b Placement of geomembrane should not be allowed to proceed until Owner's Representative has received and approved the shop drawings.

.4 Additional Submittals (In-Progress and at Completion)

.a Manufacturer's warranty

.b Geomembrane installation warranty

.c Low-temperature seaming procedures

.d Field seam non-destructive test results

.e Field seam destructive test results

.f Daily field installation reports

.g Installation record drawing

1.4 Quality Control

.1 Manufacturer's Qualifications:

.a The manufacturer of geomembrane of the type specified or similar product shall have at least five years of experience in the manufacture of such geomembrane.

.b In addition, the geomembrane manufacturer shall have manufactured at least 1,000,000 m^2 (10,000,000 ft^2) of the specified type of geomembrane or similar product during the last five years.

.2 Installer's Qualifications

.a The Geomembrane Installer shall be the Manufacturer, approved Manufacturer's Installer or a contractor approved by the Owner's Representative to install the geomembrane.

.b The Geomembrane Installer shall have at least three years of experience in the installation of the specified geomembrane or similar. The Geomembrane Installer shall have installed at least 10 projects involving a total of 500,000 m^2 of the specified type of geomembrane or similar during the last three years.

.c Installation shall be performed under the direction of a field Installation Supervisor who shall be responsible throughout the geomembrane installation, for geomembrane panel layout, seaming, patching, testing, repairs, and all other activities of the Geomembrane Installer. The Field Installation Supervisor shall have installed or supervised the installation and seaming of a minimum

of 10 projects involving a total of 500,000 m^2 of geomembrane of the type specified or similar product.

.d Seaming shall be performed under the direction of a Master Seamer (who may also be the Field Installation Supervisor or Crew Foreman) who has seamed a minimum of 300,000 m^2 of geomembrane of the type specified or similar product, using the same type of seaming apparatus to be used in the current project. The Field Installation Supervisor and/or Master Seamer shall be present whenever seaming is performed.

.e All seaming, patching, other welding operations, and testing shall be performed by qualified technicians employed by the Geomembrane Installer.

1.5 Transport, Storage, and Handling

.1 General

.a Ensure that the geomembrane is not folded at any time during the manufacture, fabrication, shipping, or installation processes.

.2 Identification

.a Each roll of geomembrane delivered to the site shall be labelled by the manufacturer. The label shall be firmly affixed and shall clearly state the manufacturer's name, product identification, material thickness, roll number, roll dimensions, and roll weight.

.b If the manufactured rolls are assembled into panels prior to shipping, the label shall also include the panel number and the roll numbers which comprise the manufactured panel.

.3 Transportation

.a Place a sacrificial strip of membrane between the geomembrane and each strap.

.b Cut off the free ends of metal strapping prior to shipping.

.c Install protective caps to cover and protect the edge of the geomembrane during transportation.

.4 Site Handling and Storage

.a Store rolls on a sacrificial sheet at site. Continuously and uniformly support rolls on a smooth, level prepared surface.

.b Geomembrane shall be protected from mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

.c Rolls shall be stored away from high traffic areas.

.d Any damage to the material resulting from manufacturing, shipping, or handling shall be identified to the Owner or the Owner’s Representative.

1.6 Project Conditions

.1 Geomembrane should not be installed in the presence of standing water, while precipitation is occurring, during excessive winds, or when material temperatures are outside the limits specified in Part 3.

1.7 Material Warranty

.2 Material warranty shall be five years or as otherwise agreed by the Manufacturer and the Owner.

1.8 Geomembrane Installation Warranty

.1 The Geomembrane Installer shall guarantee the geomembrane installation against defects in the installation and workmanship for two years commencing with the date of final acceptance.

2.0 PRODUCTS

2.1 Source Quality Control

.1 Manufacturing Quality Control

.a The test methods and frequencies used by the manufacturer for quality control/quality assurance of the above geomembrane prior to delivery shall be in accordance with GRI GM 13 for HDPE geomembrane or modified as required for project specific conditions.

.b The manufacturer's geomembrane quality control certifications, including results of quality control testing of the products, must be supplied to the Owner's Representative to verify that the materials supplied for the project are in compliance with all product and or project specifications in this Section. The certification shall be signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager. Certifications shall include lot and roll numbers and corresponding shipping information.

.c The Manufacturer will provide Certification that the geomembrane and welding rod supplied for the project are made from the same material type and are compatible.

.2 Geomembrane

.a The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this work which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes.

.b The geomembrane rolls shall be seamless, high density polyethylene (HDPE - Formulated Sheet Density ≥ 0.94g/cc) containing no plasticizers, fillers, or extenders and shall be free of holes, blisters or contaminants, and leak free verified by 100% in line spark or equivalent testing.

.c The geomembrane shall be supplied as a continuous sheet with no factory seams in rolls.

.d The geomembrane will meet the property requirements as shown in Table 4 (GRI GM 13) below:

Table 1002-4: Geomembrane Properties

Properties	ASTM Test Method	Test Value 1.5 mm	Testing Frequency
Thickness (min ave.) – lowest individual of 10 values	D5199	Nom -10%	Per roll
Density (min)	D1505/ D792	0.940 g/cc	90,000 kg
Tensile Properties [1] (min. ave.) – Yield strength – Break strength – Yield elongation – Break elongation	D6693 Type IV	 22 kN/m 40 kN/m 12 % 700%	9,000 kg
Tear Resistance (min. ave.)	D1004	187 N	20,000 kg
Puncture Resistance (min. ave.)	D4833	480 N	20,000 kg
Stress Crack Resistance [2]	D5397 (App.)	300 hr	Per GRI-GM10
Carbon Black Content (range)	D4218[3]	2.0 – 3.0%	9,000 kg
Carbon Black Dispersion	D5596	Note[4]	20,000 kg
Oxidative Induction Time (OIT) (min. ave.)[5] a) Standard OIT - or - b) High Pressure OIT	 D3895 D5885	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C[5,6] a) Standard OIT (min. ave.) - % retained after 90 days - or - b) High Pressure OIT (min. ave.) - % retained after 90 days	D5721 D3895 D5885	 55% 80%	Per each formulation
UV Resistance[7] a) Standard OIT (min. ave.) - or - b) High Pressure OIT (min. ave.) - % retained after 1,600 hrs[9]	GM11 D3895 D5885	 N.R.[8] 50%	Per each formulation

[1] Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gage length of 33 mm. Break elongation is calculated using a gage length of 50 mm.
[2] The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
[3] Other methods such as D1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.
[4] Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3.
[5] The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
[6] It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
[7] The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60 °C.
[8] Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
[9] UV resistance is based on percent retained value regardless of the original HP-OIT value.

Table 1002-5: Geomembrane Seam Properties

Geomembrane Nominal Thickness	1.5 mm
Hot Wedge Seams[1]	
– Shear strength [2], N/25 mm	525
– Shear elongation at break[3]	50
– Peel strength[2], N/25 mm	340
– Peel separation, %	25

[1] Also for hot air and ultrasonic seaming methods.
[2] Value listed for shear and peel strength are for 4 out of 5 test specimens; the 5th specimen can be low as 80% of the listed values.
[3] Elongation measurements should be omitted for field testing.

.e The geomembrane seams shall meet the property requirements as shown in Table 1 of GRI GM 19 and reproduced below:

Table 1002-6: Geotextile Properties

Property [1]	ASTM Test Method	Unit	MARV (12 oz)
Weight (typical)	D5261	oz/yd^2 (g/m^2)	12.0 (407)
Grab Tensile	D4632	lbs (kN)	300 (1.33)
Grab Elongation	D4632	%	50
Trapezoid Tear Strength	D4533	lbs (kN)	115 (0.511)
Puncture Resistance	D6241	lbs (kN)	790 (3.51)
U.V. Resistance[2]	D4355	%/hrs	70/500

[1] All values are Minimum Average Roll Value except UV resistance which is minimum value.
[2] Evaluation to be on a 2.0-inch strip tensile specimen after 500 hours of exposure.

3.0 EXECUTION

3.1 Subgrade Preparation

.1 The subgrade shall be prepared in accordance with the project specifications. The geomembrane subgrade shall be uniform and free of sharp or angular objects that may damage the geomembrane prior to installation of the geomembrane.

.2 The Geomembrane Installer and Owner's Representative shall inspect the surface to be covered with the geomembrane on each day's operations prior to placement of geomembrane to verify suitability.

.3 The Geomembrane Installer and Owner's Representative shall provide daily written acceptance for the surface to be covered by the geomembrane in that day's operations. The surface shall be maintained in a manner to ensure subgrade suitability.

.4 All subgrade damaged by construction equipment and deemed unsuitable for geomembrane deployment shall be repaired prior to placement of the geomembrane. All repairs shall be approved by the Owner's Representative and the Geomembrane Installer.

3.2 Geomembrane Placement

.1 No geomembrane shall be deployed until the applicable certifications and quality control certificates listed in Part 1 of this Section are submitted to and approved by the Owner's Representative within the

timeframe specified in the Contract Documents. If the material does not meet project specifications it shall be removed from the work area.

.2 The geomembrane shall be installed to the limits shown on the project Drawings and essentially as shown on approved panel layout drawings.

.3 No geomembrane material shall be unrolled and deployed if the material temperatures are lower than 0 degrees C unless otherwise approved by the Owner's Representative in writing. The specified minimum temperature for material deployment may be adjusted by the Owner's Representative. Temperature limitations should be defined in the preconstruction meeting. Typically, only the quantity of geomembrane that will be anchored and seamed together in one day should be deployed.

.4 No vehicular traffic shall travel on the geomembrane other than an approved low ground pressure vehicle or equivalent.

.5 Sand bags or equivalent ballast shall be used as necessary to temporarily hold the geomembrane material in position under the foreseeable and reasonably-expected wind conditions. Sand bag material shall be sufficiently close-knit to prevent soil fines from working through the bags and discharging on the geomembrane.

.6 Geomembrane placement shall not be done if moisture prevents proper subgrade preparation, panel placement, or panel seaming. Moisture limitations should be defined in the preconstruction meeting.

.7 Damaged panels or portions of the damaged panels which have been rejected shall be marked and their removal from the work area recorded.

.8 The geomembrane shall not be allowed to "bridge over" voids or low areas in the subgrade. The geomembrane shall rest in intimate contact with the subgrade.

.9 Wrinkles caused by panel placement or thermal expansion should be minimized.

.10 Build in adequate slackness to allow for thermal contraction without significant applied stress at temperatures between ambient temperature at installation and -50 degrees C.

.11 Considerations on Site Geometry: In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric locations, the total length of field seams shall be minimized. Seams shall not be located at low points in the subgrade unless geometry requires seaming at such locations and if approved by the Owner's Representative. Welds on slopes must be constructed with the upper panel overtop of the lower panel.

.12 Overlapping: The panels shall be overlapped prior to seaming to whatever extent is necessary to affect a good weld and allow for proper testing. In no case shall this overlap be less than 75 mm.

3.3 Equipment

.1 The Geomembrane Installer shall maintain at least one spare operable seaming unit on site at all times.

3.4 Seaming Procedures

.1 The welding technique shall produce a joined interface of uniform properties across the full width of the weld.

.2 Welding may only be performed within the "window" of parameters supplied by the Contractor in the written Welding Procedures.

.3 Portable structures may be used to facilitate attainment of these parameters in the area to be seamed, but must be approved by the Owner's representative.

.4 Welding shall not proceed when the prepared surfaces cannot be maintained free of moisture.

.5 All surfaces to be joined shall be cleaned free of grease, oils, dirt, and foreign material.

.6 Prepared surfaces shall not remain exposed for more than 30 minutes before welding.

.7 Cold weather installations should follow guidelines as outlined in GRI GM9.

.8 No geomembrane material shall be seamed when liner temperatures are less than 0 degrees C unless the following conditions are complied with:

.a Seaming of the geomembrane at material temperatures below 0 degrees C (measured 150 mm above the geomembrane surface) is allowed if the Geomembrane Installer can demonstrate to the Owner's Representative, using pre-qualification test seams, that field seams comply with the project specifications, the safety of the crew is ensured, and geomembrane material can be fabricated (i.e. pipeboots, penetrations, repairs. etc.) at sub-freezing temperatures.

.b The Geomembrane Installer shall submit to the Owner's Representative for approval, detailed procedures for seaming at low temperatures, possibly including the following:

i. Preheating of the geomembrane

ii. The provision of a tent or other device if necessary to prevent heat losses during seaming and rapid heat losses subsequent to seaming.

iii. Number of test welds to determine appropriate seaming parameters

.9 No geomembrane material shall be seamed when the sheet temperature is above 75 degrees C as measured by an infrared thermometer or surface thermocouple unless otherwise approved by the Owner's Representative. This approval will be based on recommendations by the manufacturer and on a field demonstration by the Geomembrane Installer using prequalification test seams to demonstrate that seams comply with the specification.

.10 Seaming shall primarily be performed using automatic fusion welding equipment and techniques. Extrusion welding shall be used where fusion welding is not possible such as at pipe penetrations, patches, repairs, and short (less than a roll width) runs of seams.

.11 Fishmouths or excessive wrinkles at the seam overlaps shall be minimized and when necessary cut along the ridge of the wrinkles back into the panel so as to effect a flat overlap. The cut shall be terminated with a keyhole cut (nominal 10 mm diameter hole) so as to minimize crack/tear propagation. The overlay shall subsequently be seamed. The key hole cut shall be patched with an oval or round patch of the same base geomembrane material extending a minimum of 150 mm beyond the cut in all directions.

3.5 Field Quality Control

The Owner's Representative shall be notified prior to all pre-qualification and production welding and testing, or as agreed upon in the preconstruction meeting.

.1 Prequalification Test Seams

.a Test seams shall be prepared and tested by the Geomembrane Installer to verify that seaming parameters (speed, temperature, and pressure of welding equipment) are adequate.

.b Test seams shall be made by each welding technician and tested in accordance with ASTM D 4437 at the beginning of each seaming period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately 3.3 m long for fusion welding and 1 m long for extrusion welding with the seam centered lengthwise. At a minimum, test seams should be made by each technician one time every four to six hours; additional tests may be required with changes in environmental conditions.

.c Two 25 mm wide specimens shall be die-cut by the Geomembrane Installer from each end of the test seam. These specimens shall be tested by the Geomembrane Installer using a field tensiometer testing both tracks for peel strength and also for shear strength. Each specimen should fail in the parent material and not in the weld, “Film Tear Bond"(F.T.D. failure). Seam separation equal to or greater than 25% of the track width shall be considered a failing test.

.d The minimum acceptable seam strength values to be obtained for all specimens tested are listed in Part 2 of this Section. Four specimens shall pass for the test seam to be a passing seam.

.e If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam can be produced.

.f A sample from each test seam shall be labelled. The label shall indicate the date, geomembrane temperature, number of the seaming unit, technician performing the test seam, and pass or fail description. The sample shall then be given to the Owner's Representative for archiving.

.2 Field Seam Non-Destructive Testing

.a All field seams shall be non-destructively tested by the Geomembrane Installer over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester, and outcome of all non-destructive testing shall be recorded and submitted to the Owner's Representative.

.b Testing should be done as the seaming work progresses, not at the completion of all field seaming, unless agreed to in advance by the Owner's Representative. All defects found during testing shall be numbered and marked immediately after detection. All defects found should be repaired, retested, and remarked to indicate acceptable completion of the repair.

.c Non-destructive testing shall be performed using vacuum box, air pressure, or spark testing equipment.

.d Non-destructive tests shall be performed by experienced technicians familiar with the specified test methods. The Geomembrane Installer shall demonstrate to the Owner's Representative all test methods to verify that the test procedures are valid.

.e Extrusion seams shall be vacuum box tested by the Geomembrane Installer in accordance with ASTM D 4437 and ASTM D 5641 with the following equipment and procedures:

.f The vacuum pump shall be charged and the tank pressure adjusted to approximately 35 kPa.

.g The Geomembrane Installer shall create a leak tight seal between the gasket and geomembrane interface by wetting a strip of geomembrane approximately 0.3 m by 1.2 m (length and width of box) with a soapy solution, placing the box over the wetted area, and then compressing the box against the geomembrane. The Geomembrane Installer shall then close the bleed valve, open the vacuum valve, maintain initial pressure of approximately 35 kPa for approximately 5 seconds. The geomembrane should be continuously examined through the viewing window for the presence of

soap bubbles, indicating a leak. If no bubbles appear after five seconds, the area shall be considered leak free. The box shall be depressurized and moved over the next adjoining area with an appropriate overlap and the process repeated.

.h All areas where soap bubbles appear shall be marked, repaired and then retested.

.i At locations where seams cannot be non-destructively tested alternate non-destructive spark testing or equivalent should be substituted.

.j Equipment for Spark testing shall be comprised of but not limited to: A hand held holiday spark tester and conductive wand that generates a high voltage

.k The testing activities shall be performed by the Geomembrane Installer by placing an electrically conductive tape or wire beneath the seam prior to welding. A trial seam containing a non-welded segment shall be subject to a calibration test to ensure that such a defect (non-welded segment) will be identified under the planned machine settings and procedures. Upon completion of the weld, enable the spark tester and hold approximately 25 mm above the weld moving slowly over the entire length of the weld in accordance with ASTM 6365. If there is no spark the weld is considered to be leak free.

.l A spark indicates a hole in the seam. The faulty area shall be located, repaired and retested by the Geomembrane Installer.

.m Care should be taken if flammable gases are present in the area to be tested.

.n All seams that are vacuum tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

.o Double Fusion seams with an enclosed channel shall be air pressure tested by the Geomembrane Installer in accordance with ASTM D 5820 and ASTM D 4437 and the following equipment and procedures:

.p Equipment for testing double fusion seams shall be comprised of but not limited to: an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of 210 kPa mounted on a cushion to protect the geomembrane; and a manometer equipped with a sharp hollow needle or other approved pressure feed device.

.q The Testing activities shall be performed by the Geomembrane Installer. Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld. The air pump shall be adjusted to a pressure of 210 kPa, and the valve closed. Allow two minutes for the injected air to come to equilibrium in the channel, and sustain pressure for five minutes. If pressure loss does not exceed 28 kPa after this five minute period the seam shall be considered leak tight. Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed and the feed hole sealed.

.r If loss of pressure exceeds 28 kPa during the testing period or pressure does not stabilize, the faulty area shall be located, repaired, and retested by the Geomembrane Installer.

.s Results of the pressure testing shall be recorded on the liner at the seam tested and on a pressure testing record.

.3 Destructive Field Seam Testing

.a One destructive test sample per 150 linear m seam length or another predetermined length in accordance with GRI GM 14 shall be taken by the Geomembrane Installer from a location specified by the Owner's Representative. The Geomembrane Installer shall not be informed in advance of the sample location. In order to obtain test results prior to completion of geomembrane installation, samples shall be cut by the Geomembrane Installer as directed by the Owner's Representative as seaming progresses.

.b All field samples shall be marked with their sample number and seam number. The sample number, date, time, location, and seam number shall be recorded. The Geomembrane Installer shall repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum box tested or spark tested. If a patch cannot be permanently installed over the test location on the same day of sample collection, a temporary patch shall be tack welded or hot air welded over the opening until a permanent patch can be affixed.

.c The destructive sample size shall be 300 mm wide by 1 m long with the seam centered lengthwise. The sample shall be cut into three equal sections and distributed as follows: one section given to the Owner's Representative as an archive sample; one section given to the Owner's Representative for laboratory testing as specified in Paragraph 5 below; and one section retained by the Geomembrane Installer for field testing as specified in Paragraph 6 below.

.d For field testing, the Geomembrane Installer shall cut 10 identical 25 mm wide replicate specimens from the sample. The Geomembrane Installer shall test five specimens for seam shear strength and five for peel strength as per ASTM 6392. Peel tests will be performed on both inside and outside weld tracks. To be acceptable, four of five test specimens must pass the stated criteria in Part 2 with less than 25% separation. If four of five specimens pass, the sample qualifies for testing by the testing laboratory if required.

.e If independent seam testing is required by the specifications it shall be conducted in accordance with ASTM 5820 or ASTM D4437 or GRI GM 6.

.f Reports of the results of examinations and testing shall be prepared and submitted to the Owner's Representative.

.g For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the Geomembrane Installer at locations indicated by the Owner’s Representative; typically 3 m on either side of the failed sample and laboratory seem tests shall be performed. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams and all seams represented by the destructive test location shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box tested until adequacy of the seams is achieved. Cap strip seams exceeding 50 m in length shall be destructively tested.

.4 Destructive test results shall be reported prior to covering of liner or within 48 hours.

.5 Identification of Defects

.a Panels and seams shall be inspected by the Installer and Owner's Representative during and after panel deployment to identify all defects, including holes, blisters, undispersed raw materials, and signs of contamination by foreign matter.

.6 Evaluation of Defects: Each suspect location on the liner (both in geomembrane seam and non-seam areas) shall be non-destructively tested using one of the methods described previously. Each location which fails non-destructive testing shall be marked, numbered, measured and posted on the daily "installation" drawings and subsequently repaired.

.a If a destructive sample fails the field or laboratory test, the Geomembrane Installer shall repair the seam between the two nearest passed locations on both sides of the failed destructive sample location.

.b Defective seams, tears, or holes shall be repaired by reseaming or applying an extrusion welded cap strip.

.c Reseaming may consist of either:

i. Removing the defective weld area and rewelding the parent material using the original welding equipment; or

ii. Reseaming by extrusion welding along the overlap at the outside seam edge left by the fusion welding process.

.d .Blisters, larger holes, and contamination by foreign matter shall be repaired by patches and/or extrusion weld beads as required. Each patch shall extend a minimum of 150 mm beyond all edges of the defects.

.e All repairs shall be measured, located and recorded

.7 Verification of Repairs on Seams: Each repair shall be non-destructively tested using either vacuum box or spark testing methods. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be reseamed and retested until a passing test results. The number, date, location, technician, and test outcome of each patch shall be recorded.

.8 Field Installation Reports: At the beginning of each day's work, the Installer shall provide the Owner's Representative with daily reports for all work accomplished on the previous work day. Reports shall include the following:

.a Total amount and location of geomembrane placed;

.b Total length and location of seams completed, name of technicians doing seaming and welding unit numbers;

.c Drawings of the previous day's installed geomembrane showing panel numbers, seam numbers and locations of non-destructive and destructive testing;

.d Results of pre-qualification test seams;

.e Results of non-destructive testing; and

.f Results of vacuum testing of repairs.

.g Hourly temperatures during seaming which includes the actual temperature of the surface of the geomembrane (using a pyrometer) and the ambient air temperature measured approximately 1 m above the geomembrane.

.h The method of removing frost from the area to be seamed (if any is present), as well as drying and cleaning of the surfaces involved, should be described.

.i The condition of the subgrade beneath the area being seamed should be assessed. If a rub sheet is used during the seam process it should be noted.

.j Complete identification of the field seaming system used, including material, methods, preheat, seaming rate, use of tents or enclosures and other details of the procedure should be documented.

.k The type, nature, number, condition, and details of trial seams, as well as the results of such tests, should be detailed.

.l The type, nature, number, and details of destructive samples and disposition of sections of the sample should be described. Proper identification is required to identify results of CQA laboratory testing in the final as-built plans of the project.

.m Any unusual condition with respect to personnel, equipment, sampling, and/or testing that may be attributable to the cold weather should be described and documented.

.9 Additional Documentation

.a A panel is defined as the unit area of a geomembrane which is to be seamed in the field. If the liner is not fabricated into panels prior to delivery, then a panel is considered to be a roll or a portion of a roll of material.

.b Each panel shall be given a Panel Identification Code, consistent with the layout plan. The Panel I.D. Code will be used for all Quality Assurance records.

.c Each Field-seam shall be identified and sequentially numbered on the as-built drawing. Include the date of seaming, identifying number of welding machine, and operator name. Identify on the drawing where the machine or operator was changed.

.d If a fabricated panel is being used, the Contractor shall also indicate the locations of all factory seams on this drawing, and shall differentiate between field seams and factory seams.

3.6 Liner Acceptance

.1 Geomembrane liner will be accepted by the Owner's Representative when:

.a The entire installation is finished or an agreed upon subsection of the installation is finished;

.b All Installer’s QC documentation is completed and submitted to the owner

.c Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete.

3.7 Anchor Trench

.1 Construct as specified on the project Drawings.

3.8 Disposal of Scrap Materials

.1 On completion of installation, the Geomembrane Installer shall dispose of all trash and scrap material in a location approved by the Owner, remove equipment used in connection with the work herein, and shall leave the premises in a neat acceptable manner. No scrap material shall be allowed to remain on the geomembrane surface.

END OF SECTION

SECTION 1003: GEOTEXTILE

1.0 GENERAL

1.1 General

.1 This specification covers nonwoven geotextile test properties for subsequent use as protection (or cushioning) materials. The typical use will be as a protective covering or underlayment of a geomembrane against puncture or tear due to rock, stones, concrete, or other hard surfaces and/or objects.

1.2 References

Where material properties are specified, the following standards are applicable:

American Society for Testing and Materials (ASTM)

.1 ASTM D 4354 Practice for Sampling of Geosynthetics for Testing.

.2 ASTM D 4355 Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

.3 ASTM D 4533 Test Method for Trapezoidal Tearing Strength of Geotextiles.

.4 ASTM D 4632 Test Method for Grab Breaking Load and Elongation of Geotextiles.

.5 ASTM D 4759 Practice for Determining the Specification Conformance of Geosynthetics.

.6 ASTM D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

.7 ASTM D 4873 Guide for Identification, Storage and Handling of Geotextiles.

.8 ASTM D 5261 Test Method for Measuring Mass per Unit Area of Geotextiles.

.9 ASTM D 5494 Test Method for the Determination of Pyramid Puncture Resistance of Unprotected and Protected Geomembranes.

.10 ASTM D 6241 Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Product Using a 50-mm Probe.

Geosynthetic Research Institute (GRI)

.1 GRI GT12. Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials.

2.0 PRODUCTS

2.1 Materials

.1 12 oz. needle-punched nonwoven geotextile made of 100% polypropylene staple fibers conforming to the following properties to meet or exceed GRI GT12.

.a Table:

Table 1003-7 Geotextile Properties

PROPERTY (1)	TEST METHOD	UNIT	MARV (12 oz.)
Weight (Typical)	ASTM D5261	oz/yd^2 (g/m^2)	12.0 (407)
Grab Tensile	ASTM D4632	lbs (kN)	300 (1.33)
Grab Elongation	ASTM D4632	%	50
Trapezoid Tear Strength	ASTM D4533	lbs (kN)	115 (0.511)
Puncture Resistance	ASTM D6241	lbs (kN)	790 (3.51)
U.V. Resistance (2)	ASTM D4355	%/hrs	70/500

Notes:
(1) All values are Minimum Average Roll Value except UV resistance which is a minimum value.
(2) Evaluation to be on a 2.0-inch strip tensile specimen after 500 hours of exposure.

3.0 EXECUTION

3.1 General

.1 Deliver, store, and handle geotextile in accordance with ASTM D4873.

.a Delivery: Each geotextile roll shall be wrapped with a material that will protect the geotextile, including the ends of the roll, from damage due to shipment, water, sunlight and contaminants. The protective wrapping shall be maintained during periods of shipment and storage. The plastic wrapping shall not be removed until deployment. Geotextile or plastic wrapping damaged during storage or handling shall be repaired or replaced, as directed. Label each roll with the manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured.

.b Storage: During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 160°F (71°C), and any other environmental condition that may damage the property values of the geotextile. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate.

.c Handling: Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Rolls shall not be dragged along the ground, lifted by one end, or dropped to the ground.

.2 Installation

.a Place geotextile directly on top of and below geomembrane as shown on the drawings. The surface must be smooth and free of sharp objects.

.b Where located below a geomembrane, maintain intimate contact between geotextile and soil so that no void spaces occur. Avoid laps and folds in the geotextile.

.c Employ sufficient anchorage to hold the geotextile in place during deployment and backfilling.

.d Do not cover geotextile prior to inspection and approval by the Owner's Representative.

.e Place fill material or geomembrane immediately after inspection is complete.

.f Placement of soil cover soil:

i. Place in a manner that prevents soil from entering the geotextile overlap zone, prevents tensile stress from being mobilized in the geotextile, and prevents wrinkles from folding over onto themselves.

ii. Maximum drop height for fill directly onto geotextile is 1 m.

iii. Minimum lift thickness prior to starting compaction is 300 mm.

.g On side slopes, soil backfill shall be placed from the bottom of the slope upward.

.h Seams and Joints: Seams shall be overlapped, minimum overlap 600 mm.

.i Heat tack or sew seams.

.j Anchor the geotextile at the perimeter of the landfarm as shown on the Drawings.

.3 Protection

.a Do not permit passage of any vehicle directly on the geotextile.

END OF SECTION

SECTION 1004: SURVEYING

1.0 GENERAL

1.1 Qualifications of Surveyor

.1 Qualified experienced Surveyor(s), acceptable to Owner's Representative.

1.2 Survey Reference Points

.1 Locate, confirm, and protect control points prior to starting site work.

.2 Preserve permanent reference points during construction.

.3 Make no changes or relocations without prior written notice to Owner's Representative.

.4 Report to Owner's Representative when reference point is lost or destroyed, or requires relocation because of necessary changes in grades or locations.

2.0 PRODUCTS

2.1 Survey Equipment

.1 RTK GPS receiver and base station with minimum 0.01 m accuracy, tripod, spare battery, battery charger, downloading hardware and software and all associated ancillary items (cables, hardlock, etc.).

.2 Automatic level with tripod.

.3 Single prism with 5 m collapsible range pole.

.4 Triple prism with tripod.

.5 50 m cloth tape (steel reinforced).

.6 5 m collapsible level rod.

.7 Magnetic pin finder (high frequency).

2.2 Survey Markers

.1 Provide all survey markers and other items required to complete work as specified, including, but not limited to:

.a Pointed stakes (minimum 1.2 m in length, 12 mm thick, 38 mm wide)

.b Pointed hubs (minimum 0.5 m in length, 20 mm thick, 38 mm wide)

.c Nails (100 mm long), spikes (250 mm long), pins (1 m long), etc.

.d Fluorescent paint, flagging, etc.

.e Felt markers, chalk, wax pens, etc.

.2 Maintain supply of survey markers for Owner's Representative's use

3.0 EXECUTION

3.1 General

.1 Establish stable temporary survey control points for use in laying out work.

.2 Establish lines and levels, locate, and lay out, by instrumentation.

.3 Prepare a topographic map of work sites prior to construction as directed by Owner's Representative to provide a baseline survey.

.4 Stake location of facilities in the field, and prepare a record drawing showing final location and contours of the facilities.

.5 Maintain surveys for quantity calculations.

3.2 Records

.1 Maintain a complete, accurate log of control and survey work as it progresses.

3.3 Submittals

.1 Submit name of Surveyor(s) to Owner's Representative.

.2 On request of Owner's Representative, submit documentation (e.g. raw survey observations) to verify accuracy of work. Maintain accuracy to 0.01 m vertically and 0.01 m horizontally.

.3 Topographic survey data shall include sufficient points and changes in slope to accurately depict the topography.

.4 Submit survey data backup for quantities of earthworks fill materials.

.5 Submit survey data in the following electronic formats or equivalent:

.a Survey point file (.csv or .xls).

.b AutoCAD File (.dxf or .dwg).

.c Copy of survey field book or field book file (.fbk).

.6 All survey data files must include the following information:

.a Date of survey, descriptive site name, and site location.

.b Survey point information including point number, descriptor, UTM co-ordinates with NAD83 datum, and elevation from sea level.

END OF SECTION