DILLON CONSULTING

CITY OF IQALUIT

Phase I Design Report (30% Submission)

Landfill and Waste Transfer Station

June 2019 | 19-9543

June 7, 2019

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Attention: Mr. Erik Marko, P.Eng. PMP
Project Manager

Iqaluit Landfill and Transfer Station
Phase I Design Report

Dear Mr. Marko:

Please find attached a copy of the Phase I Design Report for the Iqaluit Landfill and Transfer Station. This report presents the 30% design submission for the project.

If you have any questions regarding the information contained within the document, please don't hesitate to contact me at (867) 920-4555 ext. 4310, or by email at kbarnes@dillon.ca.

Sincerely,

DILLON CONSULTING LIMITED

Keith Barnes, P.Eng.
Project Manager

KGB:slg

Our file: 19-9543

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1.0 Introduction

The City of Iqaluit (City) is in the process of implementing its Solid Waste Management Strategy to service their near and long-term (75 years) municipal solid waste (MSW) disposal requirements. Founded on a previously completed conceptual design and facility siting exercise (see **Figure 1–1**), key elements of the project include a solid waste transfer station (WTS) within the immediate urban area of the City, where residential and commercial waste will be hauled to, processed, and compacted in bales or in the case of waste wood and cardboard, shredded and pelletized for use as a fuel source for an on-site biomass boiler. Tires, metals, and some construction and demolition (C&D) wastes will also be shredded and/or baled for landfilling or transported south for recycling. The resulting solid waste bales and possibly a smaller amount of unbaled C&D waste will be trucked to an engineered balefill / landfill site (Landfill) located approximately 6 km from the WTS. The vehicles transferring the waste bales will access the road leading to the Landfill from the WTS, to avoid having the transfer vehicle travel through the City.

Figure 1-1: Facility Site Locations

Other planned features of the WTS include a public drop off area for household hazardous wastes (HHW) and a vehicle logger/compactor unit; in both instances, allowing for the preparation of waste materials prior to shipping to approved management facilities in the south.

The access road that will be used to reach the new Landfill has been designed by EXP Services Inc. (EXP), who will also be providing Construction Contract Administration services for the construction of the road. It is anticipated that the construction of the road will be included in the new Landfill and WTS Contractor's scope of work.

To address their objectives, and following a competitive proposal process, the City engaged Dillon Consulting Limited (Dillon) in March 2019 to provide design and construction contract administration services to support the establishment of the WTS/baling facility and the Landfill. The Landfill will be designed for 75 years of operation. The first stage of the Landfill (Stage 1 Operational Landfill) will be constructed, which is the first two cells (e.g., five years per cell) and ancillary components to meet five and 10 year operational requirements

Development of the proposed facilities is scheduled to occur during the 2020 and 2021 construction seasons, with facility commissioning in the fall of 2021.

2.0 Purpose of this Document

As defined in the City's request for proposal (RFP) for this project and as detailed in Dillon's February 2019 proposal submission, the completion of the design and construction administration effort to support the establishment of the Landfill and WTS is to occur over four phases:

- Phase I –Pre-Design (30% Submission)
- Phase II –Preliminary Design (50% Submission)
- Phase III –Final Design (90 and 100% Submission)
- Phase IV –Contract Administration and Construction Inspection

This document addresses the deliverable requirements for **Phase I**, and presents the findings and recommendations of the following project tasks under this phase:

- Task 1 – Project Start/Kick Off Meeting/Initial Site Reconnaissance
- Task 2 – Review Existing Information and Conduct Additional Services
- Task 3 – Prepare Conceptual Design Information to Support City's Application Requirements
- Task 4 – Prepare/Submit Pre-Design Report
- Task 5– Prepare/Submit Draft Project Support Documents

Following **Section 1** (Introduction) and **Section 2** (Purpose of this Document), the Phase I Pre-Design Report is organized as follows:

- Section 3 – Key Project Assumptions
- Section 4 – Supplementary Site Investigations
- Section 5 – Facility Performance and Design Parameters
- Section 6 – Design and Construction Options Analysis
- Section 7 – Conceptual Design Information
- Section 8 – Project Support Documents
- Section 9 – Next Steps

It is acknowledged that supporting reports (including detailed supplementary information) are presented within the appendices section of this document.

3.0 Key Project Assumptions

As identified in the City's RFP, the establishment of the Landfill and WTS is to achieve the following waste management operational objectives below.

3.1 General

- Establishment of facilities to address the City's projected MSW management requirements for a 75 year design period.
- Development of a Landfill and WTS at two previously identified locations.

3.2 Waste Transfer Station

- Continuation of current waste collection procedures within the City.
- Quantification and documentation of incoming materials, using a scale and data recording system.
- Segregation of incoming materials at an enclosed WTS to extract targeted items for specialized handling with remaining residual materials being compacted into plastic-wrapped bales prior to landfilling.
- Shredding and pellitizing of cardboard and clean wood (e.g., pallets) to create pellets for use as fuel in an on-site biomass boiler.
- Shredding of tires, old furniture, and C&D waste for subsequent direction to the Landfill.
- Processing and compaction (logging) of end-of-life vehicles, segregation/packaging of HHW and separation of appliances/salvageable metals to allow for subsequent shipping to approved management facilities in the south.
- Incorporating an allowance in the WTS layout to accommodate the potential future addition of organics (e.g., food waste, dewatered wastewater treatment plant [WWTP] sludge) processing facility,

3.3 Landfill

- Definition and installation of an engineered containment liner appropriate for the identified site location, including considerations associated with permafrost and climate change.
- Definition and ongoing operation of a landfill leachate treatment system.
- Development of the overall 75 year landfill footprint in stages, with the initial two landfill cells (Stage 1 Operational Landfill), addressing anticipated disposal requirements for the first 10 years of operation.
- Installation of the final cap in stages, during the 75 year operational life of the Landfill, aligned with the proposed landfill cell development sequence.

- Definition of an overall landfill development sequence that acknowledges the placement of bales along with loose/comingled C&D waste, shredded furniture, as well as (potentially) shredded tires.

3.4 Relevant Regulations

There are a number of acts and regulations applicable to waste management activities in Nunavut. The primary legislation governing waste management in Nunavut is *The Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA), which establishes the Nunavut Water Board (NWB). A summary of the regulations, acts, legislation, and guidelines relating to the construction and operation of the Landfill and WTS are presented in **Table 3–1**.

Table 3-1: Applicable Regulations

Regulation/Act/Guideline/Bylaw	Source
Building Bylaw #710	City of Iqaluit
Highway Traffic Bylaw # 319	City of Iqaluit
Civic Holiday Bylaw #735	City of Iqaluit
Noise Bylaw #599	City of Iqaluit
Solid Waste Amendment By-Law #544	City of Iqaluit
Solid Waste By-Law # 341	City of Iqaluit
Solid Waste By-Law Amendment # 830	City of Iqaluit
Nunavut Waters and Nunavut Surface Rights Tribunal Act	Government of Canada
Water Licence Terms and Conditions	Government of Nunavut
Nunavut Environmental Protection Act	Government of Nunavut
Nunavut Public Health Act and General Sanitation Regulations	Government of Nunavut
Nunavut Wildlife Act	Government of Nunavut
Motor Vehicle Act	Government of Nunavut
Contingency Planning and Spill Reporting in Nunavut	Government of Nunavut
Waste Lead and Lead Paint (2014)	Government of Nunavut
Pesticide Regulations	Government of Nunavut
Biomedical and Pharmaceutical Waste	Government of Nunavut
Used Oil and Waste Fuel	Government of Nunavut
A Guide to Spill Contingency Planning and Reporting	Government of Nunavut
Waste Batteries (2011)	Government of Nunavut
Waste Solvent (2011)	Government of Nunavut
Waste Paint (2010)	Government of Nunavut
Waste Asbestos (2011)	Government of Nunavut

Regulation/Act/Guideline/Bylaw	Source
Waste Antifreeze (2011)	Government of Nunavut
Ozone Depleting Substances (2011)	Government of Nunavut
General Management of Hazardous Wastes (2010)	Government of Nunavut
Dust Suppression	Government of Nunavut
Ambient Air Quality (2011)	Government of Nunavut
Environmental Guideline for Used Oil and Waste Fuel	Government of Nunavut

4.0 Supplementary Site Investigations

4.1 Waste Transfer Station Environmental Site Assessment

Due to the frozen ground conditions at the site, an accurate environmental sampling program cannot be undertaken until the ground is thawed. As such, additional background environmental sampling will be conducted in the summer of 2019, to further assess the conditions at the site.

The proposed Baseline Environmental Data Investigation will focus on collecting data from soil, groundwater, and/or surface water in various areas in and around the proposed Landfill and WTS, in order to characterize current conditions at these locations. The results of the Baseline Environmental Data Investigation will be used to document the current site conditions for comparison to future sampling programs. Additionally, a Qualitative Risk Assessment and Risk Management Plan for site development will be prepared for the WTS, using the collected data.

A detailed Environmental Monitoring Plan is presented in **Appendix A**.

4.2 Landfill and Waste Transfer Station Geothermal Analysis

Wood Environment and Infrastructure Solutions, a division of Wood Canada Limited (Wood) has conducted geothermal modelling and developed geotechnical recommendations for the proposed WTS foundation and Landfill based on previous geotechnical drilling programs conducted by EXP. This information is presented in the report "*Geothermal Modelling and Geotechnical Recommendation Transfer Station and Landfill Iqaluit, Nunavut, Wood Environmental and Infrastructure Solutions, May 2019.*

4.2.1 Waste Transfer Station

4.2.1.1 Geotechnical Drilling Program

A geotechnical investigation was undertaken at the site of the proposed WTS, which is to be located on Qaqqamiut Road in the City. This work was authorized by the City via Service Contract SC000818, dated August 16, 2018.

Preliminary information indicates that the proposed structure will be an insulated metal-clad building set on a concrete pad at grade. It would be located on a 2.4 ha site. The exact location of the structure on the site and the structural details of the proposed structures were not available at the time of the preparation of this report. It is understood that other buildings may also be located at the site.

The geotechnical investigation comprised of drilling six boreholes across the site to a depth of 10 m to 15 m. The fieldwork was undertaken with an air-track drill rented from a local drilling company. During drilling, bulk soil samples were obtained from the boreholes at selected depths. The investigation revealed that the surficial soil at the site is generally sand fill, which extends to 1.5 m to 2.5 m depth (Elev. 24.4 m to 26.4 m). The fill in the central part of the site (Borehole Nos. 1 and 3 to 5) is underlain by gravelly sand to sandy gravel to 3.1 m to 9.5 m depth (Elev. 18.4 m to 25.4 m). The predominant soil underlying this stratum in the north part of the site (Borehole Nos. 1 to 3) is well graded sand to gravelly sand, which extends to the entire depth investigated (i.e., 10 m to 15 m). In the south part of the site, the predominant soil underlying the gravelly sand to sandy gravel stratum is poorly graded sand, which extends to the entire depth investigated (i.e., 10 m to 15 m).

Free water was encountered in Borehole Nos. 2 to 5 and the groundwater table was established at a depth of 1.2 m to 3.0 m below the existing ground surface (Elev. 24.9 to 26 m.)

This investigation has revealed that the geotechnical conditions at the site are suitable for construction of the proposed building on a concrete pad at grade with provisions of extruded polystyrene insulation and thermosyphons to maintain the soil below the founding level permanently frozen. Adfreeze piles are not suitable for slab on grade structures because of the loss of heat from the building to the piles. End bearing piles are not feasible since bedrock was not encountered to the maximum depth investigated (i.e., 15 m).

The concrete pad should be set on an engineered granular fill mat. The thickness of the granular mat would have to be established by undertaking a geothermal analysis of the site. The Serviceability Limit State bearing pressure will be a function of the compressive strength of the insulation used, as detailed in the *Geotechnical Report" Geotechnical Investigation Proposed Waste Transfer Station Qaqqamiut Road, Iqaluit, Nunavut, EXP Services Inc. October 2018"*.

Any other structures proposed for the site may be founded on adfreeze piles, so long as a minimum air gap of 600 mm is provided below the floor slab to prevent heat loss from the building to the piles. The criteria for design of the piles are presented in the Geotechnical Report

The site has been classified as Class C for seismic site classification, in accordance with the requirements of the National Building Code, 2015. The on-site frozen soils are not susceptible to liquefaction during a seismic event.

Limited chemical tests undertaken on selected soil samples indicate that General Use Portland cement may be used in the subsurface concrete at this site. The on-site soils are considered to be mildly corrosive to corrosive to buried steel. A corrosive specialist should be consulted if steel is to be buried at the site.

Excavation at the site for construction of the granular mat is expected to be relatively straight forward, if undertaken during the cold months when the soil is frozen, since only minimal free water would be encountered in the excavation. However, site dewatering would be required if construction is undertaken during the summer months to maintain the groundwater table below the excavation base level, during construction and the installation of the piles.

The exterior grade should be sloped away from the building to prevent water ponding adjacent to the structure.

The above noted Geotechnical Report was located in the RFP background documentation, Appendix D – Preliminary Geotechnical Investigation Report for this project.

4.2.1.2 Geothermal Analysis

The WTS design was based on the understanding that it should be supported by a mat (slab-on-grade) foundation with no crawl space between underside of the station and the ground surface. Such a foundation option for heated structures within permafrost regions with ice-rich surficial materials can be used if some device or method is applied to eliminate or considerably reduce the amount of heat released by the heated structure into the permafrost. For the current project, two foundation options were considered: 1) thermosiphons to freeze surficial soils under the heated structure; and 2) a thick layer of insulation immediately under the slab, to reduce heat flux from the heated structure.

The scope of work included the following sections required for designing suitable foundations for the WTS:

- Compilation of climate data.
- Regional geological and permafrost conditions.
- Results of geotechnical drilling.
- Results of geothermal modelling.
- Geotechnical recommendations on suitable foundation options (slab-on-grade and slab-on-grade with thermosiphons, including soil design parameters).
- Geotechnical recommendations on site grading and drainage.

Based on results of field geotechnical investigations and geothermal modelling, it was concluded that the foundation system for the WTS can be designed as a reinforced concrete slab supported on a compacted gravel pad - either with or without installation of thermosiphons. However, some limitations will apply to the slab-on-grade foundation alternative that does not include thermosiphons to remove heat energy from the area below the structure.

Geothermal Modelling and Geotechical Recommendations Report (Wood, 2019) is presented in **Appendix B**.

4.2.2 Landfill

4.2.2.1 Geotechnical Drilling Program

A preliminary geotechnical investigation (*"City of Iqaluit Preliminary Geotechnical Investigation Report, Proposed New Landfill Facility, Iqaluit, Nunavut, EXP Services Inc., May 2019")*was undertaken at the site of the proposed Landfill to be located on a 64.12 ha parcel of land approximately 8 km northwest of the City (Figure 1, EXP).

The purpose of the investigation was to establish the geotechnical and groundwater conditions at the site, and to make recommendations regarding the design and construction of the facility from a geotechnical perspective.

The preliminary geotechnical investigation comprised of drilling six sampled boreholes to a 3 m to 6 m depth, as well as five additional boreholes to a 4.4 m to 6.6 m depth for installation of PVC piping and standpipes, for long-term groundwater and ground temperature monitoring at the site.

The investigation revealed that the site predominantly contains sand and gravel, which extends to the bedrock contacted at a depth of 1.0 m to 5.0 m. This stratum has low moisture content and is free of ice lensing. Geological information indicates that the bedrock at the site is likely to be Monzogranite. At the time of the fieldwork, soil at the site was frozen to the ground surface; therefore, the groundwater table and the active layer thickness could not be established.

The salinity of the on-site soils is low. General Use Portland cement may be used in subsurface concrete requirements at the site. The concrete mix design should conform to Canada Standards Association A23.1.

The site has been classified as Class C for seismic site classification, in accordance with the requirements of Section 4.1.8.4 of the National Building Code of Canada, 2015.

The investigation revealed that the on-site soils are suitable for construction of the proposed Landfill. Since the natural soils are permeable, the landfill cell, leachate collection sump and leachate holding ponds will have to be fully lined. The guidelines recommend the following:

1. The base of the cells and the leachate holding ponds should be set at a depth of 1 m below existing grade, or 1.5 m above the seasonal high groundwater table or at the permafrost level. Information regarding the seasonal high groundwater table and the permafrost level was not available at the time of writing this report. It is likely that the seasonal high groundwater table may govern the design. Therefore, additional monitoring of groundwater and temperature are recommended on the spring prior to finalizing of the design.
2. Since the on-site soils are very permeable and clayey impermeable soils are not available in the Iqaluit area, the landfill cell and inside slopes of the berms, leachate collection sump and

leachate holding ponds will all have to be lined with two liners (i.e., a 60 mil geosynthetic clay liner and a 60 mil High Density Poly Ethylene [HPDE]) liner. A leachate collection system should be installed in a 600 mm granular layer above the HDPE liner leading to the leachate sump. Leachate from the sump should be directed to the leachate holding ponds.

3. The berms of the proposed landfill cell and the leachate holding ponds are expected to be stable when sloped back on an inclination of 3H:1V. This would require conformation based on slope stability analysis, once the design of the facility has been finalized. The inside faces of the berms of the Landfill, leachate holding ponds and the sides of the leachate collection sump should also be lined with a 60 mil geosynthetic clay liner overlain by 60 mil thick HDPE liner. The outside slopes of the berms and the leachate holding pond should be protected with coarse gravel to minimize erosion.
4. Any permanent buildings proposed to be constructed would have to be supported on rock socketed piles. Additional recommendation on foundation alternatives and design will be provided once the design is finalized.

The on-site soils underneath the Landfill are expected to thaw due to the heat generated by decomposition of the waste. Similarly, the soils under the leachate holding ponds are expected to thaw due to absorption of heat from the sun rays by the leachate. The settlements of the cell and the leachate holding ponds were estimated to vary from 20 mm to 150 mm. Therefore, it is recommended that liners should be installed with enough folds to accommodate the anticipated settlements. The manufacturer of the liners should be consulted for this purpose.

Groundwater and temperature monitoring should be undertaken at the site to establish seasonal high groundwater table and to establish the active layer thickness.

It was recommended that groundwater and gas monitoring networks should be installed to ensure that the leachate is not impacting the groundwater, and that explosive gases are not migrating from the property during operation of the Landfill.

Methane monitoring devices should be installed, in any of the structures located on the site, to ensure that methane is not accumulating in the building(s).

Preliminary Geotechnical Investigation Report (EXP, 2019) is presented in **Appendix C**.

4.2.2.2 Geothermal Analysis

The scope of work for the proposed Landfill included geothermal modelling for the baled waste, prepared by Wood Environmental and Infrastructure Solutions. The purpose of the modelling was determination of the period of time for freezing the baled waste and underlying soil of the active layer, if placement of the bales occurs at the end of summer.

Based on results of the geothermal analyses, it can be concluded that five to six years is required for complete freezing of the bale and soil below the bale, if the bale placement occurs at the end of summer or in early winter.

4.3 Landfill Baseline Environmental Data Collection

Due to the frozen ground conditions at the site, an accurate environmental sampling program cannot be undertaken until the ground has thawed. As such, additional background environmental sampling will be conducted in the summer of 2019, to further assess the conditions at the site.

The proposed Baseline Environmental Data Investigation will focus on collecting data from soil, groundwater and/or surface water in various areas in and around the proposed Landfill and WTS, in order to characterize current conditions at these locations. The results of the Baseline Environmental Data Investigation will be used to document current site conditions for comparison to future sampling programs. Additionally, a Qualitative Risk Assessment and Risk Management Plan for site development will be prepared for the WTS, using the collected data.

A detailed environmental monitoring plan is presented in **Appendix A**.

5.0 Facility Performance and Design Parameters

5.1 Waste Quantity Estimates

The estimate of the total quantity of waste anticipated at the proposed Landfill is a factor of waste generation per population and anticipated population growth for the City. The anticipated life of the proposed Landfill is 75 years. The Nunavut Bureau of Statistics (2014) has released population projections for the City to the year 2035. This population projection was used to calculate an annual population growth rate of 1.416% for projecting the population of Iqaluit beyond 2035 to the year 2094. **Table 5–1** presents a summary of the projected population of the City for the anticipated life of the project. For each summary table, complete information is provided in **Table 5–4**.

Table 5-1: Projected Population Summary, City of Iqaluit

Operating Year	Year	Projected Population
1	2020	8,090
15	2034	9,265
25	2044	10,588
35	2054	12,186
45	2064	12,359
55	2074	12,534
65	2084	12,711
75	2094	12,891

Current waste generation values provided by the City have been used as the baseline annual waste disposal quantities. At the direction of the City, an annual increase in waste generation per person of 1.00% was applied. Base assumptions for the waste densities assumptions used to arrive at the estimated disposal quantities over the life of the facility are summarized in **Table 5–2**.

Table 5-2: Assumed Waste Disposal Densities

Waste Component	Density	Source
Baled MSW	750 kg/m^3	AECOM Report (based on estimated 975kg bale weight, 0.762 m^3 per bale)
Shredded baled tires	654 kg/m^3	AECOM Report (est. 850 kg/bale)
Whole baled tires	462 kg/m^3	AECOM Report (est. 600 kg/bale)
C&D Waste	449 kg/m^3	Volume-to-Weight Conversion Factors Report (USEPA, 2016)

Table 5–3 provides the initial annual generation, and summarized annual and cumulative amounts.

Table 5-3: Waste Generation Forecast Summary Table

Operating Year	Year	Municipal Solid Waste			Wood Waste	Scrap Metal	Tires	Hazardous Waste	Cardboard	Non-Metallic C&D Waste	Mattresses	Vehicles
		Annual (Tonnes)	Cumulative (Tonnes)	Cumulative (m^3)	Annual (tonnes)	Annual (tonnes)	Annual (tonnes)	Annual (tonnes)	Annual (tonnes)	Annual (tonnes)	Annual (each)	Annual (each)
1	2020	8,580	8,580	11,440	7,300	7,714	5.0	10.0	2,704	32	312	80
15	2034	12,008	153,076	204,102	10,217	10,797	7.0	14.0	3,784	40	437	112
25	2044	15,267	290,437	387,249	12,989	13,727	8.9	17.8	4,811	46	555	142
35	2054	19,410	465,076	620,101	16,515	17,452	11.3	22.6	6,117	52	706	181
45	2064	24,678	687,110	916,147	20,997	22,188	14.4	28.8	7,777	58	897	230
55	2074	31,376	969,402	1,292,535	26,695	28,210	18.3	36.6	9,888	64	1,141	293
65	2084	39,890	1,328,304	1,771,072	33,939	35,866	23.2	46.5	12,572	70	1,451	372
75	2094	50,716	1,784,609	2,379,478	43,150	45,599	29.6	59.1	15,983	70	1,844	473

The proposed Landfill will be sized for the disposal of approximately 2.4 million m^3 of baled, wrapped MSW, and non-metallic C&D waste. Wood and cardboard waste is to be shredded at the Transfer Station and burned to supplement space heating at the Transfer Station. Scrap metal, tires, recyclables, mattresses, and vehicles are to be processed at the Transfer Station, stored, and processing or recycled.

Table 5–4 presents the data for the 75 years

City of Iqaluit
Waste Forecasts

Assumptions:

Population Growth Rate	1.42%	Recyclables Growth Rate	1.00%	Density of Baled MSW	750	kg/m^3
Municipal Solid Waste Growth Rate	1.00%	Cardboard Growth Rate	1.00%	Density of baled tires (shredded)	654	kg/m^3
Wood Waste Growth Rate	1.00%	Hazardous Waste Growth Rate	1.00%	Density of baled tires (whole)	462	kg/m^3
Scrap Metal Growth Rate	1.00%	End of Life Vehicle Growth Rate	1.00%	C&D Density	449	kg/m^3
Scrap Tire Growth Rate	1.00%	Mattress Growth Rate	1.00%			

Year		Population	Annual MSW (tonnes)	Cumulative MSW (tonnes)	Cumulative MSW Volume (m^3)	Annual Wood Waste (m^3)	Scrap Metal (m^3)	Annual Scrap Tires (tonnes)	Annual Hazardous Waste (tonnes)	Annual Cardboard (tonnes)	Non-metallic C&D waste (tonnes)	Non-metallic C&D waste, cumulative (tonnes)	Annual Mattess (each)	Annual Vehicles (each)
1	2020	8,090	8,580	8,580	11,440	7,300	7,714	5.0	10.0	2,704	32	32	312	80
2	2021	8,205	8,789	17,369	23,158	7,477	7,902	5.1	10.2	2,770	33	65	320	82
3	2022	8,318	9,002	26,371	35,161	7,659	8,094	5.2	10.5	2,837	34	99	327	84
4	2023	8,427	9,221	35,591	47,455	7,845	8,290	5.4	10.7	2,906	34	133	335	86
5	2024	8,524	9,445	45,036	60,048	8,036	8,492	5.5	11.0	2,977	35	168	343	88
6	2025	8,615	9,674	54,711	72,948	8,231	8,698	5.6	11.3	3,049	35	203	352	90
7	2026	8,694	9,910	64,620	86,161	8,431	8,910	5.8	11.5	3,123	36	239	360	92
8	2027	8,767	10,150	74,771	99,694	8,636	9,126	5.9	11.8	3,199	36	275	369	95
9	2028	8,859	10,397	85,168	113,557	8,846	9,348	6.1	12.1	3,277	37	312	378	97
10	2029	8,925	10,650	95,818	127,757	9,061	9,575	6.2	12.4	3,356	38	350	387	99
11	2030	8,993	10,909	106,726	142,301	9,281	9,808	6.4	12.7	3,438	38	388	397	102
12	2031	9,062	11,174	117,900	157,200	9,507	10,046	6.5	13.0	3,521	39	427	406	104
13	2032	9,132	11,445	129,345	172,460	9,738	10,290	6.7	13.3	3,607	39	466	416	107
14	2033	9,202	11,723	141,068	188,091	9,974	10,540	6.8	13.7	3,695	40	506	426	109
15	2034	9,265	12,008	153,076	204,102	10,217	10,797	7.0	14.0	3,784	40	547	437	112
16	2035	9,329	12,300	165,376	220,502	10,465	11,059	7.2	14.3	3,876	41	588	447	115
17	2036	9,461	12,599	177,975	237,300	10,719	11,328	7.3	14.7	3,971	42	630	458	117
18	2037	9,595	12,905	190,880	254,507	10,980	11,603	7.5	15.0	4,067	42	672	469	120
19	2038	9,731	13,219	204,099	272,132	11,247	11,885	7.7	15.4	4,166	43	715	481	123
20	2039	9,869	13,540	217,639	290,185	11,520	12,174	7.9	15.8	4,267	43	758	492	126
21	2040	10,009	13,869	231,508	308,677	11,800	12,470	8.1	16.2	4,371	44	802	504	129
22	2041	10,150	14,206	245,714	327,618	12,087	12,773	8.3	16.6	4,477	45	847	517	132
23	2042	10,294	14,551	260,265	347,020	12,380	13,083	8.5	17.0	4,586	45	892	529	136
24	2043	10,440	14,905	275,170	366,893	12,681	13,401	8.7	17.4	4,697	46	938	542	139
25	2044	10,588	15,267	290,437	387,249	12,989	13,727	8.9	17.8	4,811	46	984	555	142
26	2045	10,738	15,638	306,075	408,100	13,305	14,060	9.1	18.2	4,928	47	1,031	569	146
27	2046	10,890	16,018	322,093	429,458	13,628	14,402	9.3	18.7	5,048	48	1,079	582	149
28	2047	11,044	16,407	338,501	451,334	13,960	14,752	9.6	19.1	5,171	48	1,127	597	153
29	2048	11,200	16,806	355,307	473,742	14,299	15,110	9.8	19.6	5,296	49	1,176	611	157
30	2049	11,359	17,215	372,521	496,695	14,646	15,478	10.0	20.1	5,425	49	1,225	626	161
31	2050	11,520	17,633	390,154	520,205	15,002	15,854	10.3	20.6	5,557	50	1,275	641	164
32	2051	11,683	18,061	408,215	544,287	15,367	16,239	10.5	21.1	5,692	50	1,325	657	168
33	2052	11,848	18,500	426,716	568,954	15,740	16,634	10.8	21.6	5,830	51	1,377	673	172
34	2053	12,016	18,950	445,666	594,221	16,123	17,038	11.0	22.1	5,972	52	1,428	689	177
35	2054	12,186	19,410	465,076	620,101	16,515	17,452	11.3	22.6	6,117	52	1,480	706	181
36	2055	12,359	19,882	484,958	646,611	16,916	17,876	11.6	23.2	6,266	53	1,533	723	185
37	2056	12,534	20,365	505,323	673,764	17,327	18,310	11.9	23.7	6,418	53	1,587	741	190

Year		Population	Annual MSW (tonnes)	Cumulative MSW (tonnes)	Cumulative MSW Volume (m^3)	Annual Wood Waste (m^3)	Scrap Metal (m^3)	Annual Scrap Tires (tonnes)	Annual Hazardous Waste (tonnes)	Annual Cardboard (tonnes)	Non-metallic C&D waste (tonnes)	Non-metallic C&D waste, cumulative (tonnes)	Annual Mattess (each)	Annual Vehicles (each)
38	2057	12,711	20,860	526,183	701,578	17,748	18,755	12.2	24.3	6,574	54	1,641	759	195
39	2058	12,891	21,367	547,551	730,067	18,179	19,211	12.5	24.9	6,734	55	1,695	777	199
40	2059	13,074	21,886	569,437	759,249	18,621	19,678	12.8	25.5	6,898	55	1,751	796	204
41	2060	13,259	22,418	591,855	789,140	19,074	20,156	13.1	26.1	7,065	56	1,806	815	209
42	2061	13,447	22,963	614,818	819,757	19,537	20,646	13.4	26.8	7,237	56	1,863	835	214
43	2062	13,637	23,521	638,339	851,119	20,012	21,148	13.7	27.4	7,413	57	1,920	855	219
44	2063	13,830	24,093	662,432	883,242	20,498	21,662	14.0	28.1	7,593	58	1,977	876	225
45	2064	14,026	24,678	687,110	916,147	20,997	22,188	14.4	28.8	7,777	58	2,035	897	230
46	2065	14,224	25,278	712,388	949,850	21,507	22,727	14.7	29.5	7,966	59	2,094	919	236
47	2066	14,426	25,892	738,280	984,373	22,029	23,280	15.1	30.2	8,160	59	2,154	942	241
48	2067	14,630	26,521	764,801	1,019,735	22,565	23,845	15.5	30.9	8,358	60	2,213	964	247
49	2068	14,837	27,166	791,967	1,055,956	23,113	24,425	15.8	31.7	8,561	60	2,274	988	253
50	2069	15,047	27,826	819,793	1,093,058	23,675	25,018	16.2	32.4	8,769	61	2,335	1,012	259
51	2070	15,260	28,502	848,296	1,131,061	24,250	25,626	16.6	33.2	8,983	62	2,397	1,036	266
52	2071	15,477	29,195	877,490	1,169,987	24,840	26,249	17.0	34.0	9,201	62	2,459	1,062	272
53	2072	15,696	29,904	907,395	1,209,860	25,443	26,887	17.4	34.9	9,424	63	2,522	1,087	279
54	2073	15,918	30,631	938,026	1,250,701	26,061	27,540	17.9	35.7	9,653	63	2,585	1,114	286
55	2074	16,143	31,376	969,402	1,292,535	26,695	28,210	18.3	36.6	9,888	64	2,649	1,141	293
56	2075	16,372	32,138	1,001,540	1,335,386	27,344	28,895	18.7	37.5	10,128	65	2,714	1,169	300
57	2076	16,604	32,919	1,034,459	1,379,278	28,008	29,598	19.2	38.4	10,374	65	2,779	1,197	307
58	2077	16,839	33,719	1,068,178	1,424,237	28,689	30,317	19.6	39.3	10,627	66	2,845	1,226	314
59	2078	17,077	34,538	1,102,716	1,470,288	29,386	31,054	20.1	40.3	10,885	66	2,911	1,256	322
60	2079	17,319	35,378	1,138,094	1,517,458	30,100	31,808	20.6	41.2	11,149	67	2,978	1,286	330
61	2080	17,564	36,237	1,174,331	1,565,775	30,831	32,581	21.1	42.2	11,420	68	3,046	1,318	338
62	2081	17,813	37,118	1,211,449	1,615,266	31,581	33,373	21.6	43.3	11,698	68	3,114	1,350	346
63	2082	18,065	38,020	1,249,469	1,665,959	32,348	34,184	22.2	44.3	11,982	69	3,183	1,383	355
64	2083	18,321	38,944	1,288,414	1,717,885	33,134	35,015	22.7	45.4	12,273	69	3,252	1,416	363
65	2084	18,581	39,890	1,328,304	1,771,072	33,939	35,866	23.2	46.5	12,572	70	3,322	1,451	372
66	2085	18,844	40,860	1,369,164	1,825,552	34,764	36,737	23.8	47.6	12,877	70	3,392	1,486	381
67	2086	19,110	41,853	1,411,017	1,881,356	35,609	37,630	24.4	48.8	13,190	70	3,462	1,522	390
68	2087	19,381	42,870	1,453,887	1,938,516	36,474	38,544	25.0	50.0	13,511	70	3,532	1,559	400
69	2088	19,656	43,912	1,497,798	1,997,065	37,361	39,481	25.6	51.2	13,839	70	3,602	1,597	409
70	2089	19,934	44,979	1,542,777	2,057,036	38,269	40,441	26.2	52.4	14,175	70	3,672	1,636	419
71	2090	20,216	46,072	1,588,849	2,118,466	39,199	41,423	26.8	53.7	14,520	70	3,742	1,675	430
72	2091	20,502	47,192	1,636,041	2,181,388	40,151	42,430	27.5	55.0	14,872	70	3,812	1,716	440
73	2092	20,793	48,338	1,684,379	2,245,839	41,127	43,461	28.2	56.3	15,234	70	3,882	1,758	451
74	2093	21,087	49,513	1,733,892	2,311,856	42,127	44,517	28.9	57.7	15,604	70	3,952	1,800	462
75	2094	21,386	50,716	1,784,609	2,379,478	43,150	45,599	29.6	59.1	15,983	70	4,022	1,844	473

5.2 Approval Processes

Water licenses, and their terms and conditions are the primary means through which MSW facilities are regulated in Nunavut. The most relevant Federal and Territorial legislation, applicable to solid waste management in Nunavut, are detailed in the following sections.

5.2.1 Nunavut Water Board

The terms and conditions of the water license are set by the NWB, in consultation with federal and provincial government agencies, and other stakeholders. The primary goal of a water license is to ensure that contaminants from solid waste disposal sites do not enter watercourses or water bodies. The *Nunavut Waters and Nunavut Surface Rights Tribunal Act* and the Nunavut Waters Regulations (Regulations) define the powers and responsibilities of the NWB.

As outlined in the Solid Waste Management Plan (Government of Nunavut, 2014), the key sections of the NWNSRTA that relate to solid waste management in Nunavut include:

- Section 12, which states that no person shall deposit or permit the deposit of waste in waters in Nunavut or in any other place in Nunavut under conditions in which the waste (or any other waste that results from the deposit of that waste), may enter waters in Nunavut except in accordance with the conditions of a licence.
- Sections 14 to 34, which establishes and describe the NWB, including the size of the NWB, the positions of the NWB and their responsibilities, and various rules regarding the NWB's organizational structure and governance.
- Sections 42 to 81, which describe the rules governing the issuing of licences by the NWB. Topics addressed by the sections include the maximum term for a licence, application requirements, the application procedure, including when a public hearing is and is not required, conditions under which the Board may issue a licence, the ability for the Board to include conditions and monitoring requirements in the licence, and the requirement of a public register.
- Sections 85 to 94, which address enforcement of the NWNSRTA. In particular, Section 86 provides inspectors with the authority to examine works or take samples when they have reasonable grounds to believe waste is entering waters and to examine any relevant documents or records. Section 87 provides inspectors with the authority to order those in charge of the wastes to take remedial measures to remedy those situations. Section 90 to 94 addresses offenses and punishments, including terms for fines and imprisonment.

Examples of typical water licence terms and conditions, as they relate to solid waste management, include:

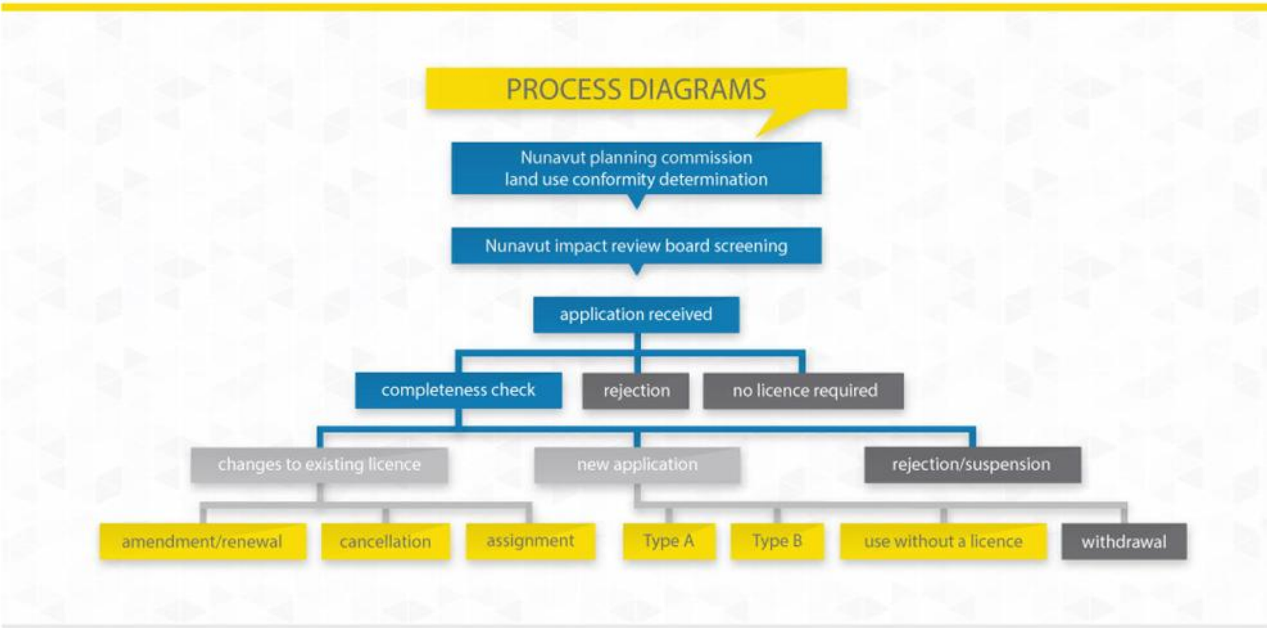
- Conditions for an effluent monitoring program, including sampling locations, frequencies and parameters.
- Posting of signage for the monitoring program.
- Requirements for submitting copies of studies, reports and plans to the NWB, including:

- Operation and Maintenance manuals;
- Construction design and drawings, including as-built; and
- Abandonment and restoration plans.

- The disposal of and permanent containment of all solid wastes at the solid waste disposal facilities.
- The segregation and storing of all hazardous materials and hazardous waste within the solid waste disposal facilities in a manner to prevent the deposit of deleterious substances into water, until such a time that the materials can be removed for proper disposal at a licensed facility.
- The implementation of measures to ensure leachate from solid waste disposal facilities and hazardous waste storage areas do not enter water.
- Annual reports that summarize:
  - Water monitoring results; modifications or major maintenance work carried out on waste disposal facilities, unauthorized discharges and follow-up actions;
  - Abandonment and restoration work recently completed or planned;
  - Updates to operation and maintenance manuals; relevant studies; and
  - Other details requested by the NWB.

Water licences for solid waste facilities are required to be renewed before they expire. If an Operator's water licence expires before it can be renewed, the operator is required to discontinue using the solid waste facility, as well as any water use covered by their water licence. Otherwise, the Operator will be in contravention of the Nunavut Land Claims Agreement and the NWNSRTA. The expiry of the license does not relieve the City of its obligations imposed by the license. The process by which the NWB regulates undertakings in Nunavut is outlined in **Figure 5–1**.

Figure 5-1: Nunavut Water Board Regulatory Process Overview (Nunavut Water Board, 2019)



Item 3 of Schedule 1 of the Regulations identify that:

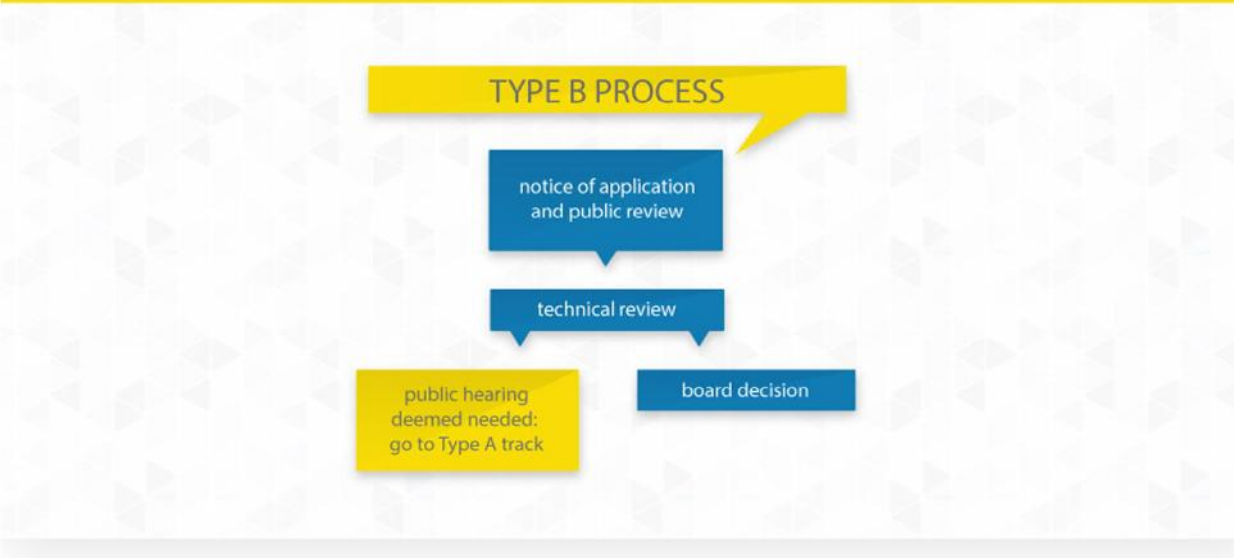
- For a Municipal Undertaking for a waste disposal or water system for a municipality a NWB, an authorization or a license is required.

Schedules 3 (Licensing Criteria for the Deposit of Waste) of the Regulations defines that:

- For any Municipal undertaking of any deposit of waste, if the water system for the municipality uses less than 300 m^3 of water per day, a Type B license is required.

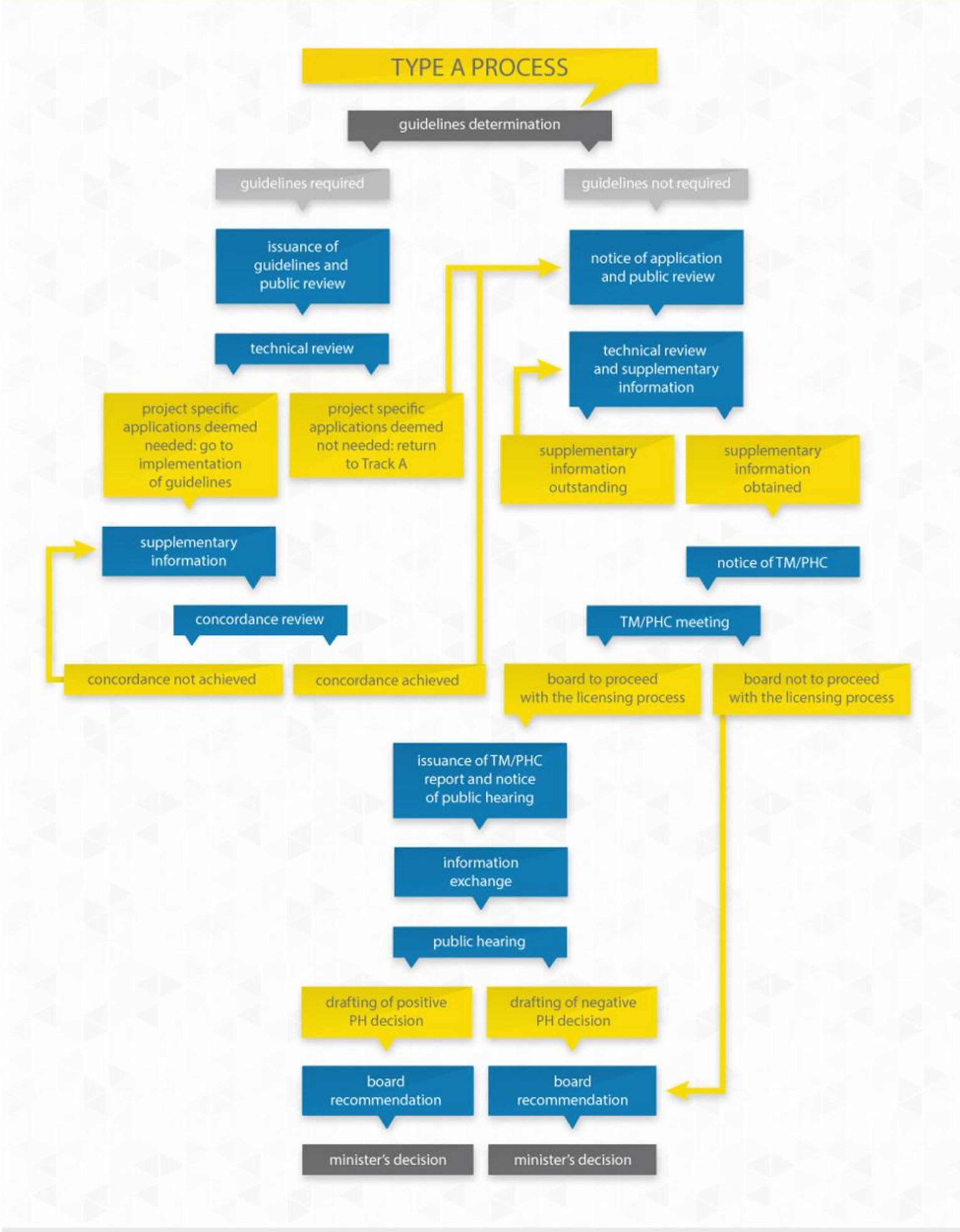
Proposed daily water usage is forecasted to be less than 300 m^3; as such, a Type B Process is anticipated. The Type B Process is presented in **Figure 5–2**.

Figure 5-2: Nunavut Water Board Type B Regulatory Process (Nunavut Water Board, 2019)



During the Technical Review process, the NWB may decide the Operator must follow Type A process, which is outlined in **Figure 5–3**.

Figure 5-3: Nunavut Water Board Type A Regulatory Process (Nunavut Water Board, 2019)



5.2.2 *Nunavut Environmental Protection Act*

The *Nunavut Environmental Protection Act* (EPA) provides general responsibilities and authority for environmental protection. The current version of the EPA has been in force since March 10, 2011. While solid waste is not mentioned specifically, the EPA regulates the discharge of contaminants into the environment. Air emissions from the open burning of mixed waste or leachate run-off could potentially be offenses under the EPA.

As outlined in the Solid Waste Management Plan (Government of Nunavut, 2014), the key sections of the EPA that relate to solid waste management in Nunavut include:

- Section 1, which provides definitions for terms such as contaminant, discharge environment and inspector.
- Section 2.2, which provides the Minister with authority to: monitor environmental quality; conduct studies and training; develop policies, standards, guidelines and codes of practice; and to collect, publish and distribute information relating to contaminants and to the preservation, protection and enhancement of the environment.
- Section 3, which allows for and describes the role of Chief Environmental Protection Officer.
- Section 5, which sets the conditions under which the discharge of a contaminant into the environment is allowed or prohibited.
- Sections 6 and 7, which provides inspectors with the authority to issue an order requiring that a discharge of a contaminant I not the environment be stopped and repair or remedy any damages that the discharge may have caused.

5.2.3 *Nunavut Public Health Act* and General Sanitation Regulations

The *Nunavut Public Health Act* (PHA) outlines the general requirements and authorities for public health and safety in Nunavut. The current version of the PHA has been in force since April 1, 2008. Section 25 of the PHA provides the Commissioner with the authority to create regulations concerning the control of waste disposal grounds for the disposal of excreta and garbage.

The General Sanitation Regulations, created under the PHA, describes the general requirements for the management and disposal of waste and minimum setbacks for waste disposal sites. They also include requirements for landfill cover and to include a scavenging system. Specific relevant sections as outlined in the Solid Waste Management Plan (Government of Nunavut, 2014) include:

- Section 1, which defines “waste disposal ground” as any place used for the disposal of garbage, refuse, excreta or other waste material.
- Section 8, which states that no building used for human habitation shall be nearer than 450 m to a waste disposal ground or on any site where the soil has been made up of any refuse, unless the refuse has been removed from the site, consolidated, or the site has been disinfected in every case and approved by a Health Officer.

- Section 24, which requires incorporated municipalities to provide a scavenging system for the general public for the collection and disposal of garbage and refuse, and that the system is operated and maintained to the satisfaction of a Medical Health Officer.
- Section 25, which requires that homes and other buildings such as schools, churches and businesses provide an adequate number of containers for the reception of garbage and refuse.
- Section 26, which provides rules around the construction and placement of garbage and refuse containers.
- Section 27, which requires that incorporated municipalities provide adequate waste disposal grounds for the disposal of all garbage, refuse, excreta and other waste matter and that waste materials are either burned, buried or covered as necessary to reduce odour and prevent the breeding of flies.
- Section 28, which requires that waste disposal grounds be located: at least 90 m from any public road allowance, railway, right-of-way, cemetery, highway or thoroughfare; at least 450 m from any building used for human occupancy or for the storage of food; and situated at such a distance from sources of water or ice for human consumption or ablution that the sources will not become polluted.

5.2.4 *Nunavut Wildlife Act*

The *Nunavut Wildlife Act* (NWA) was created to establish help with the management of wildlife and habitat in Nunavut, including the conservation, protection and recovery of Species at Risk. The Act came into force July 9, 2005. The key sections of the NWA, as outlined in the Solid Waste Management Plan (Government of Nunavut, 2014) include:

- In Section 2, “attractant” is defined to include food, food waste, compost or garbage that could attract wild animals.
- Section 66, which prohibits persons from storing, disposing of or allowing the accumulation of any waste within a critical habitat
- Section 67, which prohibits depositing waste or litter in or near any habitat.

6.0 Design and Construction Options Analysis

This section presents the summary of findings of the Design and Construction Options Analysis Technical Brief, which is presented in **Appendix E** and which also includes the Solid Waste Landfill, Waste Transfer Station and Northwest Aggregate Deposit Road – 30% Submission drawings as 11 x 17.

6.1 Waste Transfer Station

6.1.1 Weigh Scale

The scale weights all waste handling vehicles that arrive to the WTS. The scale length is 23 m to accommodate a 40 foot container and trailer instead of a waste compactor vehicle. The scale is not contained in a building.

6.1.2 Office Trailer

The office trailer is remote from the WTS building to minimize the potential for dust and mold to be present. The building contains and the office for the Facility Supervisor, a unisex barrier free washroom, a unisex locker room and a lunch room.

6.1.3 Waste Transfer Station Building

The building is a pre-engineered steel system with metal walls and roof panels that uses standard metal components, which are designed to minimize materials that are quick and efficient to construct. Tilt-Up concrete structures are typically more expensive to construct. Shipment of raw materials is a concern and repairing issues can be costly. Wood construction was not be considered due to the height and spans required.

LED lighting is recommended due to its efficiency and a low wattage versus incandescent lighting.

A front end loader is recommended instead of a skid steel vehicle, as the floor will become wet and slimy, limiting the ability of a skid steel vehicle to have enough traction to maneuver.

A portable vehicle lift is recommended, as a less dedicated floor space is required and the lift components can be moved when not in use.

A concrete tip wall is recommended to allow for storage of materials in the structure against concrete versus a thin metal sheathing.

A passive thermosyphon is recommended, as no electricity is required. The building has a heavy floor loading and is less expensive than a pile supported structural floor.

Due to the building being heated, the sprinkler system will be a wet system instead of a dry system that is normally used in buildings that are not heated.

A biomass boiler and an oil-fired hydronic boiler will provide heat for the building. The biomass boiler will be the main source of heat with the oil-fired boiler will serve as backup and for peak heating loads.

The ventilation system will include carbon dioxide and nitrogen oxide detectors, and provide ventilation for internal combustion engine vehicles.

Space for a future Sludge Room is not included.

The building does not contain any floor drains.

6.1.4 Baler

The baler is a two ram with approximate peak capacity of 20 tonnes per hour of MSW. A trench drain will collect and transfer drippings to a sump and storage tank.

6.1.5 Shredder

The shredder is designed for 6 tonnes per hour versus the 10 tonnes per hour noted in the RFP, due to the required capacity of the biomass boiler.

A hopper instead of an infeed conveyor will be utilized.

6.1.6 Logger

The logger shall bale end-of-life vehicles, white goods and miscellaneous material separately to maximize the sale value of the metals.

6.1.7 Site Features

External to the WTS space is identified for:

- Snow storage
- Tire storage
- Miscellaneous metals and white goods
- Bale storage
- HHW depot
- Future greenhouse and composting areas

6.1.8 Site Drainage

The site will be graded to drain predominately to the drainage ditch, along the eastern property boundary and Qaqqamiut Road, and to the northern boundary along the unnamed road.

6.2 Landfill

6.2.1 Waste Stream

A 1.416% growth in the population is added to the 1.0% growth of waste materials.

6.2.2 Baled Waste and Placed Construction and Debris Material

The material will be placed in the same cell to allow the C&D material to infill voids due to the "stepped" placement of the bales that would normally be filled with granular material.

6.2.3 Liner

One 80 mil textured HDPE geomembrane is recommended, as low permeability soil is not available and the Landfill is presumed to function as a "freeze-back" landfill after five or six years. Also, the production of leachate is expected to be minimized by the wrapping of the bales.

6.2.4 Leachate Treatment

The proposed treatment system of lagoons and wetland is based on the anticipated strength and volume of the leachate. The lagoons will be lined with an 80 mil HDPE geomembrane liner.

6.2.5 Daily and Intermediate Cover

Daily and intermediate cover soils will not be required due to the wrapping of the bales.

7.0 Conceptual Design Information

7.1 Waste Transfer Station

Site Entrance

The entrance of the WTS will be from Kakivak Court. Design elements of the entrance will include:

- Entrance sign
- Design vehicle will be the Transportation Association of Canada WB-24
- Electric horizontal sliding gate with security card access

Weigh Scale

All vehicles entering the site will be directed to the scale. The scale will include:

- One steel deck electronic weigh scale
- Nominal size 3 m x 23 m
- Digital load cells
- Side rails
- Red/green traffic signals at both ends with manual controller
- Recording/transaction software
- Utilized to record inbound materials as well as weighing outgoing, empty vehicles
- Potential intercom for exiting commercial vehicles
- Side skirts to limited snow buildup under the scale
- Concrete pad
- Asphalt entrance and exit ramps

Scale House

A scale house will be located adjacent to the scale will include:

- A raised prefabricated portable structure located on a gravel pad
- Steel siding and roof
- Vinyl floor tiles
- Nominal size 1.5 m x 2.4 m
- Window security bars
- Security system with autodialer
- Communication/internet system
- Door with security bars
- Electric baseboard heating and overhead cooling
- Enclosed crawlspace
- Intercom system
- Scale to be used for billing. A remote scale weight display (required to allow the driver to view the weight reading)
- Electrical distribution to be 100 amp, 120/240 VAC, single phase

- Lighting will be LED
- Dark sky friendly exterior lighting fixture above entrance door with photocell

Office Trailer

The office trailer design will be based on:

- Raised prefabricated portable structure located on a gravel pad
- Nominal size 4 m x 15 m
- Steel siding and roof
- Vinyl floor tile
- Drywall walls
- Office for the Site Supervisor
- Locker room for nine employees
- Lunch room
- Unisex washroom
- Maintenance closet
- Window security bars
- Security system
- Communication/internet system
- Door with security bars.
- Electric baseboard heating and air conditioning (office and lunch room)
- Water supply tank and associated pump inside
- Hot water tank
- Septage tank in crawlspace
- Crawlspace
- Electrical distribution to be 100 amp, 120/208 VAC, three phase
- Lighting will be LED
- Dark sky friendly exterior lighting fixture above entrance door with photocell

Waste Transfer Station

The WTS will consist of:

- Pre-engineered building with metal roof and siding
- Concrete slab on grade floor
- Thermosyphon for temperature control under the slab
- No water supply
- No septic system
- Trench drains with screens, sump pit and grinder pump
- Holding tank for liquid from baler
- Electrical room
- Mechanical room

- Fire suppression system
- Biomass boiler
- Portable emergency eyewash station
- Ventilation system with heat recovery
- Space to process end-of-life vehicles prior to crushing
- Concrete push walls
- Concrete aprons
- Exterior pad mount utility transformer with feeder cables to electrical room
- Electrical distribution to be 1200 amp, 347/600 VAC, three phase
- Lighting will be LED and designed for low temperature operation
- Emergency power

Municipal Solid Waste Baler

The baler will process MSW and will be based on:

- A peak process tonnage of 20 tonnes/hour
- Annual tonnage of 8,000 tonnes
- American Baler Model W858-T50 or equal
- Steel apron pan conveyor
- Automatic wire tier
- Bale wrapper (Cross Wrap)
- Perimeter liquid collection channel and tank

Shredder/Pellitizer

- Feedstock cardboard, clean wood
- Sized to accommodate 6 tonne per hour
- Initially five hour per day operation
- Nominal pellet size 6 to 8 mm diameter, 40 m length

Biomass Boiler

- Main/Base heating source for WTS
- Oil-fired boilers for partial backup and peak heating loads
- Boiler system for hydronic heating to unit heaters/air handling unit (to heat and ventilate the WTS)

End-of-Life Vehicles/Metal Logger

The logger will process vehicles and miscellaneous metals and white goods and will be based on:

- Located on a gravel pad
- Nominal 200 Hp baler/logger
- Knucle boom material handler

Household Hazardous Wastes Depot/Reuse Storage Area

The HHW Depot will consist of:

- Three pre-manufactured shipping container depots to deliver the site
- Shipping container on a gravel pad
- Shelving
- Containment flooring
- LED lighting
- Natural ventilation
- Electrical distribution to be 100 amp, 120/240 VAC, single phase
- Portable (heated/insulated) eyewash station

The Reuse Storage Area will consist of:

- A 40 foot shipping container on a gravel pad
- Unheated
- Shelving
- Solar lighting
- Natural ventilation

Site Security

A 2.4 m chain link fence will be located at the perimeter of the site. The entrance gate will be card coded. The bale transfer truck gate will be manually operated at Qaqqamiut Road. Closed circuit security cameras will be positioned to view and record:

- Gate/scale area
- General site area
- Interior of the office trailer and WTS
- Arriving and exiting vehicles

Site Lighting

Site lighting will be provided by:

- LED dark sky friendly compliant fixtures with photo cell control
- Fixtures mounted on 6 m galvanized steel poles
- Lighting designed to illuminate the site with an average of 10 lux

Parking

Gravel parking stalls for 10 vehicles. All stalls would be 2.8 m x 5.6 m plus 1.2 m on each side. Power receptacles will be provided.

Site Exterior Features

Space will be identified for:

- Exterior wrapped bale storage

- Temporary storage of processed end-of-life vehicles, miscellaneous metals and white goods
- Temporary storage of C&D debris, prior to delivery to the Landfill
- Tire storage
- Logger
- Snow storage
- Bollards and boulders for building, etc.

Snow Storage

Areas for snow storage will be located on the site. Boulders, nominal size 1 m^3, will be spaced on the interior of the perimeter fence to protect the fence from stored snow.

Organics Processing

An area will be identified for potential future organic composting.

7.2 Landfill

Landfill Entrance

The entrance of the Landfill will be the North West Aggregate Deposit Road. Design elements of the entrance will include:

- Entrance sign
- Design vehicle will be the Transportation Association of Canada WB-24
- Manual horizontal sliding gate

Access Road

The function of the access road is to provide access to the Landfill. Traffic will consist of:

- Vehicles to transport and place baled waste
- Authorized vehicles to delivery C&D debris
- Authorized visitors

The road will be:

- Two 4.5 m travel lanes
- 0.5 m width shoulder
- Gravel surface
- Designed to limit rock removal to “knobs”
- Stop sign
- Signs to direct and regulate road usage and traffic movement

Part-time Attendants Shelter

The shelter for the attendant will consist of:

- Prefabricated portable structure located on a gravel pad

- Steel siding and roof
- Nominal size 2.4 m x 1.5 m
- Window security bars
- Door with security bars
- Lavatory with composting toilet
- Electric baseboard heating
- Exterior gravel pad for a temporary generator(to provide power while an attendant is on-site)
- Emergency wood stove with insulated chimney (¼ cord of pallet/ woodpellets/ stored in the shelter)
- Emergency communication device
- Lock

Site Ditching/Stormwater

Ditching will consist of runon, runoff and access rod ditches. Ditches will be designed for:

- 1:100 design event
- 3:1 slide slopes
- Nominal bottom width 1.0 m
- Nominal depth 1.0 m
- Rock lining (where required to address slope, velocity and erosion concerns)

Surface water runoff control plan will be developed to:

- Minimize erosion potential
- Collect (if required) sediment runoff prior to discharge off property
- Culverts will be corrugated HDPE
- Nominal culvert cover will be 0.5 m

Landfill

Design elements of the Landfill will include:

- All infrastructure will be set back a minimum of 30 m from the property line
- An assumed 75 year life
- Designed based on a "freeze-back" landfill
- Accommodations for baled and wrapped MSW, and C&D debris
- Liner system consisting on an 80 mil HDPE geomembrane
- No perorations in the geomembrane liner
- Baled MSW and C&D debris will be co-placed in one landfill
- 4:1 berm side slopes
- 4:1 exterior landfill side slopes
- 1:20 (5%) landfill top slopes
- Base of the landfill cells will be sloped nominally from 0.7 to 8.0 %

- A 600 mm thick granular layer of 75 mm clear stone placed under the water material (to collect and convey leachate)
- The Hydrologic Evaluation of Landfill Performance Model utilized (to predict leachate generation rates)
- Perforated HDPE pipes, designed to accommodate the depth of material and operational equipment traffic and forecasted leachate flow
- Duplex pump station located in a sump in the Landfill (to periodically remove and via a forecemain direct the leachate to the holding ponds) powered by a portable generator
- Leachate production/flow to typically occur from June 1 to September 30
- Nominal 18 m depth of waste material in the Landfill
- Developed in stages or cells, with the first two, cells designed in detail
- Periodic placement of daily cover material
- No litter control fencing

Landfill Gas

The United States Environmental Protection Agency (USEPA) Landfill Gas Emission Model (LandGEM) will be utilized to predict the emission rates for landfill gas (LFG) and the need for a passive or active LFG collection and treatment system. Parameters for the model will be based on published information from Environment and Climate Change Canada.

Leachate Treatment System

The leachate treatment system will consist of:

- Ponds lined with an 80 mil HDPE geomembrane
- Engineered wetland for treatment

7.3 Class D Costing

Class D costing for the Landfill and WTS (i.e., Cell 1, Cell 2 and Leachate Treatment System) are provided in **Table 7–1** and **Table 7–2**.

Table 7-1: Waste Transfer Station – Class D Opinion of Probable Capital Budget

Item	Description	Quantity	Units	Unit Price	Budget
1	Mobilization/Demobilization (2%)	1	lump sum	$475,000	$475,000
2	**Site Works**				
1	Site Grading	10,000	m^2	$50	$500,000
2	Perimeter Fencing	500	m	$325	$162,500
3	Entrance Gate	2	m^3	$40,000	$80,000
4	Yard Lighting	15	each	$4,000	$60,000
5	Access Road to Qappamiut Road	1	lump sum	$150,000	$150,000

Item	Description	Quantity	Units	Unit Price	Budget
3	**Waste Transfer Station**				
1	Site Preparation	1	lump sum	$50,000	$50,000
2	Excavation	3,100	m^3	$100	$310,000
3	Backfill	1,500	m^3	$150	$225,000
4	Foundation/Slab	1,200	m^3	$2,500	$3,000,000
5	Rigid Insulation	2,500	m^2	$100	$250,000
6	Thermosyphon	1	lump sum	$975,000	$975,000
7	Pre-Engineered Building	1	lump sum	$1,850,000	$1,850,000
8	Pushwalls	100	m^3	$2,500	$250,000
9	Electrical Service	1	lump sum	$150,000	$150,000
10	Electrical	1	lump sum	$1,200,000	$1,200,000
11	Emergency Power Generator	1	each	$1,200,000	$1,200,000
12	Fire Alarm System	1	lump sum	$100,000	$100,000
13	Mechanical	2,200	m^2	$100	$220,000
14	Heating System	2,200	m^2	$375	$825,000
15	Security	1	lump sum	$50,000	$50,000
16	Ventilation	2,200	m^2	$230	$506,000
17	Communications	1	lump sum	$50,000	$50,000
18	Fire Protection	2,200	m^2	$160	$352,000
4	**Material Processing Equipment**				
1	MSW Baler	1	lump sum	$1,200,000	$1,200,000
2	Baler Conveyor	1	lump sum	$250,000	$250,000
3	Bale Wrapper	1	lump sum	$610,000	$610,000
4	Baler Spare Parts	1	lump sum	$100,000	$100,000
5	Shredder	1	lump sum	$980,000	$980,000
6	Pellitizer	1	lump sum	$2,500,000	$2,500,000
5	Office Trailer	1	lump sum	$200,000	$200,000
6	Scalehouse Kiosk	1	lump sum	$25,000	$25,000
7	**Weigh Scale**				
1	Portable Weigh Scale	1	lump sum	$125,000	$125,000
2	Concrete slab	50	m^3	$2,500	$125,000
3	Excavation	50	m^3	$100	$5,000
8	End-of-Life Vehicle/Metals Logger/Baler	1	lump sum	$775,000	$775,000

Item	Description	Quantity	Units	Unit Price	Budget
9	HHW Depot/Storage Containers	3	each	$125,000	$375,000
10	Reuse Depot	1	lump sum	$50,000	$50,000
11	Portable Vehicle Hoist	1	lump sum	$40,000	$40,000
12	Cargo Shipping Insurance	500	tonne	$30	$15,000
				Subtotal	**$19,890,500**
				Contingency Allowance (20%)	**$3,978,100**
				Opinion of Probable Budget	**$23,868,600**

Table 7-2: Landfill – Class "D" Opinion of Probable Capital Budget

Description	Quantity	Units	Unit Price	Budget
Mobilization/Demobilization (2%)	1	lump sum	$261,839	$261,838.62
Access/Perimeter/Maintenance Road				
Entrance and Gate	1	lump sum	$40,000	$40,000
Perimeter Road Cut	4,500	cm	$30	$135,000
Perimeter Road Fill	6,600	cm	$50	$330,000
Perimeter Road Gravel (450mm)	4,700	sm	$25	$117,500
Ditching	1,200	m	$200	$240,000
Maintenance Road Cut	225	cm	$30	$6,750
Maintenance Road Fill	1,100	cm	$30	$33,000
Maintenance Road Gravel (450 mm)	1,100	sm	$25	$27,500
Landfill Cell 1				
Excavation	383	cm	$30	$11,475
Fill	24,225	cm	$50	$1,211,250
Under Cell Thermisters	1	lump sum	$100,000	$100,000
Geotextile 1 (allowance)	16,320	sm	$5	$81,600
Grading Pad	13,770	sm	$40	$550,800
Geotextile 2	16,320	sm	$7	$114,240
80 mil HDPE Geomembrane Liner	16,320	sm	$20	$326,400
Geotextile 3	16,320	sm	$7	$114,240
Leachate Collection Granular Layer (600 mm)	15,300	sm	$75	$1,147,500
Leachate Sump	1	lump sum	$25,000	$25,000
Leachate Collection Piping (150 mm)	51	m	$300	$15,300
Leachate Header Piping (200 mm)	153	m	$325	$49,725

Description	Quantity	Units	Unit Price	Budget
Perimeter Berm	196	m	$500	$98,175
Temporary Cell Separation Berm	201	m	$400	$80,580
Access Ramp	18	m	$500	$8,925
Leachate Forcemain (75 mm)	230	m	$300	$69,000
Leachate Pump Station/Generator	1	lump sum	$250,000	$250,000
Leachate Level Monitor Standpipe	1	each	$5,000	$5,000
Sediment Control Plan	1	lump sum	$50,000	$50,000
Erosion Control Plan	1	lump sum	$50,000	$50,000
Security	17	week	$6,000	$102,000
Miscellaneous	1	lump sum	$50,000	$50,000
Landfill Cell 2				
Excavation	358	cm	$30	$10,731
Fill	23,030	cm	$50	$1,151,500
Under Cell Thermisters	1	lump sum	$50,000	$50,000
Geotextile 1 (allowance)	15,680	sm	$5	$78,400
Grading Pad	13,230	sm	$40	$529,200
Geotextile 2	15,680	sm	$7	$109,760
80 mil HDPE Geomembrane Liner	15,680	sm	$20	$313,600
Geotextile 3	15,680	sm	$7	$109,760
Leachate Collection Granular Layer (600 mm)	14,700	sm	$75	$1,102,500
Leachate Collection Piping (150 mm)	49	m	$300	$14,700
Perimeter Berm	189	m	$500	$94,325
Temporary Cell Separation Berm	194	m	$400	$77,420
Access Ramp	17	m	$500	$8,575
Sediment Control Plan	1	lump sum	$35,000	$35,000
Erosion Control Plan	1	lump sum	$35,000	$35,000
Security	26	week	$6,000	$156,000
Miscellaneous	1	lump sum	$50,000	$50,000
Leachate Treatment System				
Cascade Aerator	1	lump sum	$45,000	$45,000
Lagoons - Excavation	1,800	m^3	$30	$54,000
Lagoons - Fill	19,000	m^3	$50	$950,000
Under Lagoon Thermisters	1	lump sum	$45,000	$45,000

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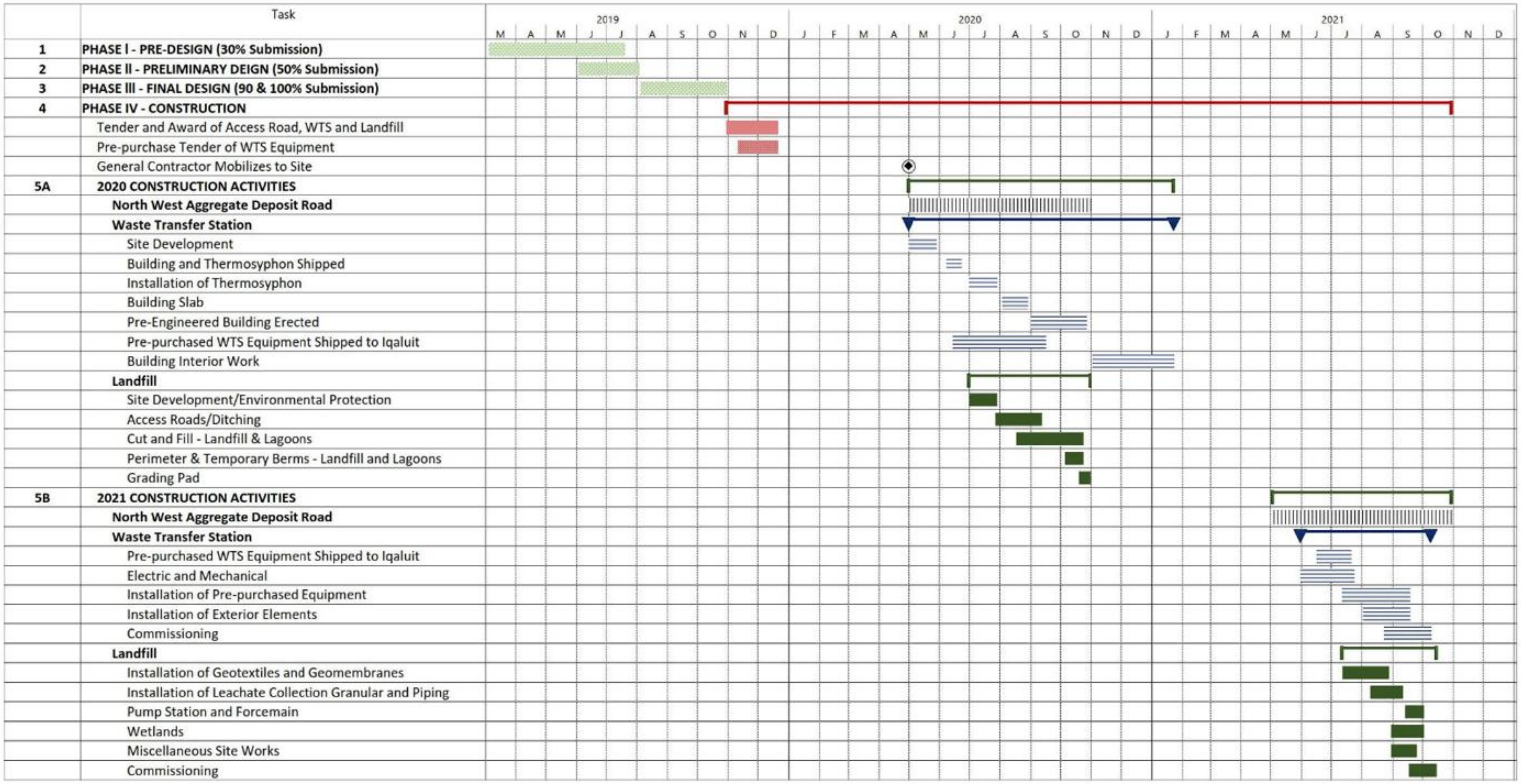
Description	Quantity	Units	Unit Price	Budget
Geotextile 1 (allowance)	13,000	m^2	$5	$65,000
Grading Pad	13,000	m^2	$40	$520,000
Geotextile 2	14,000	m^2	$7	$98,000
80 mil HDPE Geomembrane Liner	14,000	m^2	$20	$280,000
Lagoon fencing (c/w gates)	600	m	$325	$195,000
Lagoon Mechanical Aeration System	1	lump sum	$250,000	$250,000
Wetland Treatment Area (WTA) Fine Grading	18,000	m^2	$20	$360,000
Level Control Structures	3	each	$35,000	$105,000
Decant Pump and Generator	2	each	$85,000	$170,000
WTA Gravel Flow Control Berms	1,100	m	$275	$302,500
Chemical Feed System (allowance)	1	lump sum	$125,000	$125,000
Site Trailer	1	lump sum	$50,000	$50,000
Site Portable Generator	1	lump sum	$10,000	$10,000
Miscellaneous	1	lump sum	$100,000	$100,000
			Subtotal	**$13,353,770**
			Contingency Allowance (20%)	**$2,670,754**
			Opinion of Probable Budget	**$16,024,524**

7.4 Schedule

The proposed project schedule is presented in **Figure 7–1**. The design aspects of the project identified as Phase 1 to 4 follows the schedule presented in the RFP. We have assumed that exterior construction actives would begin in May and be completed by the end of October. The exception would be if the WTS was sufficiently constructed and weather tight, and that materials and equipment were on-site for interior work to continue into November and beyond. There are concerns with the North West Aggregate Deposit Road being tendered at the same time as the Landfill. Presently, there is no access road to the Landfill and the construction of the Landfill is expected to require two full construction seasons.

The schedule identifies the Landfill work commencing in July 2020, allowing work on the Aggregate Deposit Road to begin. Also, we have assumed that the Contractor would have a dedicated construction crew for the Landfill, and that equipment would be mobilized to the Landfill in July and would remain on-site, with security, until the end of October.

Figure 7-1: Proposed Project Schedule



8.0 Project Support Documents

Consistent with requirements identified in the RFP for the City Landfill and WTS assignment, a number of supporting documents were prepared to support the development of the Phase I Pre-Design package. These documents included:

- Facility Operations and Maintenance Manual
- Facility Risk Assessment Report
- Investing in Canada Infrastructure Program (ICIP) Reports (**Appendix H**)
  - ICIP Greenhouse Gas (GHG) Emissions Assessment and Report
  - ICIP Climate Change Resilience (CCR) and Report
- Closure and Decommissioning Plan
- Environmental Management, Environmental Protection and Emergency Response Plans

The following sections provide the highlights of each of these supporting documents and refer the reader to the relevant appendix at the end of the document for additional details.

Acknowledging that the overall Landfill and WTS design effort is currently at the 30% completion point, further refinements to the supporting documents are anticipated (and in select instances, are specifically identified), as the assignment moves forward through subsequent design phases.

8.1 Facility Operations and Maintenance Manual

At the Kick Off meeting for the Landfill and WTS project, the City requested that the development of an Operations and Maintenance Manual, originally proposed as a component of Phase II, be moved forward for completion as part of Phase I Pre-Design activities. An initial draft version of the Operations and Maintenance Manual is provided in **Appendix F** and incorporates information on the following Landfill and WTS components:

- Personnel
- Site Structures
- Site Equipment (Mobile and Stationary)
- Landfill Liner Development and Sequencing
- Waste Receiving, Placement and Sequencing
- Nuisance Control
- Surface Water Management
- LFG Management
- Leachate Management
- Site Monitoring
- Facility Records
- Schedule of Activities
- Emergency Response Plan

8.2 Facility Risk Assessment Report

Provided in **Appendix G**, a Facility Risk Assessment (FRA) was conducted to identify environmental, health and safety (H&S), geotechnical, facility infrastructure, and operational risks and potential mitigation measures for the Landfill and WTS. As part of the pre-design stage, the underlying goal of the FRA is to inform decision making regarding the following deliverables:

- Pre-Design Report
- Closure and Decommissioning Plan
- Draft plans and reports to support funding
- Emergency Response Plan
- Environmental Protection Plan (EPP)

Dillon worked with the City to define the scope, context and criteria, which formed the basis to conduct the risk assessment. A standardized, systematic, and transparent risk assessment and management process, with reference to ISO3100:2018 Risk Management – Guidelines, was adopted to identify, analyze and evaluate relevant risks.

Based on discussions with the City, the FRA looked at risk from the following perspectives (referred to as Risk Receptors):

- Public and employee Safety
- Financial Loss (Capital and Operational)
- Reputation
- Business Interruption/Level of Service
- Environmental
- Legal
- Technical

BowTie methodology was utilized to conduct the risk assessment. The design, construction, operation/maintenance and the closure/post-closure project elements were defined, from which various Risk Events were identified. The methodology was applied to identify and evaluate potential hazards, top events, preventive and response barriers, and consequences. A total risk score was then calculated based the likelihood and impact of each consequence on the risk receptors to determine their level of criticality. Due to its different nature, the "Technical" risk receptor was viewed as a separate category. Technical concerns and challenges based on the current level of design are provided in the FRA report.

As provided in Sections 3.2 and 3.3 of FRA, the hazard identification process is conducted with reference to the key project elements for both the Landfill and WTS under design and construction, and operations and maintenance categories. Hazards regarding the Closure and Post-Closure Phases of the Landfill are also identified and evaluated as a part of FRA.

The following results are reflected in the appended FRA report:

- Identified hazards, top risk events, consequences and applicable preventive/response barriers
- Evaluated total Risk Scores and ranking of Top Events and consequences
- Analysis of preventive and response barrier, in order to develop a robust Risk Management Plan
- A risk profile based on the individual risk scores per consequence category
- Identified Technical Risks and challenges

8.3 Investing in Canada Infrastructure Program Reports

Infrastructure Canada's Investing in Canada Infrastructure Program (ICIP) has a horizontal requirement as part of its program referred to as the Climate Lens. The Climate Lens is intended to provide meaningful insight into the climate impacts of projects and to encourage improved choices by incorporating climate change considerations into project design that are consistent with objectives outlined in the Pan-Canadian Framework for Clean Growth and Climate Change. The Climate Lens consists of two components or assessments: the GHG mitigation assessment; and the CCR Assessment (ICIP Reports). Each of these assessments are being conducted as part of this project and are described, along with a summary of their findings, in the sections below.

8.3.1 Investing in Canada Infrastructure Program Greenhouse Gas Emissions Assessment

The GHG mitigation assessment is intended to measure the anticipated GHG emission impact of the project. In this assessment, GHGs are quantified for both the project and a business-as-usual (BAU) case, which consists of the emission trajectory that is most probable in the absence of the project. In this assessment, the BAU case was the assumption that waste would continue to be handled in the manner it currently is. The GHG boundaries include direct emissions from operations, as well as indirect emissions in the form of supplied electricity. GHGs are required to be quantified for both the Construction and Operational Phases for the full lifespan of the project (75 years).

The total BAU emissions and project scenario emissions are then used to calculate a net change in GHG emissions and reductions/removals (if applicable) for the project. Finally, a financial analysis is conducted including a cost-per-tonne analysis that considers reduction estimates for year 2030 (to assess the federal component, as it relates to the Paris agreement), as well as total project cost/cumulative GHG reductions over the project lifespan. Where appropriate, GHG mitigation opportunities may be identified, where practical.

Detailed design data, such as that required for construction staging, equipment and activities, in order to properly calculate emissions, are not available at this stage. As a result, the full analysis and report for the GHG mitigation assessment will be submitted at a later date, as information becomes available.

8.3.2 Investing in Canada Infrastructure Program Climate Change Resilience Assessment and Report

The climate change resilience assessment comprises a risk management approach to assess potential future climate impacts on the infrastructure of the project. The assessment was conducted on the development area to determine climate change related impacts on the project infrastructure and develop potential resilience options. The methodology employed follows the approach described in the Climate Lens General Guidance Document issued by Infrastructure Canada. The assessment focused mainly on the infrastructure and assets related to the construction of the Landfill, as well as the project, and were assessed for the 75 year service life.

The assessment concluded with 20 moderate risks and three high risks identified. Moderate risk resilience measures were mainly related to procedural and policy measures to implement with operational staff. Some examples included leachate monitoring to help identify leaks or issues in the leachate collection system, while others included having extra stormwater infrastructure on hand (i.e., inventory) to be prepared in the event of a failure. These risks are fairly typical and anticipated, and are being incorporated into the final design of the project.

The two climate parameters driving the three high risk interactions are increasing temperatures and potential changes in permafrost. Given the nature of the climate in Iqaluit, the two interactions related to increased temperatures were a positive improvement, related to the functionality of the engineered wetland and quality of the wetland effluent. Climate change data for the region suggests that an increase in average annual temperatures will increase the functionality of the engineered wetland by providing favourable conditions for biological treatment. The third highest risk item was identified as the risk of crack or complete failure of slab/foundation construction. This risk is exacerbated by permafrost melt and more frequent events of freeze-thaw cycles. This is a known risk to the project team, and as per the report entitled “Geothermal Modelling and Geotechnical Recommendations” produced by Wood (May 14, 2019) the design team chose to incorporate thermosyphon technology into the slab/foundation design of the WTS. The Wood report investigated the impact of the thermosyphon on the expected temperature below the slab/foundation over 75 years. The assessment found that temperatures below the slab/foundation are expected to decrease over time, which suggests that the permafrost is not expected to melt in this area over the lifespan of the building. As such, no additional or unique adaptive measures were identified to be warranted for the project.

The full FRA report is provided in **Appendix G**.

8.4 Triple Bottom Line Assessment

As a component of the predesign effort, Dillon completed a triple bottom line (i.e., financial, social and environmental) impact assessment on alternatives to manage leachate generated by the City’s new Landfill. The three leachate treatment alternatives considered as part of this assessment are:

- Aerated lagoon and WTA
- Pre-treatment and haulage to the City’s WWTP
- On-site mechanical treatment

Consistent with the methodology described in Dillon's February 2019 proposal, the assessment utilized a weighted-criteria approach to arbitrate between the costs and benefits of alternatives considered. The weighted-criteria approach allocated 'points' consistent with the percentage value attributed to the assessment area. High point scores are preferable. As a result, points are allocated for potential benefits and areas with minimal or no impact, while negative impacts reduce point scores.

A shown in **Table 8–1**, the aerated lagoon and WTA alternative was identified as the most preferred based on the financial costs and the environmental criteria. While this option was not the most preferred socio-economic option, the variance in socio-economic impacts dependent on leachate treatment alternative is minor. Considering all criteria, the aerated lagoon and WTA alternative was most preferred for:

- Financial cost
- Materials
- Energy
- Water
- Emissions, effluent, waste
- Transport
- Human health
- Indigenous Rights and Interests
- Cultural resources

Table 8-1: Triple Bottom Line Assessment

Criteria	Aerated Lagoon and WTA	Utilizing the existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Life Cycle Cost ($ million)	24.43	75.16	100.82
Annual Financial Benefits (30%)	29	12	10
Environmental Cost/Benefit Score (40%)	30	18	21
Socio-economic Cost/Benefit Score (30%)	22.5	24	20.5
Overall Score[1]	81.5	54	51.5

1. The overall score is the sum of the financial, environmental and socio-economic scores.

Dillon recommends the City use an aerated lagoon and WTA leachate treatment system for the site based on the Triple Bottom Line Assessment for Leachate Treatment Alternatives, as presented in **Appendix D**.

8.5 Closure and Decommissioning Plan

The design for the City's Landfill and WTS is being developed based on an assumed 75 year design life. At the end of that period, appropriate measures will be required to support the closure and decommissioning of both facilities, acknowledging the City's obligations during a subsequent 25 year post-closure period. The Closure and Decommissioning Plan (see **Appendix I**), defines these requirements, including:

- Regulator and Public Notification
- Signage and Access Restrictions
- Building Disassembly/Demolition
- Equipment Decommissioning and Salvage
- Site Grading and Restoration
- Debris Management
- Surface Water and Leachate Management
- LFG Management
- Final Landfill Cap Installation
- Future Landfill Settlement
- Post-Closure Site Usage
- Post-Closure Inspection and Monitoring

8.6 Environmental Protection Plan, Environmental Management Plan and Emergency Response Plan Documents

The RFP for the City's Landfill and WTS project specified the requirement to prepare an Environmental Management Plan (EMP) that addressed regulatory and best practice requirements during the construction, operation, closure and post-closure of facility activities. With the EMP acting as an overarching document to define appropriate actions to support sustainable site activities throughout the 100 year operational and closure/post-closure period, further obligations and actions are detailed in the supporting EPPs (separate Construction Phase and Operations, Closure and Post-Closure documents) and Emergency Response Plan (ERP). The EMP, EPPs and ERP are all presented in **Appendix J**.

9.0 Next Steps

With reference to **Table 9–1**, the submission of the Phase I Pre-Design Report represents the second of eight key milestones in the City's Design and CCA assignment;

Table 9-1: Project Milestones

Project Milestone	Completion Date*
1. Project Kick Off Meeting	March 13, 2019
2. Phase I - Pre-Design Deliverables (30%)	May 31, 2019
3. Phase II - Preliminary Design Deliverables (50%)	July 30, 2019
4. Phase III - Final Design Deliverables (90%)	September 24, 2019
5. Phase III - Final Design Deliverables (100%)	November 5, 2019
6. Phase IV - Contractor Tendering	December 17, 2019
7. Anticipated Construction Start	May 1, 2020
8. Substantial Completion	October 31, 2021

Completed Milestone Item

* Adjusted to acknowledge change to proposal submission date to February 12, 2019

Based on comments received from the City on the content of the Phase I Pre-Design Report, and consistent with the work program presented in our proposal, Dillon will commence efforts to prepare the Phase II project documentation, with submission scheduled for July 30, 2019.

Appendix A

Supplementary Waste Transfer Station Environmental Site Assessment Investigation Report

DILLON CONSULTING

May 28, 2019

Colliers Project Leaders
Suite 700, 150 Isabella Street
Ottawa, Ontario
K1S 1V7

Attention: Mr. Erik Marko
Project Manager

Sampling Plan- Service Agreement SC902 (DRAFT)
Baseline Environmental Data Investigation
City of Iqaluit- Proposed Landfill and Waste Transfer Station

Dear Mr. Marko:

Dillon Consulting Limited (Dillon) is pleased to submit the following Sampling Plan to conduct the Baseline Environmental Data Collection program at the City of Iqaluit's (the City's) proposed Landfill and Waste Transfer Station (WTS) in Iqaluit, Nunavut (the Site). This submission includes a description of Dillon's proposed work program and assumptions/limitations to proposed activities. This plan has been prepared as a refinement to the original design proposal entitled: Proposal for Design and Construction Contract Administration Services of Solid Waste Landfill and Transfer Station, awarded to Dillon under Service Agreement SC902.

Objectives

The proposed Baseline Environmental Data Investigation will focus on collecting data from soil, groundwater and/or surface water in various areas in and around the proposed Landfill and WTS, in order to characterize current conditions at these locations. The results of the Baseline Environmental Data Investigation will be used to document current site conditions for comparison to future sampling programs. Additionally, a Qualitative Risk Assessment and Risk Management Plan for site development will be prepared for the WTS, using the collected data.

Work Program

Dillon will follow our standard health and safety (H&S) policies and procedures, including preparation of a Health and Safety Plan for all activities prior to conducting any on-site work.

The sampling program consists of installation of 10 drive-point groundwater monitoring wells at the WTS, sampling of shallow soil at the WTS, and groundwater and surface water sampling at both the WTS and Landfill locations. Fieldwork is tentatively scheduled for August 2019. Conducting this field visit in mid to late August will allow the permafrost to thaw sufficiently throughout the summer months, providing the best chance for groundwater and surface water samples to be collected across the Site.

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Table 1 below outlines the proposed Sampling Plan for the Landfill and WTS.

Table 1: Proposed Sampling Plan and Analytical Suite - Iqaluit Landfill and Waste Transfer Station

Sample Media		Sampling Location		
		WTS		Landfill
		FFTA/Storage	Staining/Storage	
Soil	Quantity	9	9	N/A
	Analyses	BTEX, F1-F4, PAHs, Glycols*, VOCs*, PFAS*	BTEX, F1-F4, PAHs, Glycols*, VOCs*	
Groundwater	Quantity	5	5	5
	Analyses	BTEX, F1-F2, dissolved metals, PAHs, Glycols*, VOCs*, PFAS*	BTEX, F1-F2, dissolved metals, PAHs, Glycols*, VOCs*	Dissolved metals, nutrients
Surface Water	Quantity	3		3
	Analyses	BTEX, F1-F2, dissolved metals, PAHs		BTEX, F1-F2, dissolved metals, PAHs

Notes:
FFTA: firefighter training area
BTEX: benzene, toluene, ethylbenzene, xylenes
PAHs: polycyclic aromatic hydrocarbons
VOCs: volatile organic compounds
PFAS: per- and polyfluoroalkyl substances
Nutrients to include Total Kjeldahl Nitrogen (TKN), ammonia nitrogen (N), nitrate (as N), nitrite (as N), sulphate, chloride, alkalinity
* to be conducted on select samples only
N/A: not applicable

Soil

Composite shallow soil samples will be collected from the top 30 cm of soil at 12 pre-determined areas of potential environmental concern at the WTS; some soil sampling locations may coincide with drive point monitoring well locations. Two bags of composite sample will be collected at each location, one for laboratory analysis and one for field screening using an RKI Eagle gas detector. All soil samples will be logged in the field for texture/grain size, colour, moisture content and visible signs of impact. Due to the volatile nature of certain parameters such as volatile organic compounds (VOCs) and light end hydrocarbons, collecting frozen soil samples will be avoided ,as this can impact sample integrity and cause skewed results.

As a portion of the WTS has been historically used as a firefighting training area (FFTA), this area will also be assessed for per- and polyfluoroalkyl substances (PFAS) contamination. Aqueous film-forming foam used for firefighting activities is known to contain PFAS and is a common source of PFAS contamination. Dillon will collect six water and six soil samples across the FFTA to determine background levels of PFAS. Some of these sample locations will coincide with locations proposed for other analyses. The additional cost for PFAS analysis will be approximately $6,500.00.

Water

Groundwater monitoring at both locations will consist of measurements of the headspace vapour readings, absence/presence of light non-aqueous phase liquid, depth to groundwater, depth to well bottom and stick-up height at all wells. Hydraulic conductivity testing and measurements of field parameters (i.e., pH, temperature, turbidity, electrical conductivity, oxidation-reduction potential) should also be conducted, but could be dependent on sampling methodology.

Groundwater samples will be collected from existing (Landfill) or new (WTS) monitoring well locations (Figure 1) using the low flow technique (electric or manual pump) into clean, laboratory supplied containers for analyses. Surface water samples will be collected from three nearby water bodies at the Landfill location and at the WTS from three points, along the adjacent watercourse (i.e., upstream, midstream and downstream; Figure 2). All collection locations will be recorded using a GPS. Samples slated for dissolved metals analysis will be field-filtered and preserved.

Reporting

Data collected during the Baseline Environmental Data Collection will be evaluated and analyzed for presentation in a Baseline Environmental Study report submitted to the City in October of 2019. This report will include field and laboratory data review for quality assurance/quality control (QA/QC) purposes, comparison of analytical data to applicable regulatory criteria, and outlines of baseline/background site conditions for future use. Additionally, a Qualitative Risk Assessment and Risk Management Plan for site development will be prepared for the WTS, using the collected data.

Other Considerations

Due to the remote nature of the Site and sampling locations, coupled with a potential for low productivity of groundwater in the monitoring wells, opportunistic sampling will be completed following a limited purge. Previous experience in similar conditions has shown that a limited purge of one bailer volume or one volume of the field reading container followed by sample collection provides a better chance of collecting a full suite of samples for laboratory analysis.

A wildlife monitor will be hired through the local Hunters and Trappers Association for field activities at the proposed Landfill location, as Dillon staff will be working in a remote area outside the City. All-terrain vehicle rentals will also be required to transport staff and their equipment to the Site, as road access has not yet been constructed.

The installation of 10 drive-point piezometers will require shipping well supplies to the City before Dillon field staff arrive on-site. While manually installing the piezometers from surface will be attempted, an excavator and operator may be required to dig test pits into which the piezometers can be installed. Once installed, field personnel will monitor the piezometers and determine if a groundwater sample can be collected. If no water is present and removing the piezometer is possible, the well may be moved to a different location.

To ensure the data quality objectives of the program are met, a field QA/QC protocol and a laboratory QA/QC protocol will be used to assist with data validation. The field QA/QC protocol will include measures to minimize the risk of sample cross-contamination, and will involve the collection of blank samples (e.g., equipment and field) and two blind field duplicates for both water and soil. Field data and laboratory results will be reviewed by the project manager and senior technical personnel to identify any discrepancies or potential errors. The results from internal laboratory QA/QC program will also be reviewed. The relative percent difference (RPD) for duplicate analyses will be reviewed to confirm results are within the acceptable ranges for RPD values.

Project Team and Schedule

Moving forward with the Baseline Environmental Data Investigation at the Site, Dillon will provide a dedicated project team with experience working in northern Canada. Due to the remote nature of this project and ensuring the H&S of Dillon employees, two Dillon field staff will mobilize to Iqaluit for this project. Selected staff for the project will be available to mobilize after mid-August to conduct the environmental sampling program. This timing will allow for an increased likelihood of sufficient groundwater and surface water to permit sampling due to reduced permafrost.

Project schedule is as follows:

Dillon field staff on-site	August 19-23, 2019
Lab Analysis Received	within three weeks of site visit
Report Due	October 25, 2019

Closure

We trust this submission meets your needs at this time. If you have any questions or require further information, please contact the undersigned at (403) 215-8885, ext. 4310.

Yours truly,

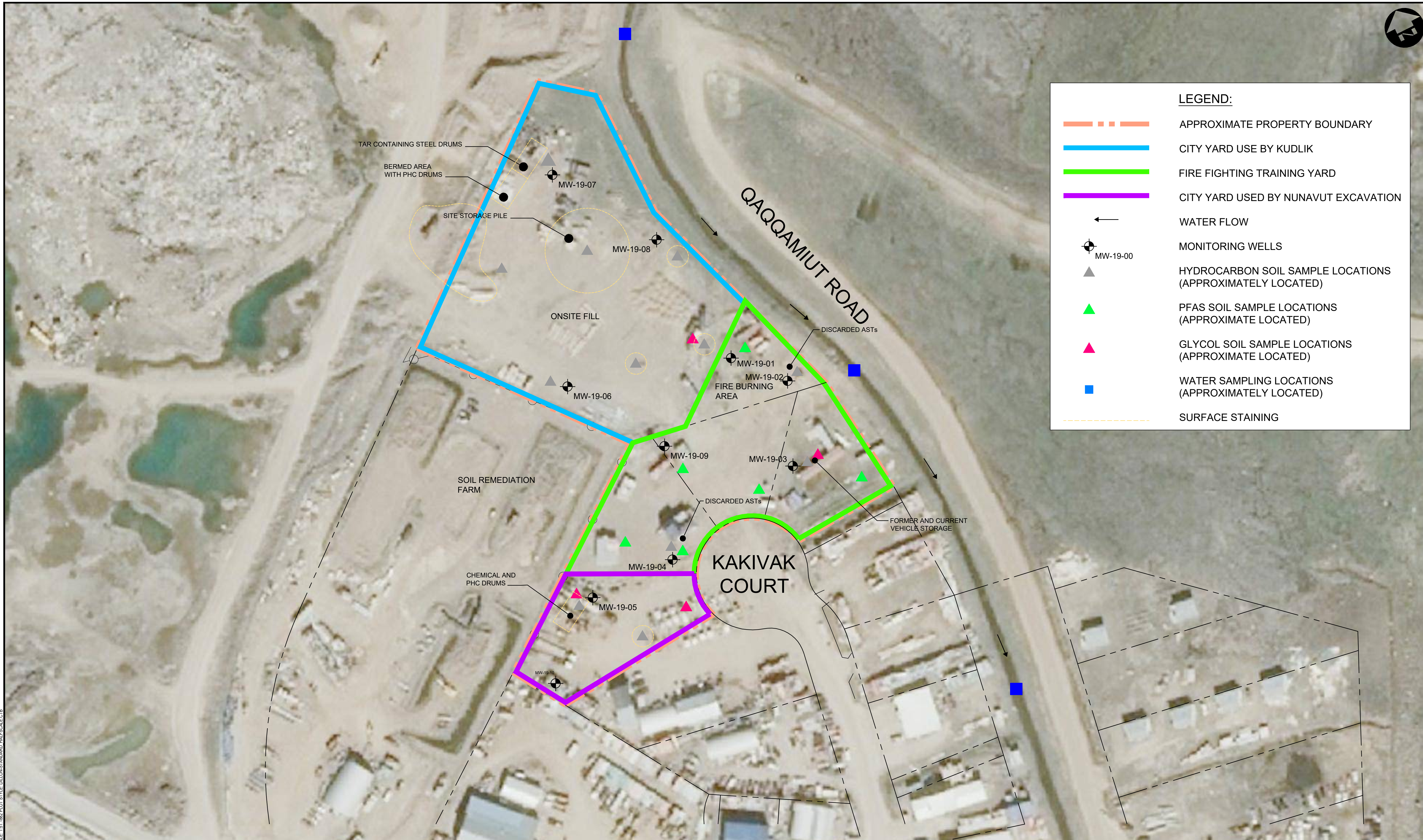
DILLON CONSULTING LIMITED

Keith Barnes, P.Eng.
Project Manager

APH:slg
Attachments: Figure 1 – Proposed Sample Locations
Figure 2 – Proposed Water Sampling Locations

Cc: Chris Shortall, P. Eng., FEC, Dillon Consulting Limited

Our File: 19-9543



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Iqaluit ᐃᖃᓗᐃᑦ

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No.	ISSUED FOR	DATE	BY
1	30% REVIEW	2019/05/31	K.B.

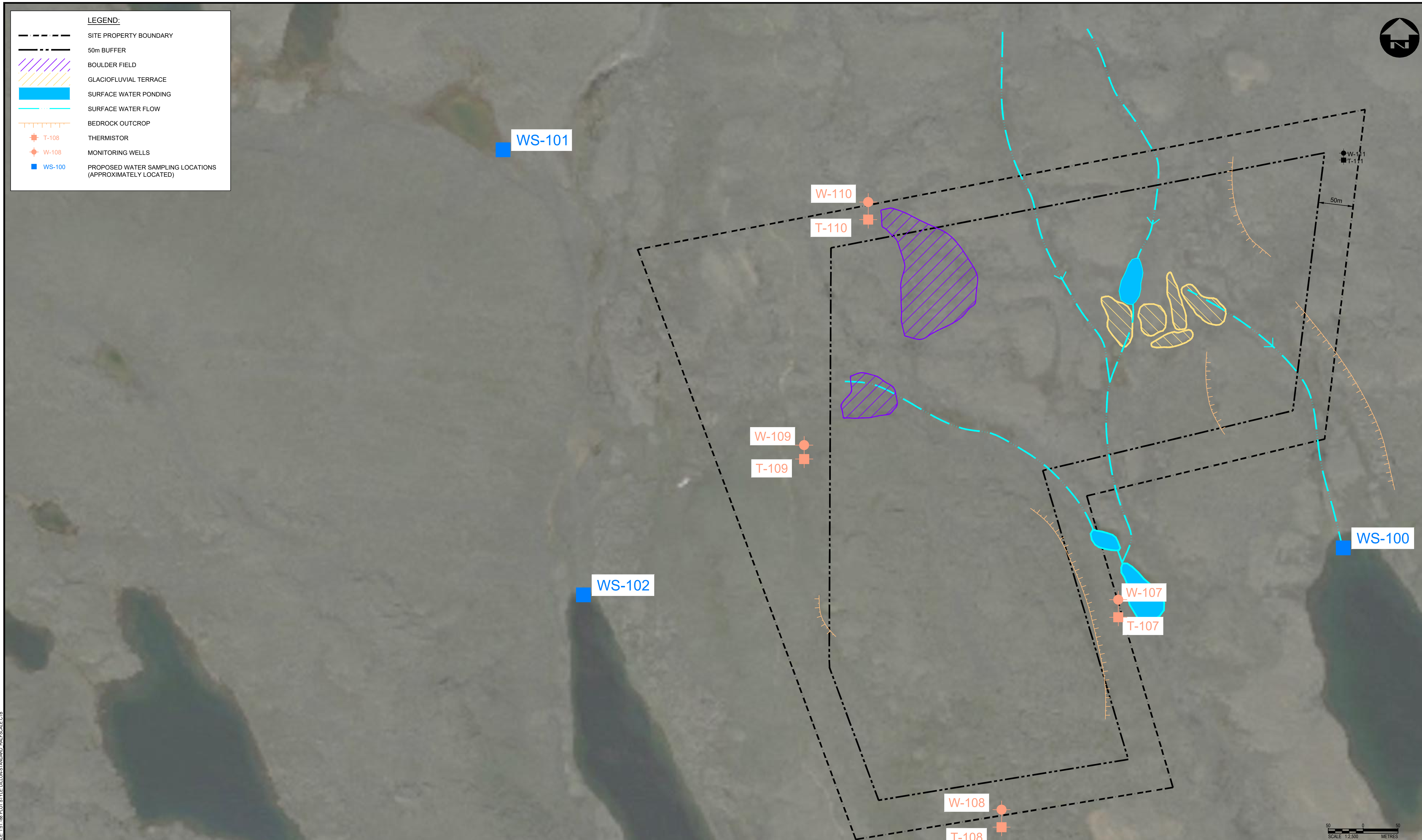
DESIGN	REVIEWED BY CR
DRAWN RCB	CHECKED BY KGB
DATE MAY 2019	
SCALE 1:500	

CITY OF IQALUIT
WASTE TRANSFER STATION

PROJECT NO. **19-9543**

PROPOSED SAMPLE LOCATIONS

FIGURE NO. **1**



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Iqaluit

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1	30% REVIEW	2019/05/31	K.B.

DESIGN	REVIEWED BY CR
DRAWN RCB	CHECKED BY KB
DATE MAY 2019	
SCALE 1:2500 (22x34) 1:5000 (11x17)	

CITY OF IQALUIT
SOLID WASTE LANDFILL

PROJECT NO. 19-9543

PROPOSED WATER SAMPLING LOCATIONS

FIGURE NO. 2

FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\PROJECTS 2019\43R... PLOT DATE: 2019-05-31 @ 2:09:19 PM PLOT SCALE: 1:51.188 PLOT STYLE: ...

Appendix B

Waste Transfer Station Geothermal Analysis Report (Wood Group)

wood.

Geothermal Modelling and Geotechnical Recommendations

Transfer Station and Landfill in Iqaluit, Nunavut
Project # CG14359

Prepared for:

Dillon Consulting limited

Calgary, Alberta

14-May-19

Geothermal Modelling and Geotechnical Recommendations

Transfer Station and Landfill in Iqaluit, Nunavut

Project # CG14359

Prepared for:

Dillon Consulting limited
Calgary, Alberta

Prepared by:

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Canada
T: 403-248-4331

14-May-19

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1.0 Introduction

At the request of Mr. Keith Barnes, Associate Engineer with Dillon Consulting Limited (Dillon), Wood Environment and Infrastructure Solutions a division of Wood Canada Limited (Wood), has conducted geothermal modeling and developed geotechnical recommendations for the proposed transfer station foundation and for the proposed landfill in Iqaluit, NU.

The geotechnical discussion provided in the present report is based on a review of the following reports and geotechnical drilling for the project:

- "Geotechnical investigation, Proposed Waste Transfer Station, Iqaluit, Nunavut, EXP Project No. OTT-00248813-AO", dated 19 October 2018. The geotechnical field investigation consisted of drilling six boreholes to depths of between 10 m and 15 m at the proposed waste transfer station site.
- "City of Iqaluit Waste Transfer Station and New Landfill Project, Desktop Study – Proposed New Landfill Site (Site 2), EXP Project No. OTT00248813-AO", dated 19 October 2018.

The reviewed geotechnical report and drilling results were prepared by EXP Services Inc.

2.0 Scope of Work

It was understood that the transfer station should be supported by a mat (slab-on-grade) foundation with no crawl space between underside of the station and the ground surface. Such a foundation option for heated structures within permafrost regions with ice-rich surficial materials can be used if some device or method be applied to eliminate or considerably reduce the amount of heat released by the heated structure into the permafrost. For the current project, two foundation options were considered: 1) thermosiphons to freeze surficial soils under the heated structure; 2) a thick layer of insulation immediately under the slab to reduce heat flux from the heated structure. The scope of work includes the following sections required for designing suitable foundations for the transfer station:

- Compilation of climate data;
- Regional geological and permafrost conditions;
- Results of geotechnical drilling;
- Results of geothermal modeling
- Geotechnical recommendations on suitable foundation options (slab-on-grade and slab-on-grade with thermosiphons, including soil design parameters); and
- Geotechnical recommendations on site grading and drainage.

The scope of work for the proposed landfill included geothermal modeling for the baled waste. The purpose of the modeling was determination of the period of time for freezing the baled waste and underlying soil of the active layer, if placement of the bales occurs at the end of summer.

3.0 Iqaluit Transfer Station and Landfill Location

The Town of Iqaluit is situated at the edge of the Hall Upland of the Davis Physiographic Region. The town overlooks the waters of Frobisher Bay, sitting on rocky terrain with numerous rock outcrops. Geographically, the town lies at about 63°45′ N latitude and 68°31′ W longitude. The proposed waste transfer station will be located on town lots 3586 228/17/18/20 and 3480 220/1 (Qaqqamuit Road), approximately 2 km north from the Iqaluit airport.

The proposed landfill site is an approximately 66.12 parcel of land, with the site to occupy approximately 22 hectares, and located approximately 8 km northwest of the City of Iqaluit.

4.0 Climate

Climate Normals data for periods 1971-2000 and 1981-2010 (Table 1) of the Iqaluit weather station were used to analyze climate conditions of the site. Comparison of the two sets of climate data (1971-2000 and 1981-2010) shows that the mean annual air temperature increased from -9.8 °C to -9.3 °C (0.5 °C increase), respectively, and the mean summer air temperature increased from 5.1 °C to 5.4 °C (0.3 °C increase), respectively. The increase of the mean winter air temperature is twice greater than the mean summer air temperature, being -17.2 °C to -16.6 °C (0.6 °C increase), respectively.

Based on the undertaken analysis of the climate data, it can be expected that the mean annual air temperature within the Iqaluit region may gradually increase within the following 20-30 years (operational life of the structure) by 1.5 °C to 2.0 °C.

Table 1: MEAN MONTHLY AIR TEMPERATURES (°C)

Time Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971-2000	-26.6	-28.0	-23.7	-14.8	-4.4	3.6	7.7	6.8	2.2	-4.9	-12.8	-22.7
1981-2010	-26.9	-27.5	-23.2	-14.2	-4.4	3.6	8.2	7.1	2.6	-3.7	-12.0	-21.3

In addition to the air temperature, wind velocity in the winter months is required for the geothermal analyses. This meteorological data for period 1981-2010 is provided in Table 2 below.

Table 2: MEAN MONTHLY WIND VELOCITY

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind velocity, m/sec	4.4	4.2	4.1	4.5	4.7	---	---	---	---	4.9	5.2	4.5

5.0 Regional Geology and Permafrost

The surficial geology map of Iqaluit was reviewed to determine the surficial geology at locations of the transfer station and landfill site. It was understood that the glacial marine delta (plain) is expected to be encountered at the transfer station site where thickness of glacial deposits reworked by marine actions may well exceed 10 m. Contrary to the transfer station site, the surficial terrain at the landfill site is shown as till veneer with fragments of till blanket. The thickness of glacial deposits at the landfill site likely does not exceed 5 m. The glacial marine and glacial deposits typically represent mix of sand, silt and clay with numerous inclusions of cobbles and boulders. The glacial marine deposits at shallow depths typically are denser and have less fine content.

The glacial marine and glacial deposits are underlain with monzogranite bedrock which mainly consists of biotite and quartz.

Iqaluit lies within the continuous permafrost zone. The thickness of the active layer has been reported to vary from 1 m to 2 m, depending on ground vegetative cover and moisture content of surficial soils.

Permafrost temperature data obtained from a few previously investigated sites in the community suggest that the mean annual permafrost temperature within the community is in the range of -4 to -5 °C at a depth of 8-10 m.

6.0 Encountered Soil Profile

6.1 Transfer Station

A geotechnical field investigation at the transfer station site was undertaken on September 14, 2018. The drilling program of the field investigation consisted of advancing 6 boreholes drilled to depths of 10-15 m using an air-track drill.

The surficial material was generally represented by fill which consisted of gravelly sand with some cobbles. Moisture conditions varied and were noted to be dry to wet. Fill thickness varied from 1.0 m to 2.0 m. No laboratory moisture testing was done on the surficial fill.

Beneath the fill, gravelly sand to sandy gravel was encountered in four boreholes with a thickness ranging from 1.1 m to 8.0 m. BH-2 had no gravelly sand layer but was noted to have a 0.2 m thick layer of cobbles and boulders beneath the fill. BH-6 also did not have gravelly sand to sandy gravel beneath the fill, poorly graded sand was beneath the fill in this location. The moisture contents were highly variable, ranging from approximately 1% to 18%.

Well to poorly graded sand was noted below the gravelly sand to sandy gravel, in all boreholes with the exception of BH-3, where the sand layer was gravelly. The well graded gravel (found in BH-1 and BH-2) had a moisture content ranging from approximately 7% to 15%. The gravelly sand in BH-3 had a moisture content ranging from approximately 6% to 18%. The poorly graded sand (found in BH-4, BH-5 and BH-6) had a high variability in moisture content, ranging from approximately 5% to 23%.

Perched water was encountered at various depths in BH-2 (1.5 m depth), BH-3 (3.0 m depth), BH-4 (1.5 m depth), and BH-5 (1.2 m depth).

Mean annual permafrost temperature was measured to be in the range of -4.0 °C to -4.5 °C in BH2 and BH4, respectively.

Bedrock was not encountered at any of the borehole locations.

6.2 Landfill Site

Due to limited access to the landfill site, it was not possible to complete the proposed borehole program.

The regional geology map showed the majority of the landfill site covered with a till veneer, which was expected to be 0.5 m to 2 m in thickness. A till blanket, which can be up to 10 m thick, was shown close to the northeast corner of the site.

Review of the topographical map showed the landfill site area as undulating, with an elevation range from 155 m to 180 m. The location chosen from the preliminary desktop study has a ground surface elevation change of approximately 7 m within the area.

7.0 Geothermal Modelling

For the current study, a 2-dimensional version of SIMTEMP software (developed in-house by Wood) was used for temperature prediction of soil temperature under the slab of the transfer station. The program uses the finite element method to compute a numerical solution for the heat transfer problem. Physical/mathematical algorithms used in the SIMTEMP model have been published and the simulation process has been verified against well-known analytical solutions and with numerical solutions produced by other commercial/non-commercial geothermal modelling software. Wood has successfully used the SIMPTEMP program for a variety of geothermal applications over the last twenty years. Two geothermal analyses were carried out for the current transfer station project: the first geothermal run was for a slab-on-grade foundation with thermosiphons, while the second run was for the slab-on-grade foundation with no thermosiphons, but with thicker insulation placed immediately under the slab, and a thicker layer of granular fill material placed below the insulation. The finite element grid for both analyses consisted of 1539 nodes and 2912 triangle finite elements.

A sketch showing the cross-section used for the finite element grid for the 2-dimensional geothermal analysis with thermosiphons is shown on Figure 1, Appendix A. It can be seen that the grid profile consists of a 0.2 m thick slab, 0.1 m thickness of insulation, 0.5 m thickness of granular fill, and a 20 m thickness of in-situ sand/gravel underlain with bedrock. The thermosiphons are placed at a depth of 0.3 m below the base of the insulation, n the granular fill, with approximately a 3.0 m spacing across the station. A similar cross-section was used for the 2-dimensional geothermal modeling with no thermosiphons. It was assumed in this analysis that the insulation thickness is 0.3 m thick, and the layer of granular fill was 2 m thick (Figure 2, Appendix A).

The geothermal analyses started from September 1 and was run over a period of 70 years. Table 3 below provides the physical and thermal properties of identified materials.

Table 3: PHYSICAL AND THERMAL PROPERTIES OF IDENTIFIED MATERIALS

Material	Dry Density, Kg/m³	Moisture Content,%	Thermal Cond., W/m/°K		Heat Capacity, MJ/m³/°K		Latent Heat, MJ/m³
			frozen	unfrozen	frozen	unfrozen	
Granular Fill	2000	5	2.14	2.10	2.100	2.260	33.496
In-situ Sand and Gravel	1800	10	2.20	1.97	2.040	2.420	60.293
Bedrock	2500	2	2.91	2.91	2.512	2.512	16.748

7.1 Boundary and Initial Conditions

The initial temperature of the materials was assumed to be 2 °C from surface to 1.5 m depth, and -4 °C from 1.5 m to 100 m depth. The room temperature within the transfer station was assumed to be 10 °C. The concrete slab and insulation were modeled in the model as heat transfer coefficients. The total heat transfer coefficient (a) of the slab and insulation was calculated by the following equation:

$$a = \frac{1}{\frac{1}{a_{conc}} + \frac{1}{a_{ins}}} \quad (1)$$

Where:

a_{conc} – heat transfer coefficient for concrete, W/m²/°C;

a_{ins} – heat transfer coefficient for insulation, W/m²/°C.

It was assumed in the calculations that the thermal conductivity of concrete and insulation is equal to 1.5 W/m/°C and 0.034 W/m/°C, respectively.

The heat transfer coefficient for the thermosiphons (a) was calculated by Equation 2 below published in the report TR-14-1 "Review of Thermosiphon Applications" prepared by US Army Engineer Research and Development Centre (ERDC) and Cold Regions Research and Engineering Laboratory (CRREL).

$$a = 15.83 + 9.8W \qquad (2)$$

Where:

W – wind velocity, m/sec, Table 2.

The temperatures of the granular fill surface or evaporator surface (T_{sur}) were calculated by the following equation:

$$a(T\_air - T\_sur) = (T\_sur - T\_node)k/D; \qquad (3)$$

Where:

a– heat transfer coefficient, W/m^2/°C;

T_{air} – ambient air temperature for 1981-2019 for thermosiphons (Table 1) or room temperature (10 °C);

T_{node} – soil temperature at depth D from granular fill surface, or from thermosiphon, °C;

D – distance between T_{sur} and T_{node} , m;

k– frozen or unfrozen soil thermal conductivity, W/m/°C.

7.2 Results

Figure 3, Appendix A, shows temperature profile at the end of August for the granular fill and in-situ sand and gravel for various years of the station operation at midpoint between thermosiphons. It can be seen on Figure 3 that the thickness of the thawed zone under the slab is about 0.5 m. Below this depth, the soil temperature quickly drops down to a temperature of approximately -4.8 °C after the first winter of thermosiphon operation. The soil temperature will gradually decrease at the 7 m depth, and after 30 and 70 years of station operation will be in the order of approximately -6.0 °C.

Figure 4, Appendix A, shows the temperature profile at the end of August for the granular fill and in-situ sand and gravel for various years of the station operation at the middle of the transfer station with no thermosiphons. As expected, the thaw depth gradually increases from approximately 2.0 m after 3 years of operation, to approximately 19.0 m at the end of the proposed 70-year service life of the transfer facility (70 years). Based on assessment of the moisture content for sand and gravel (approximately averaging 10 percent), it is considered that the total thaw settlement may approach 90-100 mm at the end of the station operational life.

8.0 Foundation Recommendations

8.1 Compacted Granular Pad Foundation

Based on results of field geotechnical investigations and geothermal modeling, it was concluded that the foundation system for the transfer station can be designed as a reinforced concrete slab supported on a compacted gravel pad – either with or without installation of thermosiphons. However, some limitations, will apply to the slab-on-grade foundation alternative that does not include thermosiphons to remove heat energy from the area below the structure. The following recommendations are provided for design and construction of slab on grade foundations, either with or without installation of thermosiphons.

8.1.1 Slab-On-Grade with Thermosiphons

Excavation for the granular pad should be at least 0.8 m deep and extend approximately 1 m beyond the footprint of the structure. The best time for excavation is late spring when the subgrade is still in a frozen state, but soil temperature to the 2 m depth likely is only marginally below 0 °C. Based on results of the geothermal modeling, it is considered that the thermosiphons can be installed 3 m apart at the 0.3 m depth below the underside of the insulation. It should be noted that final recommendations on installation of the thermosiphons will be prepared by a foundation designer.

Preparation of the subgrade for the granular pad should include removal of all localized surficial organic and compressible material. Proof rolling with locally available heavy equipment then should be carried out over the prepared subgrade for the granular pad area. Weak material identified by the proof rolling should be over excavated to a competent frozen/unfrozen surface and then be backfilled to excavation invert with compacted gravel.

Granular material for backfilling over-excavated soft zones and for pad construction should be free of organics and contain less than 10 percent fines. The gradation for gravel provided in Table 4 is intended to serve as a guideline in specifying granular material.

Table 4: RECOMMENDED GRADATION FOR 25 MM FILL

Sieve Size, mm	Percent passing by Weight
25	100
20	95-100
10	60-80
4.75	40-60
2.36	28-48
0.6	13-29
0.3	9-21
0.15	6-15
0.075	4-10

All fill up to 0.4 m depth should be placed in lifts not exceeding 0.2 m in loose thickness and should be compacted to not less than 95 percent of Standard Proctor Maximum Dry Density (SPMDD). A sand layer, compacted to at least 95 percent of SPMDD, then should be placed up to the elevation where the thermosiphons will be installed. Following installation of the thermosiphons, a leveling sand layer, approximately 0.1 m thick should be placed and compacted to 95 percent of SPMDD. Sand fill compacted to 98 percent of SPMDD then should be placed up to the elevation where the insulation will be placed. It is recommended that the extruded polystyrene insulation thickness should be not less than 100 mm. The insulation should extend over the entire excavation, and 1 m beyond the station footprint. The unfactored ULS bearing capacity of the compacted granular pad may be taken as 660 kPa, and the SLS bearing capacity may be taken 200 kPa. Short term settlement of the granular pad is expected to be in the order of 5 mm, and long-term settlement of the granular pad due to creep processes (after 70 years of operation) may expected to be in the order of 10-15 mm.

8.1.2 Slab-On-Grade with Thick Insulation

Based on results of the field geotechnical investigations and geothermal modeling, it can be concluded that a slab-on-grade foundation with thickened insulation is possible, if the following limitations are acceptable:

- The structure will tolerate a gradually increasing thaw settlement, up to approximately 50 mm after 30 years of operation;
- Installation of thermosiphons to operate for a limited period of time, may potentially be required after the 30th year of the operation to eliminate additional thaw settlement, over the period while the thermosiphons are operational; and
- The time over which the (temporary) thermosiphons are will be determined based on the tolerance of the structure to frost heave. Without temporary thermosiphons, the likely additional thaw settlement between operational years 30 and 70 is in the order of 30-40 mm.

Excavation for the granular pad should be at least 2 m deep and extend approximately 1 m beyond the footprint of the structure. The best time for excavation is late spring when the subgrade is still in a frozen state, but soil temperature to the 2 m depth are likely only marginally below 0 °C. Preparation of the subgrade for the granular pad should include removal of all localized surficial organic and compressible material. Proof rolling with locally available heavy equipment then should be carried out over the prepared subgrade for the granular pad area. Weak material identified by the proof rolling should be over excavated to a competent permafrost surface and then be backfilled to the excavation invert with compacted gravel.

Granular material for backfilling over-excavated soft zones and for pad construction should be free of organics and contain less than 10 percent fines. The gradation for gravel provided in Table 4 is intended to serve as a guideline in specifying granular material. The gradation provided is recommended for use for granular backfill that will be placed in a frozen state. Also, the moisture content of the frozen fill should be low (3-5 percent) which does not allow formation of frozen chunks of fill, which would be particularly susceptible to settlement upon thawing.

All fill should be placed in lifts not exceeding 0.2 m in loose thickness and should be compacted to not less than 98 percent of Standard Proctor Maximum Dry Density (SPMDD). A final lift of the granular pad should consist of a 0.1 m thick sand layer, compacted to at least 98 percent of SPMDD. A 300 mm thick layer of extruded polystyrene insulation should be placed on the sand layer and should be extended over the entire excavation, plus 1 m beyond the station footprint. The unfactored ULS bearing capacity of the compacted granular pad may be taken as 660 kPa, and the SLS bearing capacity may be taken 200 kPa. Short term settlement of the granular pad is expected to be in the order of 15 mm, and long-term thaw settlement of the granular pad (after 30 years of operation) may expected to be in the order of 50 mm.

9.0 Site Grading and Drainage

A site grading plan will need to address surface water management in periods of heavy runoff and snow melt. The final grade of the site should ensure that the drainage is directed away from the building to reduce the potential for thermal and water erosion. The final grade should have a minimum slope of 3 percent down away from the building within 2 m of the structure, and a minimum 2 percent slope down for several meters beyond the 2 m distance to shed water away from the structure.

Downspouts for eaves troughs should be directed away from the building with the discharge point at least 1.5 m meters from the exterior of the building. This will reduce the potential for erosion of the subgrade adjacent to the structure.

10.0 Design Review and Foundation Monitoring

It is recommended that a geotechnical review be conducted prior to finalization of design details and contract specifications. This review is considered to be an important part of the design process, as it enables Wood to ensure that the recommendations contained herein have been understood and interpreted correctly.

It is recommended that a qualified geotechnical engineer or technologist monitor the gravel pad construction.

In general, monitoring of gravel pad construction will include the following:

- Determination of dimensions for soft zones which require over excavation;
- Assessment of granular material quality; and
- Confirmation that adequate degree of compaction is obtained

The concrete slab for the transfer station should be underlain by relatively clean gravel fill to reduce the risk of sulphate attack. If this is implemented, Type GU (formerly Type 10) Portland cement can be used for the manufacture of foundation concrete.

11.0 Baled Waste Freezing

A 1-dimensional version of SIMPTEMP was used for assessment of the period of time required to freeze baled waste at the proposed landfill site in Iqaluit. It was assumed that the soil profile consists of 2 m of glacial deposits (sand and gravel at moisture content 10 percent) over granite bedrock. Based on data provided in the paper titled "Temporal variation of leachate quality from pre-sorted and baled municipal solid waste with high organic and moisture content" (Waste management, Volume 22, 2002) it was assumed that the moisture content of the baled waste, by wet weight is about 50 percent. It was also estimated, following discussion with Dillon's design engineer, that the bulk density of the baled waste is 700 kg/m^3. The physical and thermal parameters for in-situ sand and gravel are shown in Table 3 above and the parameters for the baled waste are provided in Table 5.

Table 5: PHYSICAL AND THERMAL PROPERTIES OF IDENTIFIED MATERIALS

Material	Dry Density, Kg/m^3	Moisture Content by Dry Weight ,%	Thermal Cond., W/m/°K		Heat Capacity, MJ/m^3/°K		Latent Heat, MJ/m^3
			frozen	unfrozen	frozen	unfrozen	
Baled Waste	250	140	0.70	0.41	2.100	3.320	117.496

The upper boundary conditions were taken as the mean monthly air temperatures (Table 1). An n-factor of 1.1 was applied to the mean monthly air temperatures to obtain the waste surface temperatures in summer months. In winter months, the waste surface temperatures (T_{sur}) were calculated by the following equation:

$$\frac{1}{R}(T_{air} - T_{sur}) = (T_{sur} - T_{node})k_w/D\,; \qquad (4)$$

Where:

R– snow thermal resistance, m^2 °C W^{-1};

T_{air} – ambient air temperature for 1981-2019 (Table 1) ;

T_{node} – soil temperature at some distance from the surface, °C;

D – distance between T_{sur} and T_{node} , m;

k_w– frozen or unfrozen waste thermal conductivity, W/m/°C.

A heat flux corresponding to the geothermal gradient of 0.02 °C/m was used as the bottom boundary conditions.

11.1 Results

Two geothermal analyses were carried out. For the first analysis, the baled waste at a temperature of 10 °C was placed on the unfrozen ground on October 1. It is considered as the worst-case scenario when the 3 m high bale at a temperature of 10 °C is placed on the unfrozen active layer, approximately 1.6 m thick with a temperature of approximately 2 °C.

For the second analysis, the baled waste at a temperature of 10 °C was placed on the frozen ground on December 1. It is considered as the better case scenario when the 3 m high bale at a temperature of 10 °C is placed on the partially frozen active layer (frozen from ground surface to 1.1 m depth), and only the 0.5 m thick bottom portion of the active layer is unfrozen at temperature 0.1 °C.

Figure 5, Appendix A shows the results for bales being placed on October 1 on the unfrozen ground surface. The results presented are for September30 for each year when maximum thaw of the ground is expected, to capture the bale and ground temperatures to 6 m depth. For the first year, the top 0.6 m of the bale was unfrozen (active layer in the bale). The bale was frozen from 0.7 m to 1.6 m depth. The bale and the ground were unfrozen from 1.7 m to 4.7 m depth. For year 2, the bale was frozen from 0.6 m to 2.1 m depth (thickness of frozen portion of the bale increased by 0.5 m). The bale and ground surface were unfrozen from 2.9 m to 3.8 m depth. At the end of year 3, the soil is in a frozen state beneath the bale but the soil temperature is just marginally below 0 °C . Only at the end of year 6, are the bale temperature (below bale active layer) and the soil temperature (below bale) equal, at approximately -1 °C .

Figure 6, Appendix A shows the results for bales being placed on December 31 on the frozen ground surface. The results presented are for September 30for each year when maximum thaw of the ground is expected, to capture the bale and ground temperatures to 6 m depth. For the first year, the top 0.6 m of the bale was unfrozen (active layer in the bale). The bale was frozen from 0.7 m to 1.6 m depth. The bale and the ground were unfrozen from 1.7 m to 3.4 m depth. For year 2 the ground is frozen completely beneath the bale, but the soil temperature is just marginally below 0 °C . For the following years, the ground temperature drops beneath the bales, as well as within the bottom portion of the bale, and at the end of year 5, the bale temperature (below bale active layer) and the soil temperature (below bale) are equal at approximately -1.8 °C .

It can be concluded based on results of the geothermal analyses that 5-6 years is required for complete freezing of the bale and soil below the bale, if the bale placement occurs at the end of summer or in early winter.

12.0 Limitations & Closure

12.1 Limitations

1. The work performed in the preparation of this report and the conclusions presented herein are subject to the following:

   a) The contract between Wood and the Client, including any subsequent written amendment or Change Order dully signed by the parties (hereinafter together referred as the "Contract");

   b) Any and all time, budgetary, access and/or site disturbance, risk management preferences, constraints or restrictions as described in the contract, in this report, or in any subsequent communication sent by Wood to the Client in connection to the Contract; and

   c) The limitations stated herein.

2. **Standard of care:** Wood has prepared this report in a manner consistent with the level of skill and are ordinarily exercised by reputable members of Wood's profession, practicing in the same or similar locality at the time of performance, and subject to the time limits and physical constraints applicable to the scope of work, and terms and conditions for this assignment. No other warranty, guarantee, or representation, expressed or implied, is made or intended in this report, or in any other communication (oral or written) related to this project. The same are specifically disclaimed, including the implied warranties of merchantability and fitness for a particular purpose.

3. **Limited locations:** The information contained in this report is restricted to the site and structures evaluated by Wood and to the topics specifically discussed in it, and is not applicable to any other aspects, areas or locations.

4. **Information utilized:** The information, conclusions and estimates contained in this report are based exclusively on: i) information available at the time of preparation, ii) the accuracy and completeness of data supplied by the Client or by third parties as instructed by the Client, and iii) the assumptions, conditions and qualifications/limitations set forth in this report.

5. **Accuracy of information:** No attempt has been made to verify the accuracy of any information provided by the Client or third parties, except as specifically stated in this report (hereinafter "Supplied Data"). Wood cannot be held responsible for any loss or damage, of either contractual or extra-contractual nature, resulting from conclusions that are based upon reliance on the Supplied Data.

6. **Report interpretation:** This report must be read and interpreted in its entirety, as some sections could be inaccurately interpreted when taken individually or out-of-context. The contents of this report are based upon the conditions known and information provided as of the date of preparation. The text of the final version of this report supersedes any other previous versions produced by Wood.

7. **No legal representations:** Wood makes no representations whatsoever concerning the legal significance of its findings, or as to other legal matters touched on in this report, including but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel.

8. **Decrease in property value:** Wood shall not be responsible for any decrease, real or perceived, of the property or site's value or failure to complete a transaction, as a consequence of the information contained in this report.

9. **No third-party reliance:** This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or Contract. Any use or reproduction which any third party makes of the report, in whole or in part, or any reliance thereon or decisions made based on any information or conclusions in the report is the sole responsibility of such third party. Wood does not represent or warrant the accuracy, completeness, merchantability, fitness for purpose or usefulness of this document, or any information contained in this document, for use or consideration by any third party. Wood accepts no

responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on this report or anything set out therein. including without limitation, any indirect, special, incidental, punitive or consequential loss, liability or damage of any kind.

10. **Assumptions:** Where design recommendations are given in this report, they apply only if the project contemplated by the Client is constructed substantially in accordance with the details stated in this report. It is the sole responsibility of the Client to provide to Wood changes made in the project, including but not limited to, details in the design, conditions, engineering or construction that could in any manner whatsoever impact the validity of the recommendations made in the report. Wood shall be entitled to additional compensation from Client to review and assess the effect of such changes to the project.

11. **Time dependence:** If the project contemplated by the Client is not undertaken within a period of 18 months following the submission of this report, or within the time frame understood by Wood to be contemplated by the Client at the commencement of Wood's assignment, and/or, if any changes are made, for example, to the elevation, design or nature of any development on the site, its size and configuration, the location of any development on the site and its orientation, the use of the site, performance criteria and the location of any physical infrastructure, the conclusions and recommendations presented herein should not be considered valid unless the impact of the said changes is evaluated by Wood, and the conclusions of the report are amended or are validated in writing accordingly.

    Advancements in the practice of geotechnical engineering, engineering geology and hydrogeology and changes in applicable regulations, standards, codes or criteria could impact the contents of the report, in which case, a supplementary report may be required. The requirements for such a review remain the sole responsibility of the Client or their agents.

    Wood will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

12. **Limitations of visual inspections:** Where conclusions and recommendations are given based on a visual inspection conducted by Wood, they relate only to the natural or man-made structures, slopes, etc. inspected at the time the site visit was performed. These conclusions cannot and are not extended to include those portions of the site or structures, which were not reasonably available, in Wood's opinion, for direct observation.

13. **Limitations of site investigations:** Site exploration identifies specific subsurface conditions only at those points from which samples have been taken and only at the time of the site investigation. Site investigation programs are a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions.

    The data derived from the site investigation program and subsequent laboratory testing are interpreted by trained personnel and extrapolated across the site to form an inferred geological representation and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite this investigation, conditions between and beyond the borehole/test hole locations may differ from those encountered at the borehole/test hole locations and the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

    Final sub-surface/bore/profile logs are developed by geotechnical engineers based upon their interpretation of field logs and laboratory evaluation of field samples. Customarily, only the final bore/profile logs are included in geotechnical engineering reports.

    Bedrock, soil properties and groundwater conditions can be significantly altered by environmental remediation and/or construction activities such as the use of heavy equipment or machinery, excavation, blasting, pile-driving or draining or other activities conducted either directly on site or on adjacent terrain. These properties can also be indirectly affected by exposure to unfavorable natural events or weather conditions, including freezing, drought, precipitation and snowmelt.

During construction, excavation is frequently undertaken which exposes the actual subsurface and groundwater conditions between and beyond the test locations, which may differ from those encountered at the test locations. It is recommended practice that Wood be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered at the test locations, that construction work has no negative impact on the geotechnical aspects of the design, to adjust recommendations in accordance with conditions as additional site information is gained and to deal quickly with geotechnical considerations if they arise.

Interpretations and recommendations presented herein may not be valid if an adequate level of review or inspection by Wood is not provided during construction.

14. **Factors that may affect construction methods, costs and scheduling:** The performance of rock and soil materials during construction is greatly influenced by the means and methods of construction. Where comments are made relating to possible methods of construction, construction costs, construction techniques, sequencing, equipment or scheduling, they are intended only for the guidance of the project design professionals, and those responsible for construction monitoring. The number of test holes may not be sufficient to determine the local underground conditions between test locations that may affect construction costs, construction techniques, sequencing, equipment, scheduling, operational planning, etc.

    Any contractors bidding on or undertaking the works should draw their own conclusions as to how the subsurface and groundwater conditions may affect their work, based on their own investigations and interpretations of the factual soil data, groundwater observations, and other factual information.

15. **Groundwater and Dewatering:** Wood will accept no responsibility for the effects of drainage and/or dewatering measures if Wood has not been specifically consulted and involved in the design and monitoring of the drainage and/or dewatering system.

16. **Environmental and Hazardous Materials Aspects:** Unless otherwise stated, the information contained in this report in no way reflects on the environmental aspects of this project, since this aspect is beyond the Scope of Work and the Contract. Unless expressly included in the Scope of Work, this report specifically excludes the identification or interpretation of environmental conditions such as contamination, hazardous materials, wild life conditions, rare plants or archeology conditions that may affect use or design at the site. This report specifically excludes the investigation, detection, prevention or assessment of conditions that can contribute to moisture, mold or other microbial contaminant growth and/or other moisture related deterioration, such as corrosion, decay, rot in buildings or their surroundings. Any statements in this report or on the boring logs regarding odours, colours, and unusual or suspicious items or conditions are strictly for informational purposes

17. **Sample Disposal:** Wood will dispose of all uncontaminated soil and rock samples after 30 days following the release of the final geotechnical report. Should the Client request that the samples be retained for a longer time, the Client will be billed for such storage at an agreed upon rate. Contaminated samples of soil, rock or groundwater are the property of the Client, and the Client will be responsible for the proper disposal of these samples, unless previously arranged for with Wood or a third party.

12.2 Closure

The recommendations presented herein are based on the subsurface information provided in two geotechnical reports prepared by others for the currently proposed transfer station and landfill sites and estimates of subsurface soil properties based on the experience of Wood personnel with similar materials. Should the subsurface conditions encountered during subsequent phases of this project appear to be different than those described in this report, Wood should be advised immediately, and recommendations contained herein would be revised, if necessary.

Wood trusts that the information presented in this report satisfies the current needs of Dillon Consulting Limited. If there are questions or requests for additional information, please contact the undersigned at your convenience.

Yours truly,

Wood Environment & Infrastructure Solutions,
A Division of Wood Canada Limited

REGISTERED PROFESSIONAL ENGINEER
A. TCHEKHOVSKI
LICENSEE
NWT/NU

May 14, 2019

14-05-2019

Alexandre Tchekhovski, Ph. D., P. Eng.,
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Reviewed by:

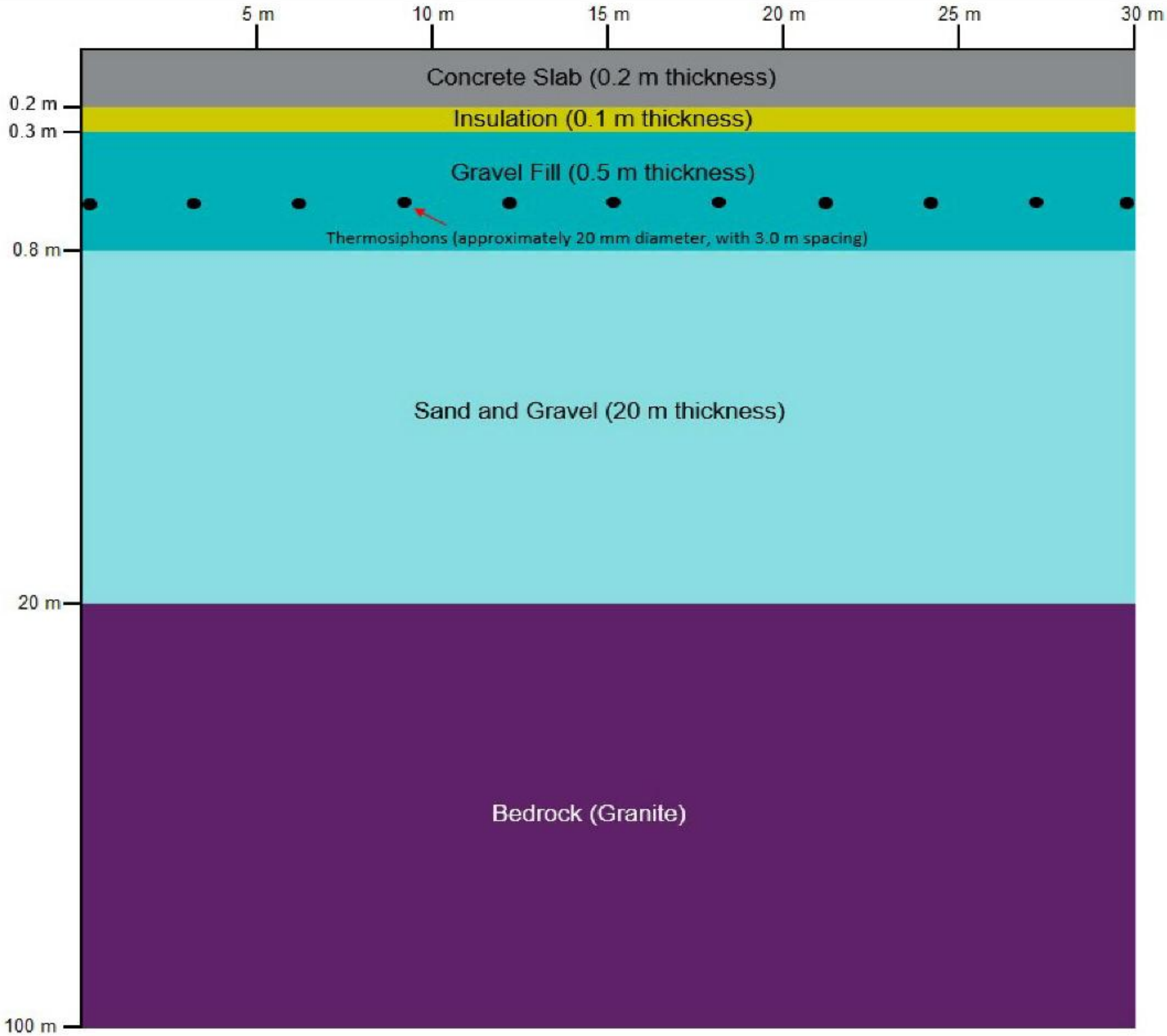
Kevin Spencer, M. Eng., P. Eng.,
Senior Associate Geotechnical Engineer

PERMIT TO PRACTICE
Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited
Signature
Date May 14, 2019
PERMIT NUMBER: P 047
NT/NU Association of Professional Engineers and Geoscientists

AT/JL/KS
Attach.

Appendix A

Figures 1 - 6



CLIENT: **Dillon Consulting Ltd.**

PROJECT: **Geothermal Modelling for Transfer Station and Landfill**

TITLE: **Finite Element Grid for Geothermal Model with Thermosiphons**

DATE:	JOB No.:	FILE:	FIGURE No.:	REV.
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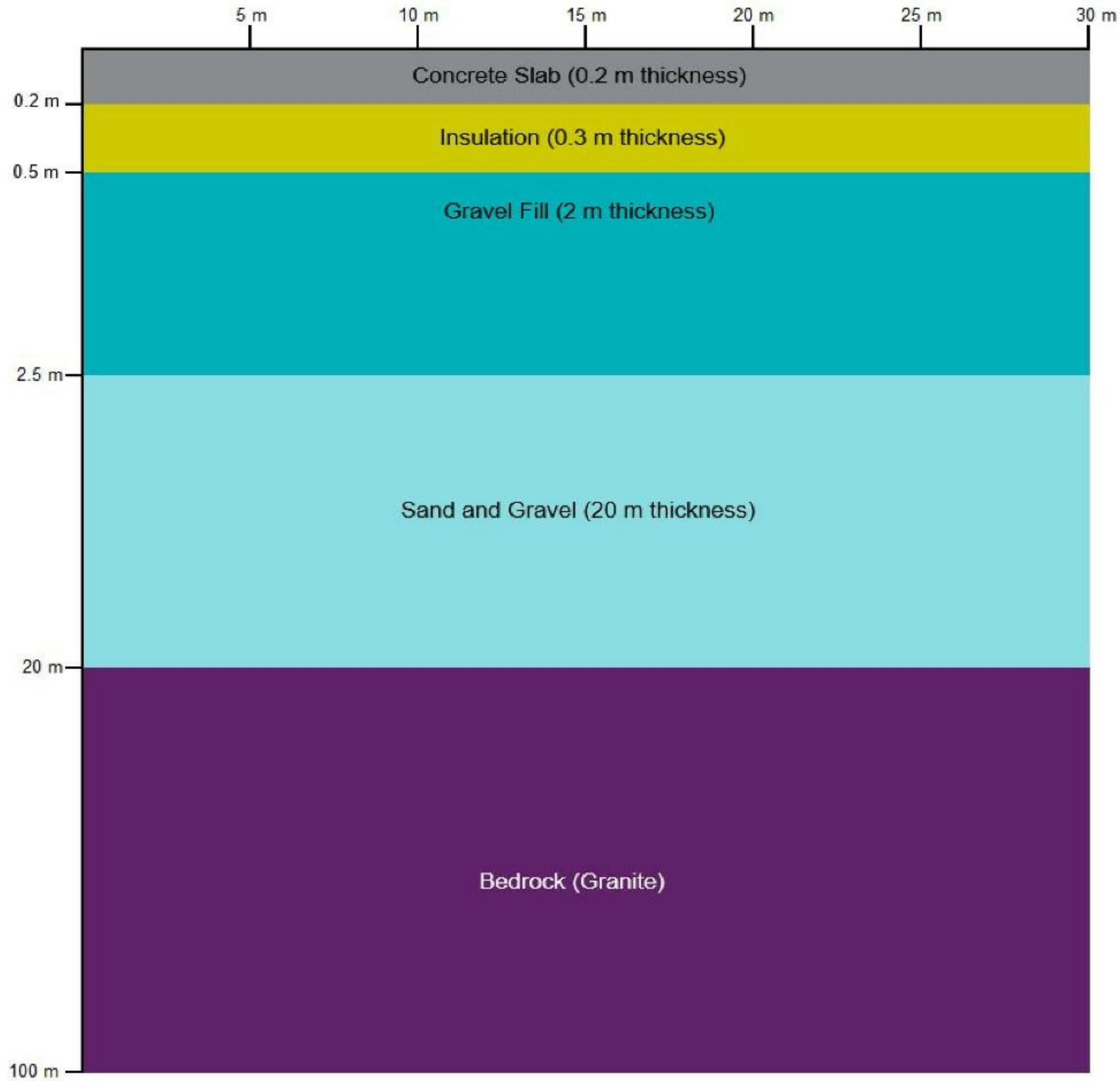

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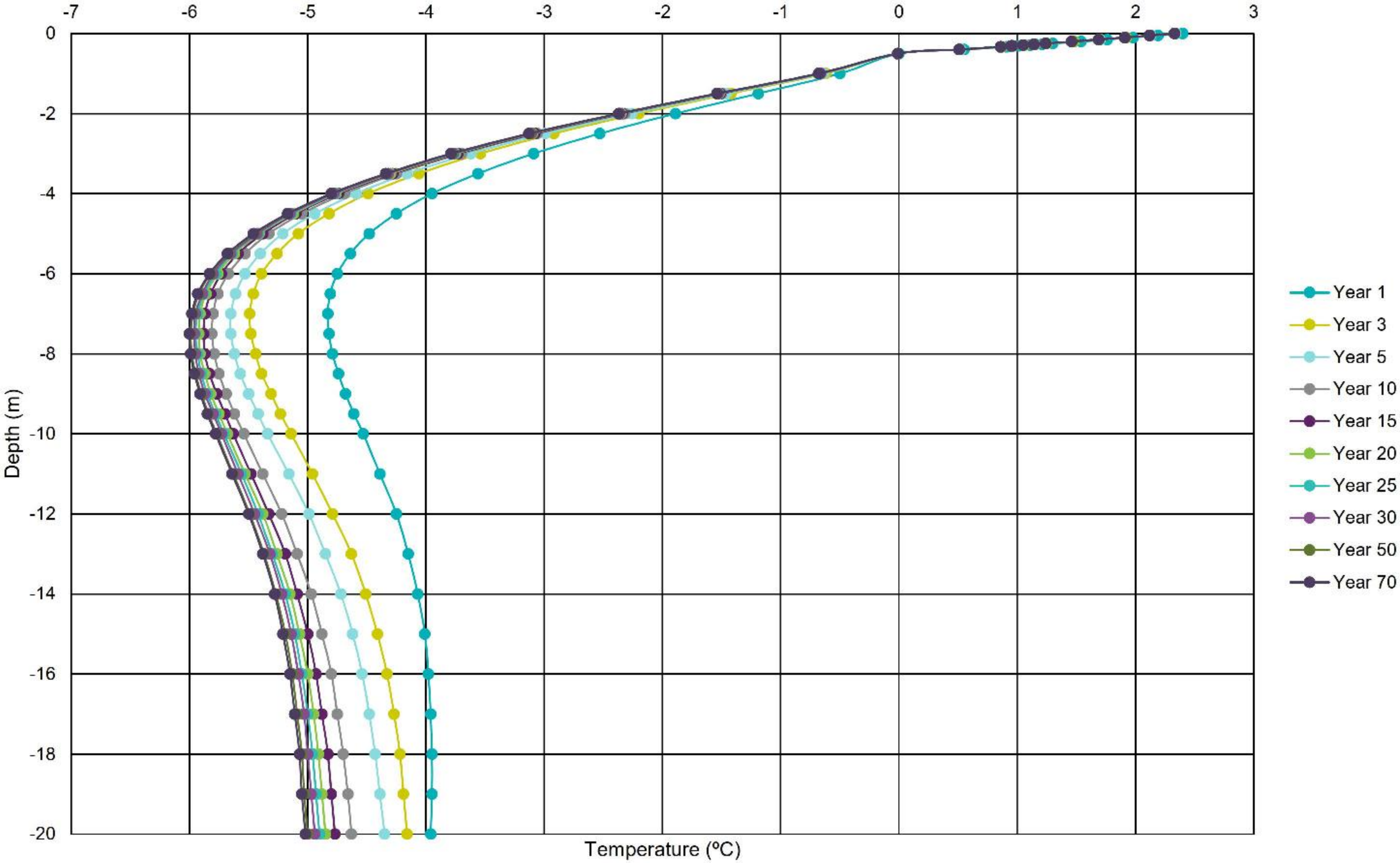
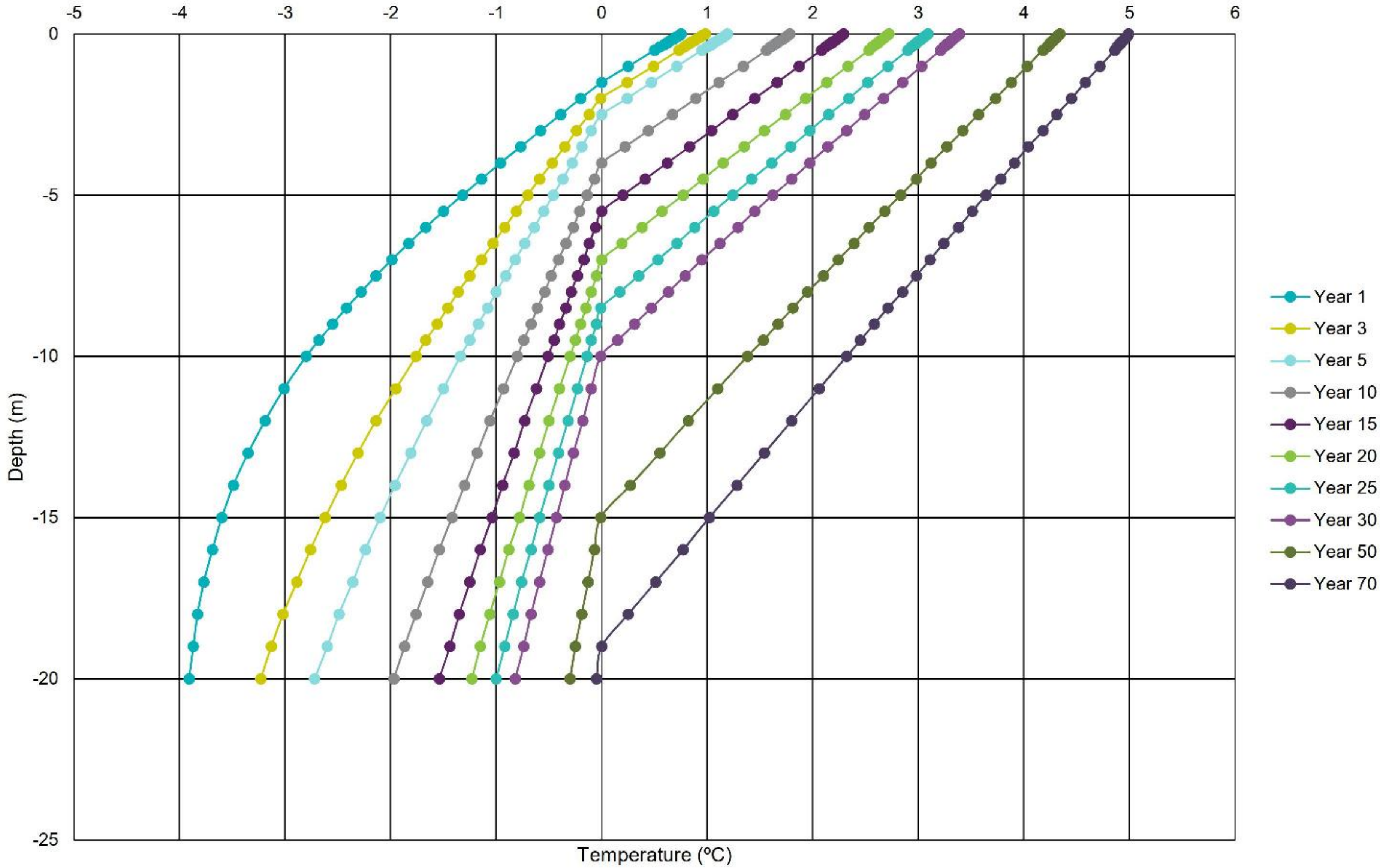
	TITLE: Finite Element Grid for Geothermal Model without Thermosiphons				
CLIENT: Dillon Consulting Ltd.	DATE: May 2019	JOB No.: CG14359	FILE: Figure 1 to 6_May 13.xlsx	FIGURE No.: 2	REV. 0



wood.	PROJECT: Geothermal Modelling for Transfer Station and Landfill			
	TITLE: Soil Temperature Under Insulation for Geothermal Scenario with Thermosiphons			
CLIENT: Dillon Consulting Ltd.	DATE: May 2019	JOB No.: CG14359	FILE: Figure 1 to 6_May 13.xlsx	FIGURE No.: 3	REV. 0



CLIENT: Dillon Consulting Ltd.	PROJECT: Geothermal Modelling for Transfer Station and Landfill
	TITLE: Soil Temperature Under Insulation for Geothermal Scenario with no Thermosiphons

DATE:	JOB No.:	FILE:	FIGURE No.:	REV.
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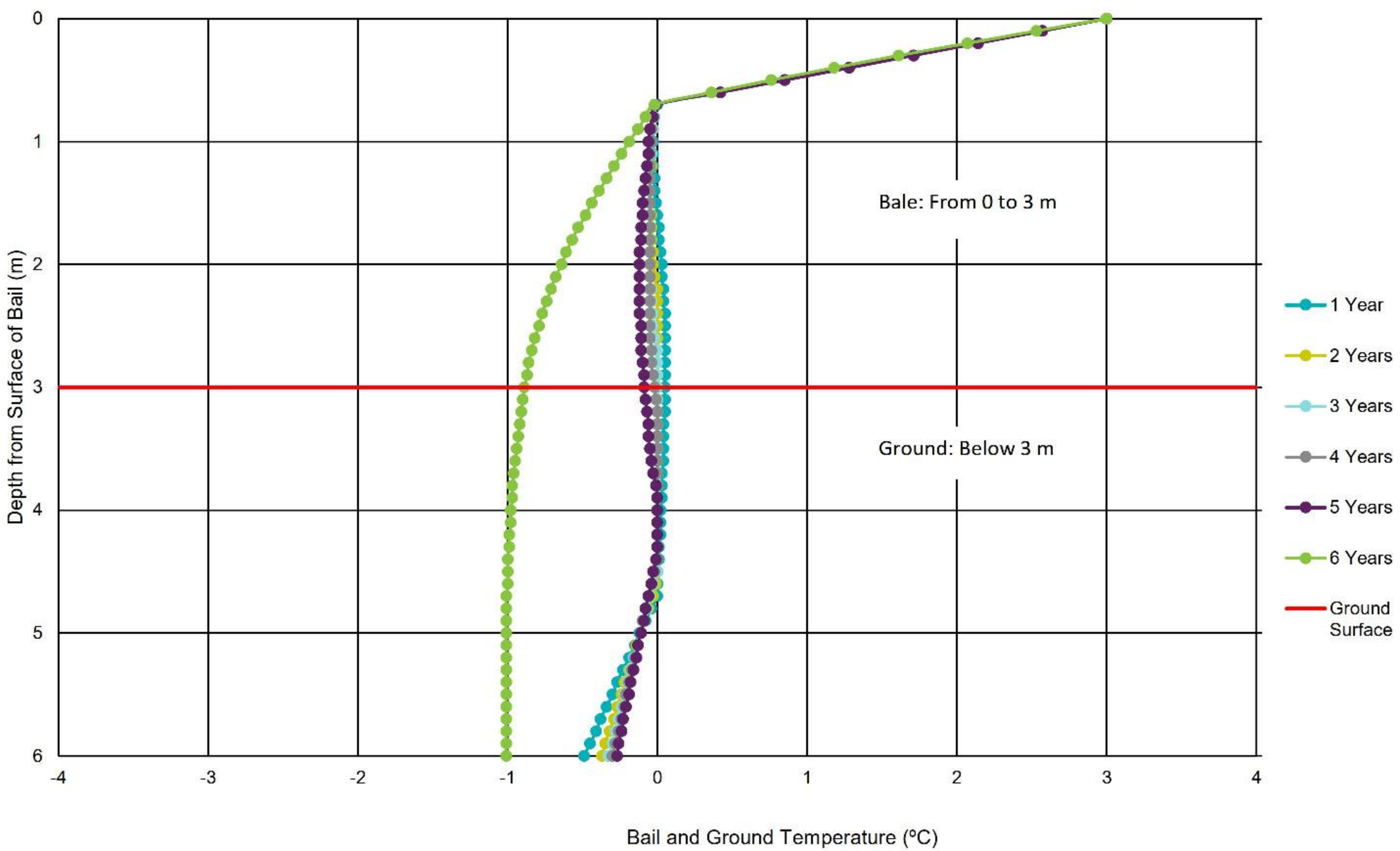
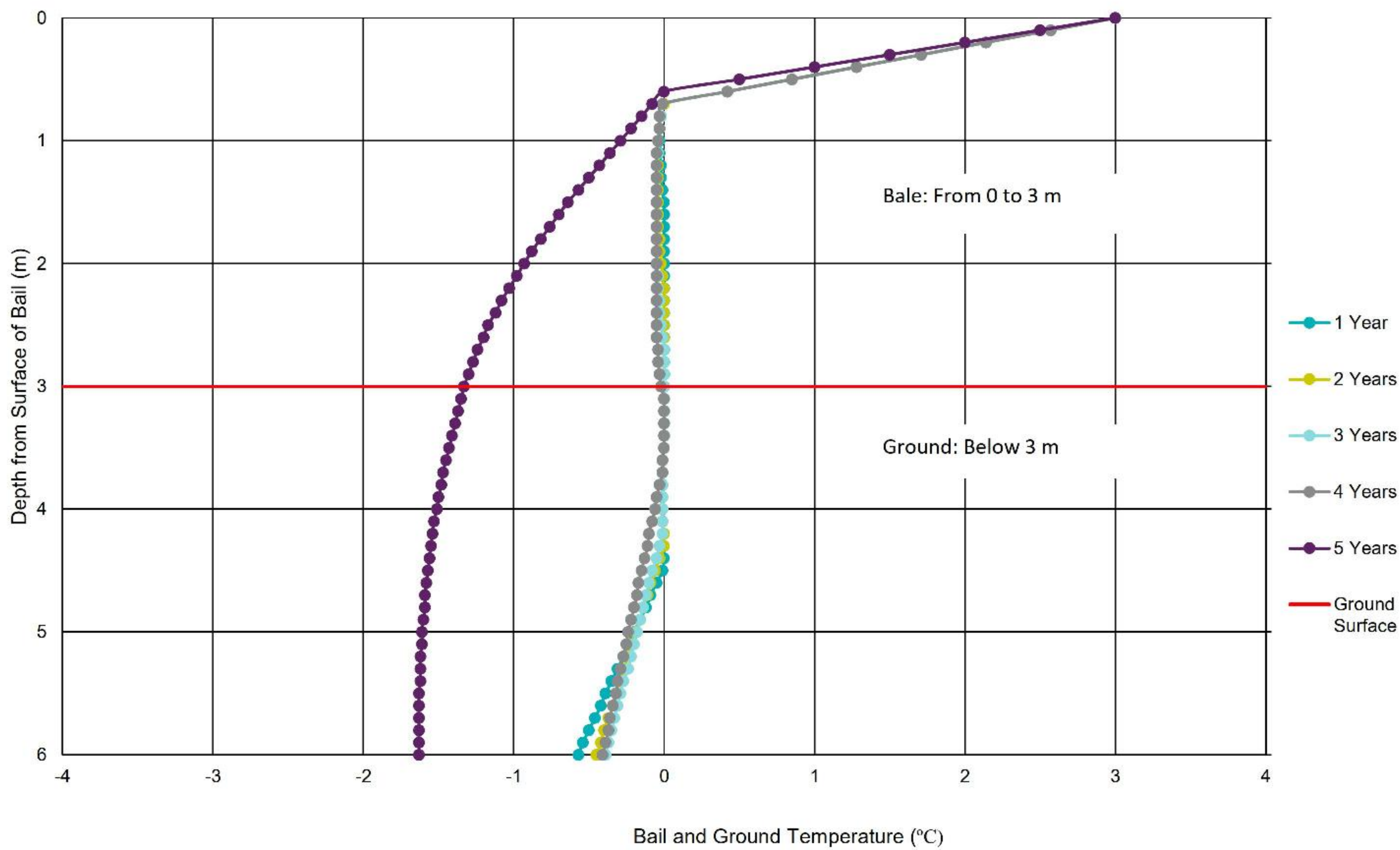


wood.	PROJECT:	Geothermal Modelling for Transfer Station and Landfill
	TITLE:	Temperature from Surface of Garbage Bail Extending to 4 m Below Ground Surface, Bales Placed Oct 1
CLIENT: Dillon Consulting Ltd.	DATE: May 2019	JOB No.: CG14359 · FILE: Figure 1 to 6_May 13.xlsx · FIGURE No.: 5 · REV.: 0



wood.

CLIENT: Dillon Consulting Ltd.

PROJECT:	Geothermal Modelling for Transfer Station and Landfill
TITLE:	Temperature from Surface of Garbage Bail Extending to 4 m Below Ground Surface, Bales Placed Dec 1

DATE:	JOB No.:	FILE:	FIGURE No.:	REV.
May 2019	CG14359	Figure 1 to 6_May 13.xlsx	6	0

Appendix C

Landfill Drilling Program Report (EXP Services Inc.)

City of Iqaluit

Preliminary Geotechnical Investigation Report

Type of Document
Draft

Project Name
Proposed New Landfill Facility
Iqaluit, NU

Project Number
OTT-00248813-A0

Prepared By: Surinder K. Aggarwal, M.Sc., P.Eng.

Reviewed By: Ismail M. Taki, M.Eng., P.Eng.

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6
Canada

Date Submitted
May 13, 2019

City of Iqaluit

P.O. Box 460
City of Iqaluit, Nunavut X0A 0H0

Attention: Mr. Matthew Van Strien, Procurement Officer

Preliminary Geotechnical Investigation Report

Type of Document:
Draft

Project Name:
Proposed New Landfill Facility
Iqaluit, NU

Project Number:
OTT-00248813-A0

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Manager, Geotechnical Services
Earth and Environment

Date Submitted:
May 13, 2019

Legal Notification

This report was prepared by EXP Services Inc. for the account of the **City of Iqaluit.**

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. EXP Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this project.

Executive Summary

A preliminary geotechnical investigation was undertaken at the site of the proposed landfill facility to be located on a 64.12-hectare parcel of land approximately 8 km northwest of the City of Iqaluit (Figure 1). This work was authorized by the City of Iqaluit via Service Contract SC000818 dated August 16, 2018.

The purpose of the investigation was to establish the geotechnical and groundwater conditions at the site and to make recommendations regarding the design and construction of the facility from a geotechnical perspective.

The proposed landfill will comprise of a landfill cell, leachate collection sump and leachate holding ponds. A potential equipment building, and site trailers are also proposed to be installed at the site as per the preliminary site plan layout provided by Dillon Consulting on May 7, 2019.

Initial plan and scope of work called for the drilling of five (5) sampled boreholes throughout the site. However, additional drilling and installation was requested prior to the execution of the fieldwork by the designers. Therefore, the preliminary geotechnical investigation comprised of drilling six (6) sampled boreholes (Boreholes BH-101 to BH-106) to 3 m to 6 m depth and five additional boreholes (TH-107/W-107 to TH-111/W-101) to 4.4 m to 6.6m depth for installation of PVC piping and standpipes for long-term groundwater and ground temperature monitoring at the site.

The investigation revealed that the site predominantly contains sand and gravel, which extends to the bedrock contacted at a depth of 1.0 m to 5.0 m. This stratum has a low moisture content and is free of ice lensing. Geological information indicates that the bedrock at the site is likely to be Monzogranite. At the time of the fieldwork, soil at the site was frozen to the ground surface and therefore, the groundwater table and the active layer thickness could not be established.

The salinity of the on-site soils is low. General Use (GU) Portland cement may be used in subsurface concrete requirements at the site. The concrete mix design should conform to CSA A23.1.

The site has been classified as Class C for seismic site classification in accordance with the requirements of Section 4.1.8.4 of the National Building Code of Canada, 2015.

The investigation has revealed that the on-site soils are suitable for construction of the proposed landfill. Since the natural soils are permeable, the landfill cell, leachate collection sump and leachate holding ponds will have to be fully lined. The guidelines recommend the following:

1.) The base of the cells and the leachate holding ponds should be set at a depth of 1 m below existing grade or 1.5 m above the seasonal high groundwater table or at the permafrost level. Information regarding the seasonal high groundwater table and the permafrost level was not available at the time of writing this report. It is likely that the seasonal high groundwater table may govern the design. Therefore, additional monitoring of groundwater and temperature are recommended on the spring prior to finalizing of the design.

2.) Since the on-site soils are very permeable and clayey impermeable soils are not available in the Iqaluit area, the landfill cell and inside slopes of the berms, leachate collection sump and leachate holding ponds will all have to be lined with two liners, i.e. a 60 mil geosynthetic clay liner and a 60 mil High Density Poly Ethylene (HPDE) liner. A leachate collection system should be installed in a 600 mm granular layer above the HDPE liner leading to the leachate sump. Leachate from the sump should be directed to the leachate holding ponds.

3.) The berms of the proposed landfill cell and the leachate holding ponds are expected to be stable when sloped back on an inclination of 3H:1V. This would require conformation based on slope stability analysis once the design of the facility has been finalized. The inside faces of the berms of the landfill, leachate holding ponds and the sides of the leachate collection sump should also be lined with a 60 mil geosynthetic clay liner overlain by 60 mil thick HDPE liner. The outside slopes of the berms and the leachate holding pond should be protected with coarse gravel to minimize erosion.

4.) Any permanent buildings proposed to be constructed would have to be supported on rock socketed piles. Additional recommendation on foundation alternatives and design will be provided once the design is finalized.

The on-site soils underneath the landfill are expected to thaw due to the heat generated by decomposition of the waste. Similarly, the soils under the leachate holding ponds are expected to thaw due to absorption of heat from the sun rays by the leachate. The settlements of the cell and the leachate holding ponds were estimated to vary from 20 mm to 150 mm. It is therefore recommended that liners should be installed with enough folds to accommodate the anticipated settlements. The manufacturer of the liners should be consulted for this purpose.

Groundwater and temperature monitoring should be undertaken at the site to establish seasonal high groundwater table and to establish the active layer thickness.

It is also recommended that groundwater and gas monitoring networks should be installed to ensure that the leachate is not impacting the groundwater and that explosive gases are not migrating from the property during operation of the landfill.

Methane monitoring devices should be installed in any of the structures located on the site to ensure that methane is not accumulating in the building(s).

The above and other related considerations are discussed in greater detail in the accompanying report.

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1 Introduction

EXP Services Inc. (EXP) has carried out a preliminary geotechnical investigation at the site of the proposed landfill to be located on a 22-hectare site approximately 8 km northwest of the City of Iqaluit at the approximate location shown on Figure 1. This work was authorized by the City of Iqaluit via Service Contract SC000818 dated August 16, 2018.

The proposed facility would comprise of a solid waste storage cell, leachate collection sump and two leachate holding ponds. A potential equipment building, and site trailers are also proposed to be installed at the site as per the preliminary site plan layout provided by Dillon Consulting on May 7, 2019.

A preliminary layout plan of the facilities and cross-sections of the landfill cell and the leachate collection sump were provided for preparation of this report. These plans and sections indicate that the bottom of the landfill cell will vary from Elev. 155 m to Elev. 172 m. The height of the berms of the landfill cell will vary from approximately 2.5 m to approximately 8 m (Elev. Approximately 158.5 m to approximately 172.0 m). The crest width of the berms is approximately 4 m. The invert of the leachate holding ponds and the heights of the berms were not provided.

The investigation was undertaken to provide preliminary comments related to:

1.) Geotechnical and groundwater profile at the site;
2.) Define key properties of the on-site soils;
3.) Ground temperature and active layer thickness;
4.) Groundwater table;
5.) Seismic site classification in accordance with the requirements of National Building Code of Canada 2015 Edition and comment on liquefaction potential of on-site soils;
6.) Recommend base preparation for construction of the landfill cell and the leachate holding ponds;
7.) Assess the need to line the proposed cell and ponds and recommend suitable type of liners;
8.) Settlements of the landfill cell and leaching holding ponds due to the ice thawing in soil pores;
9.) Steepest berm slopes that will be stable under static and seismic loading conditions;
10.) Suitability of on-site soils for construction of the berms and as cover material.

It is noted that seepage and contaminant transport assessment and thermal regime assessment (spatially and temporally) was not part of the terms of reference.

The comments and recommendations given in this report are preliminary since they are based on preliminary design concept and subject to change. This office must be given an opportunity to revise the report once the design of the facilities is finalized.

2 Site Description

The proposed landfill site would be located on a 64.12-hectare parcel of land located approximately 8 km northwest of the City of Iqaluit (Figure 1). The proposed landfill would comprise of a solid waste storage cell, leachate collection sump and two leachate holding ponds.

Figure 2 also shows the existing site conditions and proposed installation. A review of this plan indicates that a hummock is located in the south part of the site. The elevation of the top of the hummock is Elev. 179 m approximately on east, north and south sides. Along the west property boundary, the elevations of the hummock at the property boundary vary from Elev. 170 m at the center to Elev. 150 m approximately at the southwest corner, and at Elev. 145 m at the northwest corner of the site. In addition, three hummocks are located along the north property boundary with their peak elevations at Elev. 172 m to 173 m approximately. A valley is located in the central portion of the site and extends from northwest corner of the site in a southeasterly direction. The bottom of the valley is at Elev. 158 m to 156 m approximately. Therefore, it is evident that the terrain at the site is hummocky and undulating.

Two drainage ditches are located along the east boundary of the landfill site and run in a north-south direction. The ditches converge into one ditch close to the southeast corner of the landfill site. Another drainage ditch is located close to the west boundary of the landfill site and runs in a southeast direction to ponds located at the east boundary of the site.

3 Procedure

Access to the site was only available by ATV and through rough and undulating site topography and entailed crossing numerous water-logged areas; as such, it was not possible to mobilize the drilling equipment to the site in the summer without potential damage to the terrain/tundra and crossing water bodies. As a result, it was agreed to complete a desktop study for the site as presented in our letter dated October 19, 2018 and delay the fieldwork until the winter of 2019. For this purpose, Canadrill Ltd. (Canadrill), a local drilling company, completed modifications and mounted the air-track drill on a mechanical shovel which in turns was used to drag the compressor and associated equipment throughout the tundra and snow covered area to allow the completion for the investigation in March-April of 2019 (refer to Photos in Appendix A).

The fieldwork for this project was undertaken between March 26 and April 4, 2019 using an air-track drill mounted on a mechanical shovel rented from Canadrill. The fieldwork was supervised on a full-time basis by a senior geotechnician from EXP experienced with permafrost soils and northern construction techniques.

Initial plan and scope of work called for the drilling of five (5) sampled boreholes throughout the site. However, additional drilling and installation was requested prior to the execution of the fieldwork by Dillon Consulting, i.e. the designers retained for this project.. Therefore, the preliminary geotechnical investigation comprised of drilling six sampled boreholes (Boreholes BH-101 to BH-106) to 3 m to 6 m depth and five additional boreholes (TH-107/W-107 to TH-111/W-101) to 4.4 m to 6.6m depth for installation of PVC piping and standpipes for long-term groundwater and ground temperature monitoring at the site.

The locations of the boreholes were established in the field by EXP's representative using a GPS and are shown on the appended Site Plan, Figure 2. Their elevations were established using contour plans provided on a topographical survey prepared by Arctic UAV acting as a sub-contractor to EXP in the summer of 2018, and therefore are considered approximate. Therefore, it is recommended that the final locations and elevations of the boreholes be established in the summer prior to final issuance of the report.

The coordinates of the boreholes and their elevations have been tabulated on Table 1.

Table 1: Locations and Estimated Elevations of Boreholes

Borehole No.	Eastings	Northings	Estimated Elevations (m)
BH-101	520917	7075935	162.0
BH-102	520843	7076288	162.0
BH-103	520543	7076508	151.0
BH-104	520978	7076619	163.0
BH-105	521235	7076674	168.0
BH-106	521094	7076291	155.5
TW-107	521117	7076090	154.0

Table 1: Locations and Estimated Elevations of Boreholes (Continued)			
Borehole No.	**Easting**	**Northing**	**Estimated Elevation**
TW-108	520966	7075812	153.5
TW-109	520669	7076316	159.0
TW-110	520755	7076668	164.0
TW-111	521441	7076739	179.5

During drilling, bulk soil samples were obtained from different depths from Boreholes BH-101 to BH-106. All the soil samples retrieved were visually examined and logged. Samples were preserved in watertight plastic bags. A portion of each sample was placed in a smaller plastic bag and weighted on-site to assure accurate moisture content determination. Boreholes TH/W 107 to TH-111/W-111 were not sampled but were logged based on examination of the drill cuttings. The soil samples were transported to the EXP laboratory in the City of Ottawa, Ontario, where they were visually examined in the laboratory by a senior geotechnical engineer and borehole logs prepared. The engineer also assigned the laboratory testing, which consisted of performing natural moisture content on all the samples and grain-size analyses, pH, sulphate, chloride and electrical conductivity tests on selected soil samples.

Installation of solid PVC piping with a capped bottom was completed at each of the borehole locations TH-107 to TH-111. In addition, another shallow slotted pipe was also installed at each of these locations to a depth of 2.4 m. The solid and slotted PVC pipes were installed at the request of Dillon Consulting for long-term temperature and groundwater monitoring at the site. Photographs of the installation are included in Appendix A.

4 Site Geology

A review of the surficial geology map of Iqaluit was undertaken and the surficial geology at the landfill site has been plotted on Figure 3. It indicates that the majority of the site comprises of a till veneer (T_v) except close to the northeast corner of the site where it is expected to be till blanket (T_b).

The geological map indicates that the till veneer (T_v) is approximately 0.5 m to 2 m thick. According to the geological information, greater than 40 percent of this area is expected to be composed of the till and less than 60 percent is expected to comprise of rock layers, knobs and rubble.

The till blanket (T_b) is expected to be 1 m to 10 m thick with undulating plain with minor fluted, hummocky, ridged or channeled areas. The hummocky till consists of a sediment resulting from dry land erosion that is unsorted to poorly sorted and contains particles ranging in size from clay to boulders, suspended in a matrix of mud or sand.

The bedrock at the site underlying the till is expected to be Monzogranite.

The site visit revealed the presence of bedrock outcrops at the northeast and southeast corners of the site. A field of boulders was also noted at the north side of the site (Figure 3).

5 Soil Description

A detailed description of the subsurface soil and groundwater conditions determined from the boreholes are given on the attached Borehole Logs, Figures 4 to 14 inclusive. The borehole logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the locations where sampling was conducted. Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions.

It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Note on Sample Descriptions" preceding the borehole logs form an integral part of this report and should be read in conjunction with this report.

A review of the borehole logs indicates the following soil stratigraphy in descending order:

5.1 Tundra

In Borehole Nos. BH-101 and BH-106, a surficial layer of tundra 50 mm thick was encountered.

5.2 Weathered Bedrock

In Borehole BH-103, the surficial layer is weathered bedrock, which extends to 1.0 m depth (Elev. 150.4 m).

5.3 Sand and Gravel

The predominant overburden soil in Boreholes BH-101 to BH-106 - except Borehole in BH-103 - is sand and gravel with cobbles and boulders, which extends to 1.0 m to 5.0 m depth (Elev. 153.5 m to 166.5 m). This stratum is moist. Its natural moisture content varied from 1.7 to 21.5 percent.

The results of the ten (10) grain-size analyses performed on the overburden samples have been summarized on Table 2 and the individual test results have been plotted on Figures 15 to 24 inclusive. This table indicates that the soil composition consists of 5 to 25 percent clay and silt, 49 to 82 percent sand and 8 to 46 percent gravel. It is noted that cobbles and boulders in the overburden were not sampled. Therefore, the gradations presented on Table 2 do not represent whole samples and some of the sand may have been pulverized to finer particles as a result of the drilling operation.

Table 2: Summary of Grain-Size Analyses on Overburden Samples

Borehole No.	Depth. (m)	Soil Composition (%)			Figure No.
		Silt and Clay	Sand	Gravel	
BH-101	0 – 1	9	72	19	15
BH-101	1 – 2	10	73	17	16
BH-102	0 – 1	25	71	4	17
BH-102	1 – 2	16	78	6	18
BH-104	0 – 1	5	50	45	19
BH-104	2 – 3	15	77	8	20
BH-104	3 – 4	5	84	11	21
BH-105	0 – 1	6	74	20	22
BH-106	0 – 1	17	75	8	23
BH-106	1 – 2	21	71	8	24

5.4 Bedrock

The boreholes were drilled using an air-track drill rig, which breaks down the soil and bedrock to fine cuttings. The cuttings area spewed to the surface. As a result, the cuttings were mixed and it is not possible to accurately establish the bedrock depth, type or its condition. Therefore, the depth to bedrock indicated is approximate.

A review of the geological maps of Iqaluit indicates that the bedrock is likely to be Monzogranite.

5.5 Water Levels

Water levels could not be determined since the soil was frozen to the ground surface. The groundwater table is expected to be the highest during the spring season subsequent to the seasonal thaw. Readings should be taken in the standpipes during the spring season to establish the groundwater table at the site.

6 Ground Temperature Readings/Groundwater Monitoring

Solid PVC pipe with capped bottom and top was installed at each of the borehole locations TH-107 to TH-111. In addition, another shallow slotted pipe was also installed at each of these locations to a depth of 2.4 m. The solid and slotted PVC pipes were installed at the request of Dillon Consulting for long-term temperature and groundwater monitoring at the site. Photographs of the installation are included in Appendix A.

The first set of readings of the temperature was undertaken on April 18, 2019 and have been tabulated on Table 3. A review of Table 3 indicates that the soil is frozen from the ground surface down. In addition, significant temperature difference was recorded at the location of T-109 compared to the other locations. The suspected reason for this difference is likely caused by the fact that the thermistor at the location of T-109 was left inside the PVC pipe for almost two weeks prior to the collection of the readings, whereas readings in the other thermistors were collected within 15 minutes from the time when the thermistor was lowered into the PVC pipe For more accurate and reliable temperature measurements at the site, it is recommended, that individuals thermistors with appropriate depths should be permanently installed in each PVC pipe and the inner space between the PVC pipe and thermistor be backfilled with sand. The thermistors should be allowed to stabilize for at least 1 week prior to collection of the first readings and then subsequent readings can be collected as required.

It is recommended that periodic groundwater readings should be taken in the boreholes during late spring and summer months to establish the active layer thickness. The active layer thickness is expected to be maximum at the end of summer or early fall.

Table 3: Summary of Temperature Measurements collected on April 18, 2019

T-107		T-108		T-109	
Depth of Bulb (m)	Temperature (Celsius)	Depth of Bulb (m)	Temperature (Celsius)	Depth of Bulb (m)	Temperature (Celsius)
1.3	0.3	1.0	-0.9	1.8	-1.0
0.8	1.4	0.5	0.7	1.3	-0.1
-0.3	-0.5	0.0	-0.7	0.7	-0.9
-0.8	-2.5	-0.5	0.9	0.2	0.5
-1.3	-1.7	-1.5	-5.1	-0.3	-12.4
-1.8	0.2	-2.0	-4.4	-1.2	-14.2
-2.3	-2.3	-2.5	-5.4	-1.7	-14.1
-2.8	0.4	-3.0	-4.4	-2.2	-13.9
-3.3	-0.7	-3.5	-4.0	-2.7	-13.6
-3.8	-0.1	-4.0	-5.5	-3.2	-13.1
-4.3	-2.0	-4.5	-5.8	-3.7	-12.6
-4.8	-0.9	-5.0	-4.7	-4.2	-12.0
-5.3	0.8	-5.5	-3.5	-4.7	-11.3
-5.8	-0.2	-6.0	-4.2	-5.2	-10.8
-6.3	-1.1	-6.5	-3.6	-5.7	-10.2
-6.8	0.3	-7.0	-2.9	-6.2	-9.7

T-110		T-111			
Depth (m)	Temp (Celsius)	Depth (m)	Temp (Celsius)		
1.5	-0.8	2.0	-1.7		
1.0	0.0	1.5	1.7		
0.5	0.4	1.0	2.3		
0.0	-3.7	0.5	0.4		
-0.5	-4.1	0.0	3.3		
-1.0	-4.1	-0.5	-1.0		
-1.5	-4.8	-1.0	0.7		
-2.0	-4.7	-1.5	-0.2		
-2.5	-5.1	-2.0	-1.5		
-3.0	-5.2	-2.5	0.2		
-3.5	-4.6	-3.0	-1.3		
-4.0	-4.8	-3.5	-2.9		
-4.5	-4.0	-4.0	-0.7		
-5.0	-4.1	-4.5	-2.4		
-5.5	-4.4	-5.0	-2.3		
-6.0	-2.8	-5.5	-2.7		Bead above GS

7 Soil Salinity

The salinity of the on-site soils was measured by conducting electrical conductivity tests on selected samples. The test results have been listed on Table 4.

Table 4: Salinity of On-Site Soils

Borehole No.	Sample Depth (m)	Salinity in Parts Per Thousand (ppt)
101	3.0 – 4.0	0.042
102	1.0 – 2.0	0.052
104	2.0 – 3.0	0.059
104	3.0 – 4.0	0.040
105	0 – 1.0	0.060
106	1.0 – 2.0	0.061

The above readings indicate that the on-site soils are low in salinity.

8 Chemical Tests on Soil Samples and Subsurface Concrete Requirements

Chemical tests limited to pH, sulphates, chlorides and electrical conductivity were performed on six selected soil samples. The test results are given on Table 5. The testing was performed by AGAT Laboratories, Mississauga, Ontario.

Table 5: Results of Chemical Tests on Soil Samples

Parameter	Borehole No. and Depth						Threshold Values
	BH 101 3 m – 4 m	BH 102 1 m – 2 m	BH 104 2 m -3 m	BH 104 3 m - 4 m	BH 105 0 m – 1 m	BH 106 1 m – 2 m	
pH	7.93	8.04	8.17	8.03	7.68	7.71	< 5
Sulphates (%)	0.0007	0.0004	0.0017	0.0003	0.0021	0.0016	0.1
Chlorides (%)	0.0005	0.0004	0.0007	0.0006	0.0003	0.0009	0.04
Electrical Resistivity (ohm/cm)	15150	12345	10870	16130	10750	10525	< 700 ohm.cm High corrosion potential

The test results indicate the soil contains a sulphate content of less than 0.1 percent, and a chloride content of less than 0.04 percent. This concentration of sulphates and chlorides in the soil would have a negligible potential of attach on subsurface concrete. Therefore, General Use (GU) Portland cement may be used in the subsurface concrete at this site. The concrete for the site should be designed in accordance with the requirements of CSA- A23.1-17.

The resistivity results indicate that the subsurface soil is not corrosive to buried steel.

9 Site Classification and Seismic Site Response

The investigation has revealed that the geotechnical conditions at the site consist of 0.6 m to 4.0 m of sand and gravel overburden underlain by bedrock. Geological maps indicate that the bedrock is likely to be Monzogranite. Therefore, the site has been classified as **Class C** for seismic site response in accordance with the requirements of Section 4.1.8.4 of the National Building Code of Canada, 2015.

The overburden soils are also considered to be non-liquefiable.

10 Discussion and Recommendations

The proposed solid waste disposal facility will comprise of solid waste storage cell, a leachate collection sump, and two leachate holding ponds. The cell and the leachate holding pond will be made by construction of berms around them. Preliminary site plan and sections of the solid waste storage cell were provided for preparation of the report.

It is considered that from a geotechnical perspective, there are three important considerations for construction of the cell and the leachate holding ponds. These are:

1.) Prevention of leakage of leachate from the cell and the holding ponds to the environment, which would necessitate lining of the cells with geosynthetic liners since the on-site soils are permeable.

2.) Stability of the berm slopes including selection of suitable material for construction of the berms, its placement and proper compaction.

3.) Degradation of the permafrost beneath the cell and the leachate holding ponds and resulting settlements of the berms and the bases. These three aspects are discussed in detail below.

10.1 Excavation for Construction of Cell and Leachate Holding Ponds

It is recommended that the proposed footprint of the new cell and the leachate holding ponds should extend at least 2 m beyond the toe of the outside berm slopes. The extended footprint should be stripped of any existing tundra, organic/peat layers and/or any other soft natural materials encountered to expose a structurally stable subgrade of either unfrozen or frozen natural inorganic soils. The subgrade should be reviewed and approved by qualified geotechnical personnel.

It is recommended that any over-excavation required should be carried out in stages such that an over-excavated area can be backfilled to pre-existing grades within one day. This is intended to limit the time of exposure for underlying permafrost soils and minimize short-term permafrost thaw and global instability of the berms. If over-excavated areas are not backfilled to at least the current grade the same day, then additional thawing of the frozen soils is anticipated, potentially resulting in soft soil conditions throughout the base and requiring over-excavation to remove the soft soils. It is also noted the site contains deposit of silt and sandy silt, which are dilatant and will become wet and saturated when thawed. Therefore, an allowance should be made in the contract for the removal and replacement of such material, if encountered during construction with granular stable material.

10.2 Base Preparation of Cell and Leachate Holding Ponds

Guidelines indicate that for construction of the base of the landfill cell and the leachate holding ponds, unconsolidated soils should be preferably excavated to a depth of 1 m, to the permafrost line or to 1.5 m above the seasonal high groundwater table, whichever is encountered first. Because of the time of the year when the preliminary geotechnical investigation was undertaken, the on-site soils were frozen up to the ground surface, and therefore, seasonal high groundwater table or the permafrost line could not be established. It appears that the seasonal high groundwater table may govern the design. However, the guidelines also indicate that alternatively the hydraulic gradient could be lowered by installation of an appropriate drainage and pumping system. Groundwater drainage system should provide for positive drainage of the groundwater away from the landfill site.

Excavation should be undertaken to the proposed subgrade level. The exposed subgrade should be proof rolled with a heavy roller. Five hundred millimeters of granular fill should then be placed in 300 mm lift thicknesses on the subgrade and each lift compacted to at least 95 percent of Standard Proctor Maximum Dry Density in accordance with ASTM D-698-12e2 (SPMDD). It is anticipated that the on-site soils will be suitable for this purpose provided that particles greater in size than 150 mm are discarded.

Depending on the exposed soils, the placement of the initial lift(s) of material may be inhibited by the build-up of excess porewater pressures within the native subgrade. It is recommended that emphasis be placed on covering the permafrost the same day as excavation and returning the area to current grade. Compaction should be monitored by qualified geotechnical personnel, and if the lift begins to exhibit signs that excess porewater pressure exists within the underlying materials (spongy or rolling appearance under traffic), then compaction should be stopped immediately and the next lift placed. Lifts above current grade should be placed and compacted to at least 95% of the SMPDD as outlined above and this may require that the initial lifts be allowed to drain over the course of several days.

10.3 Solid Waste Storage Cell and Leachate Holding Pond Lining

There is a scarcity of silty clay in Iqaluit and it is unlikely that silty clay would be available for lining of the solid waste storage cell and the leachate holding pond. It is therefore considered that two flexible membrane liners would be required. The construction of the bases of the cell and the leachate holding ponds may consist of the following:

- 500 mm of compacted granular base material;
- Non-woven geotextile;
- Geosynthetic clay liner, minimum thickness 60 mil.
- 60 mil. thick High Density Poly Ethylene (HPDE) liner;
- 300 m of protective layer consisting of compacted free-draining granular material;
- 300 mm leachate collection layer containing drains;
- Protective geotextile.

Solid waste may be stored above the protective geotextile. The leachate holding pond will not require installation of the drainage system.

10.4 Berm Construction

It is considered that the on-site sand and gravel overburden would be suitable for constructing the berms provided cobbles and boulders greater than 150 mm are removed. Proper compaction of the fill will be necessary to ensure stability of the berm slopes.

Based on the laboratory testing undertaken and previous experience in the area, the engineering properties of the soils listed on Table 6 may be assumed for slope stability analysis.

Table 6: Engineering Properties of Soils Selected for Slope Stability Analysis

Soil Type	Unit Weight (kN/m^3)	Effective Cohesion, C' (kPa)	Effective Angle of Internal Friction Ø' (degrees)
Sand and Gravel Fill compacted to minimum 95% SPMDD	22.0	0	34°
In-situ Sand and Gravel	22.0	0	35°
Compacted Waste	10.0	0	18°

The inclination at which the berm slopes would be stable is a function of a number of factors including:

1.) Height and width of the berms;
2.) Height of solid waste in the cells;
3.) Material used to construct the berms and its degree of compaction;
4.) Height of leachate in the holding ponds.

For preliminary design purposes, it may be assumed that berm slopes at an inclination of 3H:1V would be stable. A detailed slope stability analysis would be required once the design has been finalized to determine the stable slope inclination of the berms. The slope stability analysis would take into consideration slope loading (static and seismic).

The inside slopes of the berms of the cell and leachate holding ponds should also be lined with synthetic liners as discussed previously. The upper end of the liners (at the crest of the berms) should be buried in approximately 0.6 m deep key trench and backfilled with well compacted fill.

The outside slopes of the berms should be provided with suitable erosion protection.

Test pits are recommended prior to tendering and in the summer to evaluate the characteristics of the on-site granular material and their potential re-use in the construction of the berms and for general grading purpose at the site.

10.5 Groundwater Control

A number of streams cross the site and carry the runoff in a south to southeasterly direction. In order to facilitate construction of the landfill, it would be necessary to have a 1.5 m separation between the seasonal high groundwater table and the leachate. Therefore, construction of drainage ditch around the landfill will be required to direct the flow away from the landfill. This may be achieved by construction of drainage ditch around the perimeter of the landfill to divert the surface water from the site. The drainage ditch should be deep enough to capture all the run off during the period when the active layer is fully thawed.

The drainage ditch should be constructed prior to commencement of the excavation work on the site to minimize water control difficulties during construction and to allow the soil to dry. The construction of the drainage ditch will also minimize groundwater flow under the proposed cells during summer months thereby minimizing the potential of settlement of the berms due to washing out of the fines as a result of the groundwater flow under the cells.

Seepage of water into the excavations during construction should be anticipated. Any water entering the excavation may be collected in a shallow ditch located along the perimeter of the excavation and pumped from sump located at the low point. Care should be exercised when discharging the water to ensure that it does not result in erosion or transportation of sediment in accordance with the applicable government regulations.

10.6 Settlement of Cell and Berms

The on-site soils are expected to be thaw stable since they are predominantly free draining and contain low ice content. However, the on-site soils under the cell and the ponds will thaw due to the heat generated by decomposition of the waste and under the leachate holding pond due to absorption of heat from the sun rays by the leachate. Therefore, settlement of the bases of the cells and the berms were estimated. For this purpose, it was assumed that the on-site soils may thaw up to the underlying bedrock. The thaw strain of the soils was estimated based on soil type and estimated density. The settlements computed varied from 20 mm to 150 mm at the locations of Boreholes BH-101 to BH-106 inclusive.

It is recommended that the liners should be installed with several folds to prevent large strain development in the liners due to settlement of the ground. The manufactured of the liners should be consulted for this purpose.

10.7 Permanent Buildings Foundation

Any permanent building required to be constructed as part of the proposed facility will have to be supported on rock socketed piles. Other Types of foundation may be available depending on type of structures proposed as well as intended use. EXP can provide additional foundation recommendation once the plans and designs of the facility and all its component are finalized.

10.8 Monitoring Requirements

It is recommended that groundwater and gas monitoring networks should be installed to ensure that the leachate is not impacting the groundwater and that explosive gases are not migrating from the property during operation of the landfill.

Methane monitoring devices should be installed in any of the structures located on the site to ensure that methane is not accumulating in the building(s).

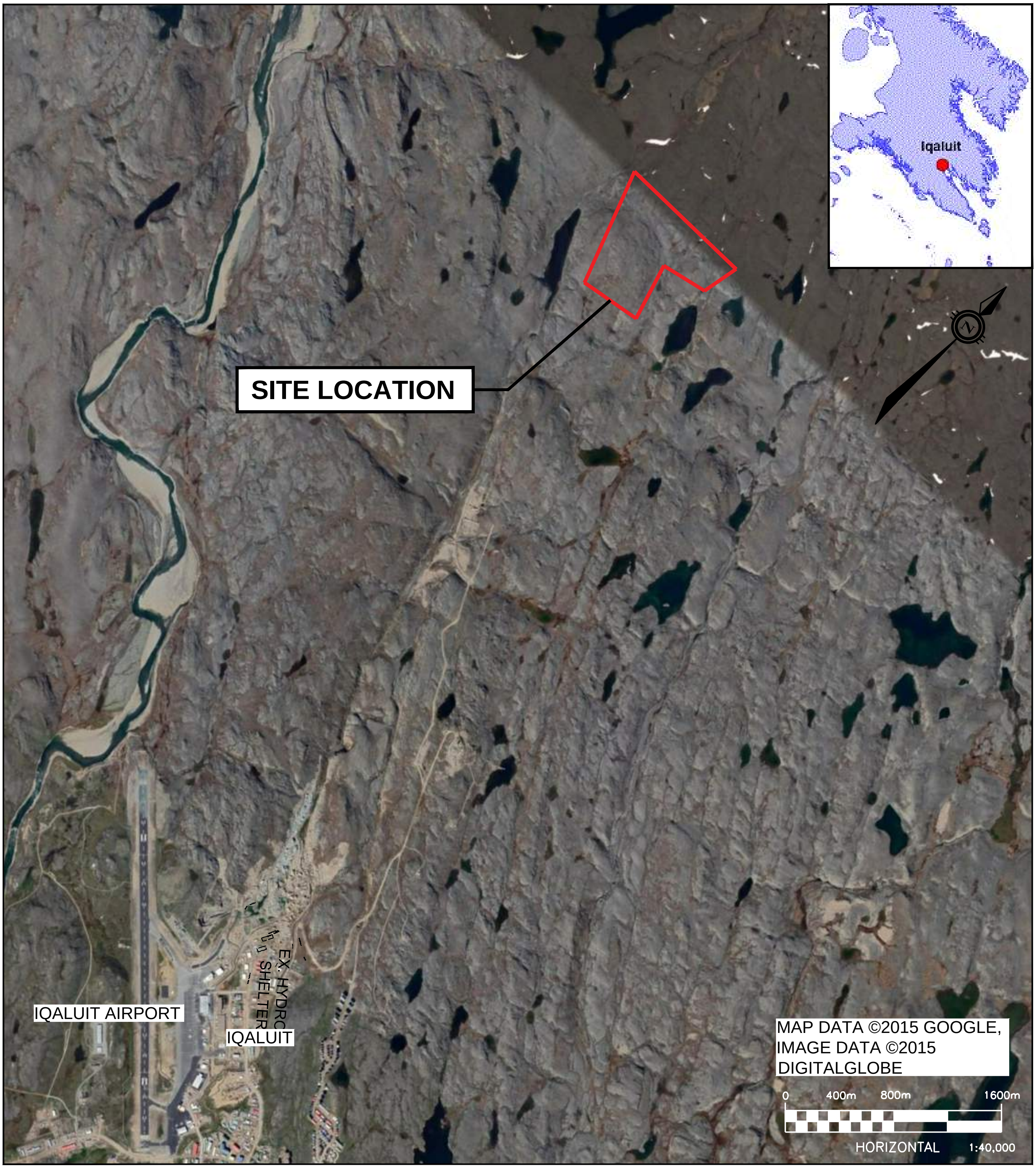
11 General Comments

The comments given in this report are intended only for guidance of design engineers and are preliminary in nature. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well, as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The information contained in this report in no way reflects on the environmental aspects of soil. Should specific information be required, additional testing may be necessary.

Should you have any questions, please do not hesitate to contact this office.

Figures



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scale 1:10 000	PROJECT: PROPOSED LANDFILL SITE CITY OF IQALUIT, IQALUIT, NU	project no. OTT-00248813-A0
date May 2019		design SA / checked IT
drawn by J.R.	TITLE: SITE LOCATION PLAN	FIG 1

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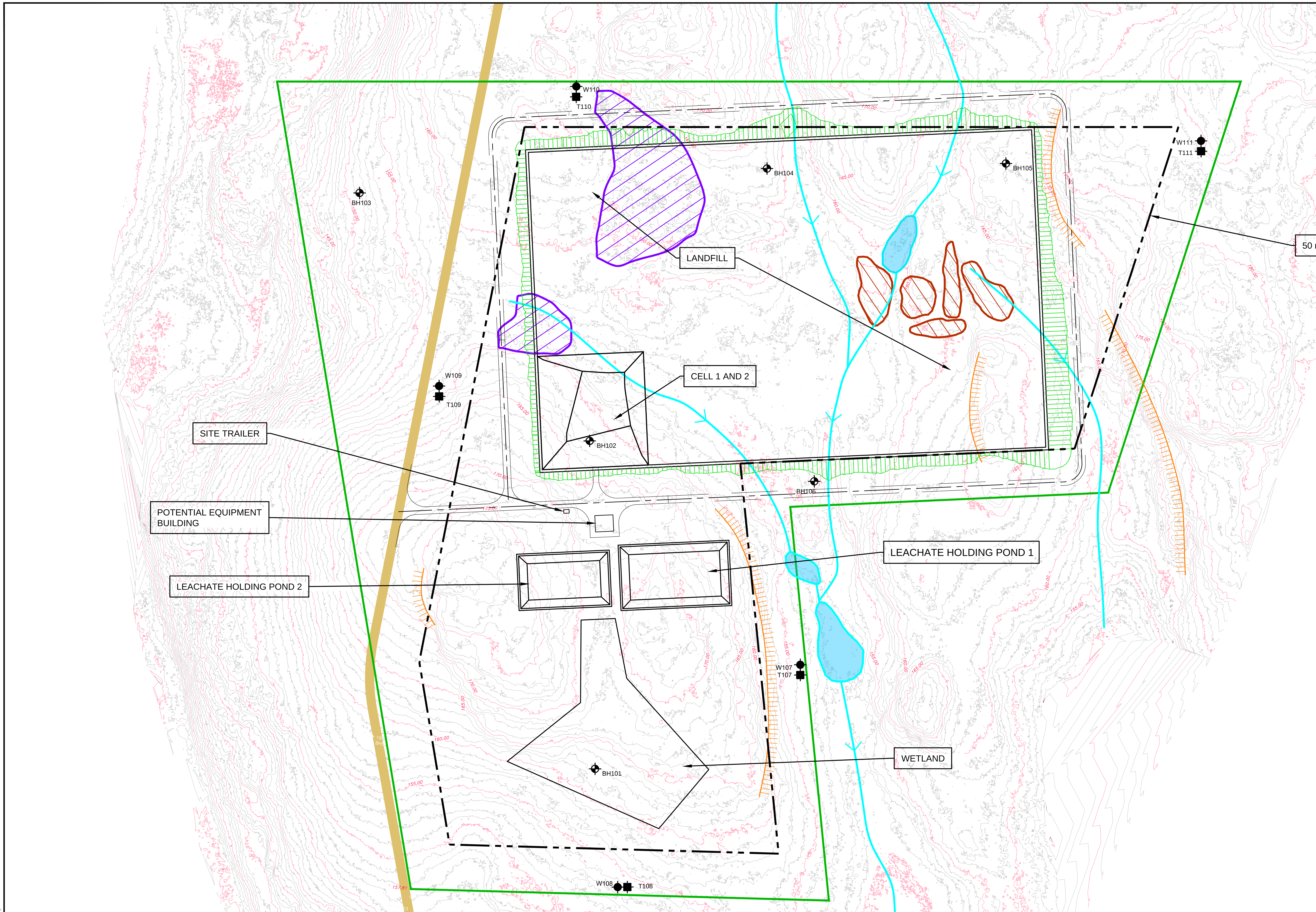

NOTE:
REFERENCE DRAWING – PROPOSED CONDITIONS SITE PLAN, SHEET NO. 2 BY DILLON CONSULTING, RECEIVED ON MAY 7, 2019

LEGEND

- CONTOUR EVERY 5.0m
- SITE BOUNDARY
- FUTURE ROAD
- BOULDER FIELD
- GLACIOFLUVIAL TERRACE
- GROUND WATER AND PONDING
- BEDROCK OUTCROP
- BH101 — BOREHOLE NUMBER AND LOCATION
- T107 — THERMISTOR NUMBER AND LOCATION
- W107 — ACTIVE WATER STATION NUMBER AND LOCATOIN

NOTES:
1. THE BOUNDARIES AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. SOIL SAMPLES AND ROCK WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.

Filename: p:\projects\civil\248000\ott-00248813-a0 – iqaluit waste transfer station\execution\wts-land site bh plan 2019-05.dwg
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Pen Table: exp-64.ctb
References: xref-PHOTO.dwg; 199543-02-SITE-DES-Proposed.dwg

CAUTION
THE POSITION OF ALL POLE LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND AND OVERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, DETERMINE THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES AND ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

SCALE: 0 20m 40m 80m — HORIZONTAL 1:2000

NORTH

DESIGNED BY

REVIEWED BY

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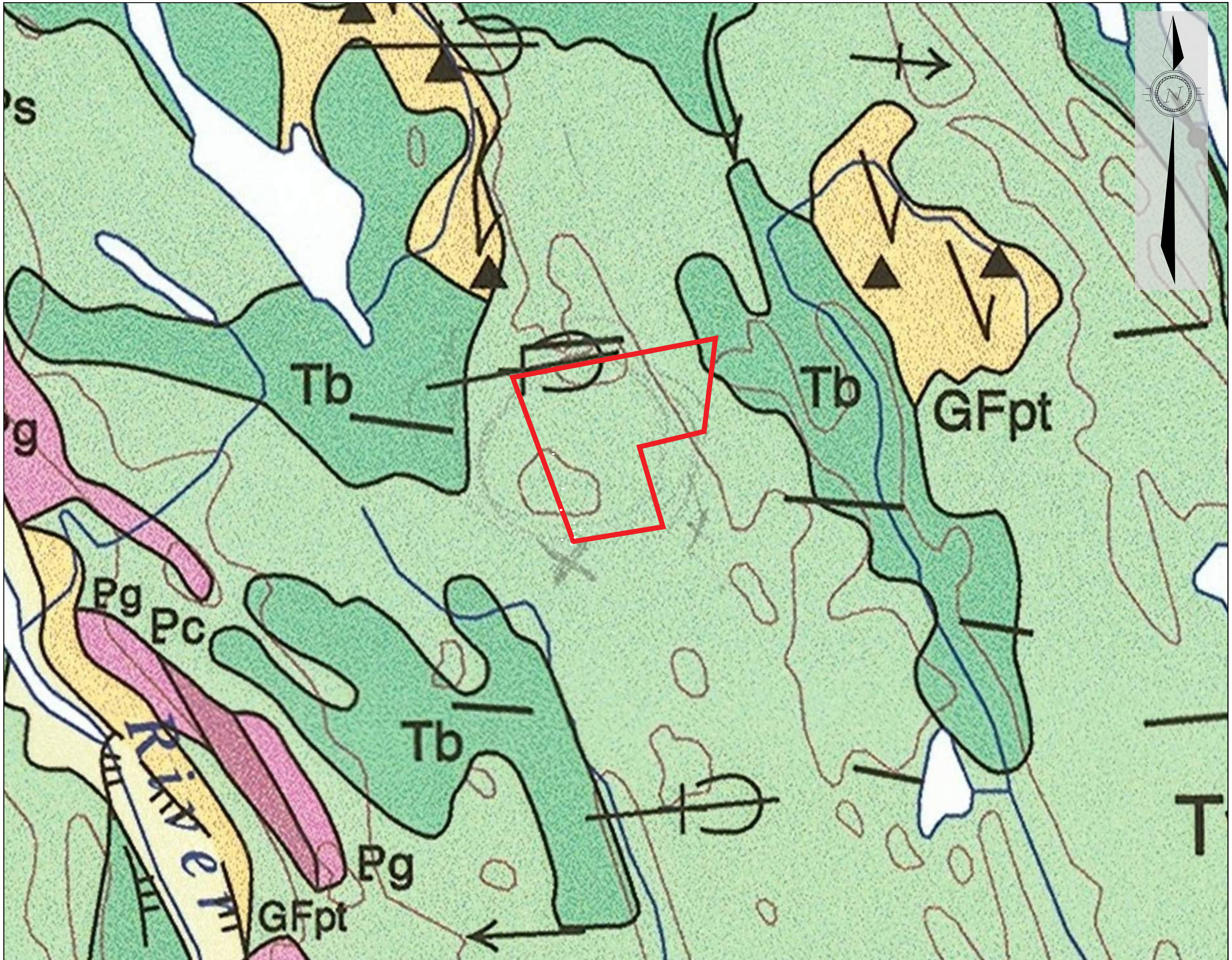
CHECKED: ---
CAD: MN
PROJECT MANAGER: IT
APPROVED: IT

PROJECT: PROPOSED IQALUIT LANDFILL
CITY OF IQALUIT, NUNAVUT.

TITLE: BOREHOLE LOCATION PLAN

PROJECT No.: OTT-248813-A0
SURVEY: exp
DATE: APRIL 2019
DRAWING No.: FIG 2



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HODGSON, D.A. 2003 SURFICIAL GEOLOGY, FROBISHER BAY, BAFFIN ISLAND, NUNAVUT; GEOLOGICAL SURVEY OF CANADA, MAP 2042A

LEGEND

Fpt	FLUVIAL DEPOSIT: GRAVEL, SAND, BOULDERS, SILT
GFpt	GLACIALFLUVIAL OUTWASH: STRATIFIED GRAVEL AND SAND
Tb	TILL BLANKET: 1.0 - 10.0 m THICK
Tv	TILL VENEER 0.5 - 2.0 m THICK
Pc	MARBLE
Pg	MONZOGRANITE OF PALEOPROTEROZOIC CUMBERLAND BATHOLITH
	PROPOSED LOCATION OF LAND FILL

SCALE

0 200m 400m 800m

HORIZONTAL 1:20,000

CLIENT

CITY OF IQALUIT

PROJECT

PROPOSED LANDFILL FACILITY

TITLE

SURFICIAL GEOLOGY

date	MAY 2019	project no.	OTT-00248813-A0
design by	S.A.	drawing no.	FIG 3
prepared by	J.R.		
reviewed by	S.A.		

Filename: r:\240000\248000\248813-a0 iqaluit waste transfer station\gelwts- fig 4 surf geol 2019-05.dwg
Last Saved: 5/13/2019 12:22:14 PM
Last Plotted:5/13/2019 12:23:18 PM Plotted by: OniA
Pen Table:: trow standard, july 01, 2004.ctb

Notes On Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Societv for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by **exp** Services Inc. also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

0.002 0.006 0.02 0.06 0.2 0.6 2.0 6.0 20 60 200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Log of Borehole BH 101 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 4

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B   Checked by: S.K.A

Legend	Symbol	Legend	Symbol
Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation (m)	Depth (m)	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
			162	0				
		TUNDRA ~50 mm	161.9					
		SAND & GRAVEL (SW) Fine to coarse with cobbles and boulders, grey-brown, moist, frozen. No visible ice (Nf)				× (~0.5 m)	✋	
				1		× (~1.5 m)	✋	
		BEDROCK Mozogranite of Cumberland Batholith	160.2	2		× (~2.5 m)	✋	
				3		× (~3.5 m)	✋	
			157.2	4				
		Borehole Terminated at 4.8 m Depth						

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 102 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 5

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Legend		Legend	
Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation (m)	Depth (m)	Natural Moisture Content %	SAMPLES	Natural Unit Wt. kN/m³
		SILTY SAND & GRAVEL (SM) Fine to coarse with cobbles and boulders, brown, moist, frozen. No visible ice (Nf)	162	0			
				0.5	×	grab	
				1.5	×	grab	
		BEDROCK Mozogranite of Cumberland Batholith	159.6	2.4			
				2.5	×	grab	
				3.5	×	grab	
				4.5	×	grab	
				5.5	×	grab	
		Borehole Terminated at 6.0 m Depth	156.0	6			

Chart scales: Standard Penetration Test N Value 20, 40, 60, 80; Shear Strength (kPa) 50, 100, 150, 200; Combustible Vapour Reading (ppm) 250, 500, 750; Natural Moisture Content % / Atterberg Limits (% Dry Weight) 20, 40, 60.

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 103 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 6

Page. 1 of 1

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Legend	Symbol	Legend	Symbol
Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation (m)	Depth (m)	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
		WEATHERED BEDROCK	151	0				
		BEDROCK Mozogranite of Cumberland Batholith	150.4			×	grab	
				1				
						×	grab	
				2				
						×	grab	
		Borehole Terminated at 3.0 m Depth	148.0	3				

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 104 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 7

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Legend	
Split Spoon Sample	⊠
Auger Sample	◧
SPT (N) Value	○
Dynamic Cone Test	—
Shelby Tube	■
Shear Strength by Vane Test	+ S
Combustible Vapour Reading	□
Natural Moisture Content	×
Atterberg Limits	⊢○
Undrained Triaxial at % Strain at Failure	⊕
Shear Strength by Penetrometer Test	▲

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation (m)	Depth (m)	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
		SILTY SAND & GRAVEL (SM-SW) Fine to coarse, frequent cobbles and boulders, grey-brown, moist, frozen. No visible ice (Nf)	163	0				
			159.0	4				
		BEDROCK Mozogranite of Cumberland Batholith						
			157.0	6				
		Borehole Terminated at 6.0 m Depth						

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 105 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 8

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B   Checked by: S.K.A

Legend		Legend	
Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation (m)	Depth (m)	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
		SAND & GRAVEL (SP) POoorly graded, fine to coarse with cobbles and boulders, brown, moist, frozen. No visible ice (Nf)	168	0				
		BEDROCK Mozogranite of Cumberland Batholith	166.5	1.5				
		Borehole Terminated at 5.0 m Depth	163.0	5				

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 106 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 9

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B   Checked by: S.K.A

Legend	Symbol	Legend	Symbol
Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation	Depth (m)	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
		TUNDRA ~50 mm	155.5 / 155.4	0				
		SAND & GRAVEL (SM) Fine to coarse with cobbles and boulders, grey, moist, frozen. No visible ice (Nf)				× (~21)	Grab	
				1		× (~17)	Grab	
		BEDROCK Mozogranite of Cumberland Batholith	153.5	2		× (~5)	Grab	
				3		× (~6)	Grab	
		Borehole Terminated at 4.0 m Depth	151.5	4				

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 5/13/19

Log of Borehole BH TW107 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 10

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B   Checked by: S.K.A

Legend		Legend	
Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation (m)	Depth (m)	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
			154	0				
		TUNDRA ~50 mm	153.9					
		SAND & GRAVEL With cobbles and boulders. No visible ice (Nf)						
		BEDROCK Mozogranite of Cumberland Batholith	150.4					
			147.2					
		Borehole Terminated at 6.8 m Depth						

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Thermister Pvc Pipe installed to 6.8 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH TW108 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 11

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B   Checked by: S.K.A

Legend	Symbol	Legend	Symbol
Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation	Depth	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
			153.5	0				
		TUNDRA AND FROZEN SOIL ~150 mm	153.3					
		SAND & GRAVEL With cobbles and boulders. No visible ice (Nf)		1				
				2				
		BEDROCK Mozogranite of Cumberland Batholith	150.8	3				
				4				
				5				
				6				
		Borehole Terminated at 7.0 m Depth	146.5	7				

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Thermister PVC Pipe installed to 7.0 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 5/13/19

Log of Borehole BH TW109 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 12

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Legend	Symbol	Legend	Symbol
Split Spoon Sample	☒	Combustible Vapour Reading	□
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲

SOIL DESCRIPTION	Estimated Geodetic Elevation (m)	Depth (m)
	159	0
TUNDRA ~150 mm	158.8	
SAND & GRAVEL With frequent cobbles and boulders, frozen. No visible ice (Nf)	156.6	
BEDROCK Mozogranite of Cumberland Batholith	152.8	
Borehole Terminated at 6.2 m Depth		

Chart columns: Standard Penetration Test N Value (20, 40, 60, 80); Shear Strength kPa (50, 100, 150, 200); Combustible Vapour Reading (ppm) (250, 500, 750); Natural Moisture Content %, Atterberg Limits (% Dry Weight) (20, 40, 60); SAMPLES; Natural Unit Wt. kN/m³. Depth scale 0–6.

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Thermister PVC Pipe installed to 6.2 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH TW110 (DRAFT)

Project No: OTT-00248813-B0

Figure No. 13

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type: Airtrack Drill Rig

Datum: Estimated Geodetic Elevation

Logged by: S.B   Checked by: S.K.A

Legend	Symbol	Legend	Symbol
Split Spoon Sample	☒	Combustible Vapour Reading	□
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation (m)	Depth	Standard Penetration Test N Value (20 40 60 80) / Shear Strength kPa (50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20 40 60)	SAMPLES	Natural Unit Wt. kN/m³
			164	0				
		TUNDRA AND FROZEN SOIL ~150 mm	163.8					
		SAND & GRAVEL Frequent boulders, frozen. No visible ice (Nf)		1, 2				
		BEDROCK Mozogranite of Cumberland Batholith	161.6	3, 4, 5				
		Borehole Terminated at 6.0 m Depth	158.0	6				

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Thermister PVC Pipe installed to 6.0 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH TW111 (DRAFT)

Project No:	OTT-00248813-B0
Project:	Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit
Location:	City of Iqaluit, Nunavut
Date Drilled:	'March 24 to April 4, 2019
Drill Type:	Airtrack Drill Rig
Datum:	Estimated Geodetic Elevation
Logged by:	S.B
Checked by:	S.K.A

Figure No. 14

Page. 1 of 1

Legend	Symbol	Legend	Symbol
Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◨	Natural Moisture Content	X
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲

GWL	SYMBOL	SOIL DESCRIPTION	Estimated Geodetic Elevation	Depth	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
			179.5	0				
		TUNDRA AND FROZEN SOIL ~100 mm	179.4					
		SAND & GRAVEL Frequent boulders, frozen. No visible ice (Nf)		1				
		BEDROCK Mozogranite of Cumberland Batholith	178.1	2, 3, 4, 5				
			174.0					
		Borehole Terminated at 5.5 m Depth						

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Thermister PVC Pipe installed to 5.5 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Appendix A: Photographs Collected During Drilling (March and April 2019)

Photo 1 – Typical Air Track Mounted on a Mechanical Shovel and Compressor

Photo 2 – Borehole Drilling Operation - Typical

Photo 3 – Borehole Drilling Operation - Typical

Photo 4 – Temperature and Groundwater Monitoring Installation in TH110/W-110 (Typical)

Photo 4 – Temperature Monitoring in TH-110 - Typical

Photo 5 – Temperature Monitoring in TH-110 - Typical

Appendix B: Results of Chemical Tests on Soil Samples

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC
2650 QUEENSVIEW DRIVE, UNIT 100
OTTAWA, ON K2B8H6
(613) 688-1899

ATTENTION TO: Ismail M. Taki

PROJECT: OTT-248813-A0

AGAT WORK ORDER: 19Z453898

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Apr 26, 2019

PAGES (INCLUDING COVER): 5

VERSION*: 2

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

NOTES

VERSION 2:Revised report issued April 26, 2019.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories
5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 19Z453898
PROJECT: OTT-248813-A0

CLIENT NAME: EXP SERVICES INC
SAMPLING SITE:Loyalist, Ont
ATTENTION TO: Ismail M. Taki
SAMPLED BY:exp

Inorganic Chemistry (Soil)

DATE RECEIVED: 2019-04-05
DATE REPORTED: 2019-04-26

			SAMPLE DESCRIPTION:	BH1 SS2 2.5'-4.5'	BH15 SS2 2.5'-4.5'	BH17 SS3 5'-7'	BH22 SS3 5.5'-8.5'	BH26 SS3 5.5'-7.5'	BH31 SS3 5'-7'	BH39 SS4 7.5'-9.5'	BH48 SS2 3'-5'
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2019-03-12	2019-03-13	2019-03-15	2019-03-20	2019-03-19	2019-03-22	2019-03-18	2019-03-19
Parameter	**Unit**	**G / S**	**RDL**	**114353**	**114355**	**114356**	**114357**	**114358**	**114359**	**114360**	**114361**
pH (2:1)	pH Units		N/A	7.94	7.99	8.18	7.99	8.19	8.17	8.27	8.01
Electrical Conductivity (2:1)	mS/cm		0.005	0.179	0.284	0.190	0.177	0.250	0.199	0.226	0.196
Sulphate (2:1)	%		0.0002	0.0006	0.0070	0.0034	0.0034	0.0072	0.0038	0.0048	0.0030

			SAMPLE DESCRIPTION:	BH67 SS3 5'-7'	BH74 SS4 7.5'-9.5'
			SAMPLE TYPE:	Soil	Soil
			DATE SAMPLED:	2019-03-13	2019-03-14
Parameter	**Unit**	**G / S**	**RDL**	**114362**	**114363**
pH (2:1)	pH Units		N/A	8.09	8.22
Electrical Conductivity (2:1)	mS/cm		0.005	0.435	0.128
Sulphate (2:1)	%		0.0002	0.0063	0.0019

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

114353-114363 EC, pH and Sulphate were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil).
Revised on 2019 April 26
Revision: This is a revision of a previous report issued on 2019 April 12. At client's request, the concentration units for sulphate have been changed from µg/g to %.

Certified By:

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
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FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: EXP SERVICES INC
PROJECT: OTT-248813-A0
SAMPLING SITE:Loyalist, Ont

AGAT WORK ORDER: 19Z453898
ATTENTION TO: Ismail M. Taki
SAMPLED BY:exp

Soil Analysis

RPT Date: Apr 26, 2019			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Inorganic Chemistry (Soil)															
pH (2:1)	120874		8.15	8.19	0.5%	N/A	100%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	120771		0.214	0.222	3.7%	< 0.005	104%	90%	110%	NA			NA		
Sulphate (2:1)	118571		0.0014	0.0016	13.3%	<0.00002	98%	70%	130%	107%	70%	130%	112%	70%	130%

Comments: NA signifies Not Applicable.

Certified By:

AGAT Laboratories
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http://www.agatlabs.com

Method Summary

CLIENT NAME: EXP SERVICES INC
PROJECT: OTT-248813-A0
SAMPLING SITE:Loyalist, Ont
AGAT WORK ORDER: 19Z453898
ATTENTION TO: Ismail M. Taki
SAMPLED BY:exp

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH

76882

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Laboratory Use Only

Work Order #: 19Z453898

Cooler Quantity: plastic bag

Arrival Temperatures: 20.3 | 20.1 | 20.3

Custody Seal Intact: ☐Yes ☐No ☐N/A

Notes: no ice

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: Exp Services
Contact: Ismail Taki
Address: 2650 Queensview dr Suite 100 Ottawa ON K2B 8H6
Phone: 613-688-1899 Fax:
Reports to be sent to:
1. Email:
2. Email:

Regulatory Requirements:

☐ No Regulatory Requirement

(Please check all applicable boxes)

☐Regulation 153/04
Table (Indicate One): ☐Ind/Com ☐Res/Park ☐Agriculture
Soil Texture (Check One): ☐Coarse ☐Fine

☐Sewer Use: ☐Sanitary ☐Storm
Region (Indicate One)
☐MISA

☐Regulation 558
☐CCME
☐Prov. Water Quality Objectives (PWQO)
☐Other (Indicate One)

Is this submission for a Record of Site Condition? ☐ Yes ☐ No

Report Guideline on Certificate of Analysis: ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☒ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)
☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: OTT-252122
Site Location: Loyalist Ont
Sampled By: exp
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☒ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Analysis columns: Field Filtered - Metals, Hg, CrVI (Y/N); O. Reg 153: Metals and Inorganics; ☐ All Metals ☐ 153 Metals (excl. Hydrides); ☐ Hydride Metals ☐ 153 Metals (Incl. Hydrides); ORPs: ☐ B-HWS ☐ Cl⁻ ☐ CN ☐ Cr⁶⁺ ☐ EC ☐ FOC ☐ Hg ☐ pH ☐ SAR; Full Metals Scan; Regulation/Custom Metals; Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3+NO_2; Volatiles: ☐ VOC ☐ BTEX ☐ THM; PHCs F1 - F4; ABNs; PAHs; PCBs: ☐ Total ☐ Aroclors; Organochlorine Pesticides; TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs; Sewer Use; pH; Sulphate; Electro Conductivity

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	pH	Sulphate	Electro Conductivity
BH 1 SS 2 2.5'-4.5'	Mar 12/19					✓	✓	✓
BH 15 SS 2 2.5'-4.5'	Mar 13					↓	↓	↓
BH 17 SS 3 5'-7'	Mar 15					↓	↓	↓
BH 22 SS 3 5.5'-8.5'	Mar 20					↓	↓	↓
BH 26 SS 3 5.5'-7.5'	Mar 19					↓	↓	↓
BH 31 SS 3 5'-7'	Mar 22					↓	↓	↓
BH 29 SS 4 7.5'-9.5'	Mar 18					↓	↓	↓
BH 48 SS 2 3'-5'	Mar 19					↓	↓	↓
BH 67 SS 3 5'-7'	Mar 13					↓	↓	↓
BH 74 SS 4 7.5'-9.5'	Mar 14					↓	↓	↓

Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
Ryan Di Giuseppe	Apr 4/19	5:00pm	[signature]	19-04-05	9h28
CB/No to FedEx	19-04-05	16h00	[signature]	19/4/16	11:30

Page 1 of 1

Nº: T078139 ✓

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Erik Marko, Colliers Project Leaders - Erik.Marko@colliersprojectleaders.com

Appendix D

Assessment of Leachate Treatment Options Report

DILLON CONSULTING

CITY OF IQALUIT

Triple Bottom Line Assessment of Leachate Treatment Options (Draft)

Landfill and Waste Transfer Station

May 2019 | 19-9543

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Figures

Tables

References

1.0 Triple Bottom Line Assessment for Leachate Treatment Alternatives

The City of Iqaluit (City) is in the process of implementing its Solid Waste Management Strategy to service their near and long-term (75 years) municipal solid waste disposal requirements. Founded on a previously completed conceptual design and facility siting exercise, key elements of the project include a solid waste transfer station (WTS) within the immediate urban area of the City, where residential and commercial waste will be hauled to, processed, and compacted in bales or in the case of waste wood and cardboard, shredded and pelletized for use as a fuel source for an on-site biomass boiler. Tires, metal and some construction and demolition (C&D) wastes will also be shredded and or baled for landfilling or transported south for recycling. The resulting solid waste bales, and possibly a smaller amount of unbaled C&D waste, will be trucked to an engineered balefill landfill site located approximately 6 km from the WTS (see **Figure 1**). The vehicles transferring the waste bales will access the road leading to the landfill site from the WTS to avoid having the transfer vehicle travel through the City.

Figure 1: Facility Site Locations

To address their objectives, and following a competitive proposal process, the City engaged Dillon Consulting Limited (Dillon) to provide design and construction contract administration services to support the establishment of the WTS/baling facility and the engineered Landfill site. The engineered landfill will be designed for 75 years of operation but for the construction/build portion of the project, only the first stage of the landfill (Stage 1 Operational Landfill) will be constructed (e.g., first two cells and ancillary components to meet five and 10 year operational requirements; e.g., five years per cell).

As a component of the predesign effort, Dillon completed a triple bottom line (i.e., financial, social and environmental) impact assessment on alternatives to manage leachate generated by the City's new solid Waste Landfill (henceforth knows as 'the Site'). Consistent with the methodology described in Dillon's February 2019 proposal, the assessment utilized a weighted-criteria approach to arbitrate between the costs and benefits of alternatives considered. The weighted-criteria approach allocated 'points' consistent with the percentage value attributed to the assessment area. High point scores are preferable. As a result, points are allocated for potential benefits and areas with minimal or no impact, while negative impacts reduce point scores.

The Triple Bottom Line Assessment for Leachate Alternatives is divided into sections covering the alternatives, methods and assessment of the leachate treatment alternatives.

- **Section 1.1** provides an overview and description of the feasible leachate treatment alternatives considered.

- **Section 1.2** details the Triple Bottom Line assessment methods, including the breakdown of the weighted-criteria and their respective justifications.
- **Section 1.3** assesses the financial costs and risks associated with each leachate treatment alternative.
- **Section 1.4** assesses the environmental costs and benefits of each leachate treatment alternative.
- **Section 1.5** assesses the socio-economic costs and benefits of each leachate treatment alternative.
- **Section 1.6** provides a summary of the financial, environmental and socio-economic assessments including key trade-offs. This section also includes the recommendation for the preferred leachate treatment method.

The Triple Bottom Line Assessment as conducted for this assignment has a variety of limitations. The assessment is based on initial information available at time of reporting (e.g., the initial stages of project work program) and may change based on more information/progress of design. However, the current level of detail is considered appropriate for a Triple Bottom Line review of alternatives at this stage of project.

It is also assumed all options are considered to be technically feasible and will be accepted by the regulator as a viable technology. The risks associated with each option are considered to be 'upset conditions' likely to result in financial, social or environmental consequences. All costs are high-level and best understood as orders of magnitude for the potential costs of alternatives. The costs are not to be considered "opinions of probable costs", as these will be developed at later stages of the project. However, the costs are considered appropriate for comparison purposes. Similarly, project footprints are provided for comparison purposes but will be subject to change.

Overall, the Triple Bottom Line Assessment for Leachate Treatment Alternatives provides a recommendation for the preferred leachate treatment method, considering the potential for each alternative to impact the finances of the City and the environment including the socio-economy.

1.1 Leachate Alternatives

With reference to Phase I/Task 3 in Dillon's February 2019 proposal, as well as minutes from the project Kick Off Meeting, three leachate treatment alternatives are considered as part of this assessment:

- Aerated lagoon and Wetland Treatment Area (WTA);
- Pre-treatment and haulage to the City's wastewater treatment plant (WWTP); and
- On-site mechanical treatment.

These alternatives have different financial parameters, risks, and environmental/social costs and benefits. The nature of leachate generation in northern communities suggests that the majority of the year will see no or little leachate produced, until the snow melt occurs in June/July. At this point, any precipitation that took place during the winter and remained on the Landfill would melt and produce leachate over the summer months, in addition to rainfall received during June to September. An important aspect of the treatment system will also be its ability to scale up over the life of the Landfill. Unlike a municipal WWTP, which usually experiences moderate loading shortly after commissioning, the leachate treatment system is expected to see a more gradual increase in leachate production over its 75 year life. As new landfill cells are opened and previous cells close, leachate quantity and quality will fluctuate. The treatment system must be able to be modified over the 75 year life to handle these changes.

1.1.1 Alternative 1: Aerated Lagoon and Wetland Treatment Area

A common method of managing wastewater in both northern and southern Canada is through the use of engineered wetlands. Native plants provide a surface for biofilm to grow, which filters the water naturally as leachate passes through it. This alternative includes a constructed lagoon that receives pumped leachate from the landfill collection system. The lagoon would store and partially treat leachate that is pumped out from the landfill before discharging to a wetland area downstream. For this alternative, an area of approximately 2.5 ha for the lagoon and wetland is anticipated to be used. Plant growth would be encouraged and supported in the short-term (e.g., 1 to 3 years), following construction of the wetland, and with routine monitoring to review system performance and effluent quality on a semi-annual basis.

Capital costs would be primarily be associated with earthworks and imported liner materials related to the lagoon construction. Operationally, it would require little maintenance other than effort associated with pumping and water level monitoring.

This alternative, as expected, presents the lowest operational cost, as the only mechanical components would be transfer pumping systems and aeration equipment for the lagoon and wetland.

1.1.2 Alternative 2: Pre-Treatment and Haulage to the City's Existing Wastewater Treatment Plant

The City is currently completing construction (scheduled for completion late winter 2020) of a new WWTP to manage municipal wastewater generated within the community. The new plant is intended to serve the City through to 2041, at which point it will either require replacement or major upgrades (assuming population trends, as predicted). Based on the 2017 Nunami Stantec Report, the plant will consist of the following processes:

- Preliminary treatment to screen out coarse solids;
- Primary treatment to reduce total suspended solids;
- Secondary treatment via moving bed biofilm reactors and dissolved air flotation to reduce organic and remaining solids loading; and
- Process solids handling via belt filter press and mechanical compressor.

While the City's proposed treatment technology would likely be capable of treating some of the leachate effluent contaminants (such as biochemical oxygen demand and total suspended solids), it would not be optimized for ammonia or metals removal, which are anticipated to be present in medium-high strength in the leachate. This alternative; therefore, includes pre-treatment at the Site and on-site storage (either insulated fabricated tanks or lined earthen ponds) to balance truck haul trips to the City's WWTP. For this alternative, an area of 2.5 ha for the pre-treatment is anticipated to be used.

Operationally, this treatment selection would require chemical consumption and leachate haulage between the landfill and the City's WWTP. A project footprint at the landfill would also be required for the pre-treatment system and storage, but it would be less than that necessary for a full scale lagoon and WTA. The primary disadvantages of this alternative relate to impacts on the City's WWTP and greenhouse gas (GHG) generation from truck trips. Last, as the proposed design life of the City's WWTP is approximately one third of the overall landfill's design life, future City WWTPs would be required to handle the leachate.

1.1.3 Alternative 3: On-Site Mechanical Treatment

An on-site treatment alternative to a WTA is a mechanical treatment system that would discharge to the adjacent land environment using a level spreader or similar technology. Under this alternative, a treatment plant, somewhat similar in process technology to that of the City's new WWTP, would be constructed near the Site using an area of approximately 0.8 ha. In contrast to the previous alternative, which would also require a mechanical system for pre-treatment, this alternative would utilize a larger scale treatment plant with multiple unit processes to reduce metal concentrations in the effluent in addition to biological contaminants. It would have a smaller project footprint compared to the WTA, but would require more operator attention and carry with it high annual costs relative to other alternatives. Due to the operational complexity, the treatment system would require a qualified operator.

1.2 Triple Bottom Line Methods

The Triple Bottom Line Impact Assessment uses a weight-criteria analysis identifying the costs and benefits of the three identified leachate treatment alternatives considering the project lifecycle (75 years). Dillon has considered a variety of financial, environmental, and social factors specific to the study area and regional character. As part of the social factors, Dillon considered economic factors such as the impact of the leachate treatment alternatives on the local economy.

1.2.1 Overview of Process and Key Variables

As an initial step, Dillon highlighted key relevant baseline information based on the study report completed by EXP. Next, the team considered the project effects, costs and benefits associated with the changes based on the proposed alternatives. All items were "financialized", where possible, to standardize the units of measurement for consistent comparison. Recognizing that all items cannot be financialized, Dillon developed a weighted-criteria decision framework, where the non-financial and financial changes associated with alternatives are considered.

Weighting was developed based on established best practices and consultation with the City. The weighting was done in two stages. The first stage weighed the social, financial and environmental criteria out of 100. It was determined environmental factors would be the largest grouping due to the variety of environmental pathways of effect (40%). Financial and social considerations were slightly lower (30% each), as fewer effect pathways were developed and there was potential for interaction between these alternatives.

The second stage considered subcomponents of financial, social and environmental factors that may be impacted by the Site. Criteria were weighted based on the potential magnitude and consequences of effect for each treatment method. For example, the variety of recreation opportunities near the Site resulted in a higher weighting (or point totals) on the land use criteria where recreation and tourism is captured. Cultural resources were weighted lower as "there are no culturally designated or significant heritage features currently identified within the Site. No existing records for archaeological, paleontological or place name records occur on the Site (EXP 2018)." Therefore, it is less likely activities related to leachate construction and operation will impact cultural resources. Similar considerations were undertaken for all criteria to develop the allocation of points by area of assessment.

1.2.2 Triple Bottom Line Scoring Criteria

Based on the overall process and the key variables specific to the Site, and based on the preliminary engineering design, Environmental Site Assessment, and Physical and Biological Assessment Reports, (**Table 1**), Dillon defined the following triple bottom line assessment criteria, which utilizes a weighted-criteria method. The values associated with each item may be considered as potential weights or points with the sum of 100.

Table 1: Triple Bottom Line Scoring Methods

Criteria	Value	Description
Financial	30	Limited capital is available for construction and operation of the facility overall; subsequently, the leachate treatment. Cost-effective alternatives with lower capital and operating costs that minimize risk are more desirable.
-Financial Performance	25	*The financial score is equal to the lowest cost alternative over the cost of the alternative multiplied by the number of available points (25). Therefore, the alternative with the lowest financial cost scored 25 points and all other scores are relative to that.*
-Financial Risk	5	*Financial risk considered the likelihood of additional capital or operating costs associated with the leachate treatment alternatives. It is preferable to develop and alternative with the lowest risk of additional costs associated with the construction and operation of the leachate treatment.*
Environmental	40	The leachate treatment for the project will have an impact on the local environment, including land, air, water and ecosystems. It will also contribute to climate change through the emission of GHGs. These impacts are undesirable. Alternatives that minimize environmental impacts and risk are very desirable, as shown by the greatest weighting being provided to environmental factors. The subcategories provided below align with the Global Reporting Initiative Standards environmental aspects.

Criteria	Value	Description
-Materials	*3*	*It is preferred to minimize the amount of natural resources and manufactured chemicals. Leachate treatment may involve the use of chemicals, which may also increase the risk of a spill.*
-Energy	*5*	*The leachate treatment alternatives will have varying energy consumption. It is preferred to minimize the amount of amount of energy required.*
-Water	*3*	*Leachate treatment alternatives will have varying water requirements. It is preferred to minimize the amount of water that is required/consumed and maximize the amount of water recycled/re-used.*
-Biodiversity	*5*	*The leachate treatment for the* project *may have an impact to ecosystems, vegetation and wildlife.*
-Emissions, effluent, waste	*3*	*The leachate treatment alternative may result in waste. It is preferred to minimize the amount of waste generated.*
	5	*Water discharge quality associated with leachate treatment may impact surface water, groundwater, or soil.*
	5	*The leachate treatment alternative may have varying GHG outputs.*
	6	*The leachate treatment method may alter noise and air quality (NO_x, SO_x), including odour at receptor sites.*
-Transport	*5*	*Transport associated with leachate treatment alternatives (including the number and frequency of trucks) will have an impact on GHGs emissions and noise.*
Socio-economic	30	The social environment surrounding the project has the potential to be altered by how the new facility treats leachate. Physical disturbances to the land and environmental nuisance effects may impact community members. Alternatives that minimize negative effects or result in positive changes to the human environment are preferred.
-Socio-community	*6*	*Nuisance effects associated with the treatment of leachate may have an impact on the community including water quality, odour, noise and air quality. It is preferred to minimize nuisance effects.*
-Land Uses	*8*	*The treatment with leachate will change existing uses of the land impacting the* Site *and the surrounding area. This may include disrupting existing industrial/recreational uses and visual changes. It is preferred to minimize disturbances to land users.*
-Economic	*4*	*The procurement of capital and labour throughout the lifecycle of the* project's *leachate treatment may have an impact on the local economy. It is preferred to maximize economic benefits within the local community.*
-Human Health	*4*	*The treatment of leachate may carry risks that could impact human health for those near the* Site. *It is preferred to minimize human health risk.*
-Indigenous Rights and Interests	*5*	*Traditional uses of the land may be impacted by the* project's *leachate treatment alternative due to the nuisance effects and physical land use. It is preferred to minimize disturbances to traditional activities.*
-Cultural resources	*3*	*Cultural heritage and archaeological sites may be altered by the* project. *It is preferred to minimize disturbances to these sites.*

Note:
Financial, Socio-economic and Environmental scores are the sum of the scoring criteria below the entry. For example, the environmental 40 points is the sum of materials, energy, water, biodiversity, emissions and transport scores.

Methods for calculating individual costs and benefits for specific disciplines are included in subsequent sections. Relevant baseline and project information relating to the specific discipline is also included in these sections.

1.3 Financial

The financial costs related to construction and operations of the leachate treatment system are considered as part of the preferred alternative, as there are limits to the capital available for the construction of the project. This directly impacts the capital available for leachate treatment construction. Operations costs also affect the viability of the project, as financial constraints will exist during the operation stage.

1.3.1 Construction Costs

Each alternative will have construction costs associated with the construction of the leachate treatment. Costs associated with the Triple Bottom Line Assessment are estimates as of May 1, 2019, as described in **Section 1.0**. These costs were prepared in April 2019, and are expected to have a large variance from the actual construction costs identified in future design and reporting documents. The purpose of providing costs in this section is to provide comparative costs for the leachate treatment alternatives.

Costs for the aerated lagoon and WTA alternative are estimated to be $3.44 million. These costs would include earthworks, liner, fencing, an aeration system, control structures, distribution piping and portable pumping systems.

The pre-treatment and haul to the City's WWTP alternative is estimated to be $2.18 million. These costs include earthworks, pond liner, treated holding tank/pond, the treatment system and building.

The on-site mechanical treatment alternative is estimated to be $4.85 million. These costs include earthworks, liner, a biological treatment system, a metals treatment system, treatment building and pumping systems. All alternatives assume a 50% contingency.

Additional detail and key assumptions for the capital cost estimate are provided in **Table 2**. Costs should be viewed as orders of magnitude and should be used for comparison purposes only. These costs do not reflect the actual construction cost estimates for any option.

Table 2: Leachate Option Capital Cost Summary ($millions)

Item	#1: Aerated Lagoon & WTA		#2: Pre-Treat & Haul		#3: On-Site Mechanical Treatment	
	Assumption	Cost	Assumption	Cost	Assumption	Cost
Earthworks	40,000 m^3	$1.20	15,000 m^3 plus holding tank for trucking	$0.60	15,000 m^3	$0.45
Pond liner	14,000 m^2	$0.49	5,000 m^2	$0.18	5,000 m^2	$0.18
Treatment equipment	Aeration equipment	$0.25	Metal precipitation system	$0.50	Metal precipitation and biological treatment systems	$2.30
Pumping & piping systems	Control MHs, transmission piping, pump station	$0.13	Control MHs, transmission piping, pump station	$0.08	Control MHs, transmission piping, pump station	$0.11
Ancillary items	Fencing, gates, signage,	$0.21	Treatment building	$0.10	Treatment building	$0.20
Contingency	50%	$1.15	50%	$0.73	50%	$1.61
TOTAL	**Order of magnitude**	**$3.44**	**Order of magnitude**	**$2.18**	**Order of magnitude**	**$4.85**

Notes:

1) Options #2 and #3 would also require additional engineering design costs (typically 8-12% of capital value), as the assumption at the request for proposal stage was on a lagoon and wetland treatment system.

2) Lagoon and WTA based on sufficient pond sizes to hold one years' worth of leachate to balance freeze/thaw periods.

3) Both mechanical treatment options (#2 and #3) are based a physical-chemical separation process for heavy metals. Option #3 includes an additional biological treatment step for biological oxygen demand and total suspended solids removal.

4) All systems are based on approximately 4,400 m^3/year of low-strength leachate treatment.

5) Land based effluent disposal assumed (no outfall infrastructure).

6) Generator costs excluded and assumed to be covered under general landfill budget.

7) 50% contingency carried due to level of design completed and uncertainty regarding each option.

1.3.2 Operating Costs

Each proposed alternative will have costs over the 75 year operation period. Similar to construction costs, operation costs are estimates based on assumptions. These costs are expected to have a large variance from the actual operation costs identified in future design and reporting documents. The purpose of providing costs in this section is to provide comparison costs for leachate treatment alternatives. Costs were inflated by approximately 2% annually, the midpoint of the Bank of Canada's inflation target (Bank of Canada 2019). These costs are likely to include:

- **Labour** – It is assumed labourers will receive the median wage for Iqaluit of $70,695 prorated over the work period annually (Statistics Canada 2017). The on-site mechanical treatment alternative operator is identified as requiring additional skills so a 20% premium is added to their wages. Part-time employment is assumed to be 50% of median income.
  - The aerated lagoon and WTA alternative assumed a part-time operator for 12 months.
  - The pre-treatment and haul to the City's WWTP alternative assumed one part-time operator for eight months and one full-time operator for four months. In addition, there will be two full-time truck drivers for four months.
  - The on-site mechanical treatment alternative assumed one part-time operator for eight months and one full-time operator for four months.
- **Upkeep** – Assumed to be 1% of equipment costs in all cases.
- **Fuel usage** – The projected motor size was assumed for each alternative. It was assumed the motor would run constantly for four months. Diesel was assumed to cost $0.50 per kWh (Sullivan 2017).
- **Testing/Process Improvements** – Assumed based on experience with similar systems.
- **Chemical Consumption** – Assumed based on experience with similar systems.
- **Major Equipment Replacement** – Assumed that each alternative is expected to have three major equipment replacement intervals over the 75 year life of the landfill. They are expected to occur on or around years 20, 40 and 60 for the pre-treatment, and hauled to the City's WWTP alternative and the on-site mechanical treatment alternative, and years 25, 50 and 75 for the aerated lagoon and WTA alternative.

The total costs for operation of the leachate treatment alternatives during the lifecycle of the project are provided in **Table 3**.

Table 3: Summary of Estimated Operational Costs ($ million) – 75 Year Life Cycle

Operational Area	Aerated Lagoon and WTA	Utilizing the Existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Labour	$6.04	$16.10	$8.85
Upkeep	$0.85	$ 1.37	$2.05
Fuel Usage	$9.39	$12.81	$25.62

Operational Area	Aerated Lagoon and WTA	Utilizing the Existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Testing/Process Improvements	$2.56	$5.12	$8.54
Chemical Consumption	-	$34.16	$42.70
Major Equipment Replacement	$2.14	$3.42	$8.21
Total Operation Costs	$20.99	$72.98	$95.96

Note:
Sums may not add up due to rounding.

1.3.3 Revenue

None of the three leachate treatment alternatives are expected to generate direct revenue for the Site. In some larger cities throughout North America, the sludge that is produced, as part of the treatment process, can be further treated and conditioned into a soil amendment product and sold to the general public; however, that is not considered to be a viable alternative for the Iqaluit landfill for various reasons:

- Very high capital investment cost;
- Variability in leachate quality could impact finished product quality (this process is typically reserved for municipal wastewater);
- Operational requirements and complexity are quite high; and
- The market for soil amendment products in Iqaluit and the surrounding areas would be limited.

The costs associated with leachate treatment may impact other design areas for the project. Therefore, project revenue and costs cannot be held constant, allowing for a return on investment calculation on leachate treatment methods. As result, revenue generation was not considered as part of the financial evaluation of alternatives for leachate treatment.

1.3.4 Construction and Operational Financial Risk

With any wastewater treatment system, there are risks associated with capital construction and short-/long-term operations. This assessment considers only the financial risks or risks that could result in financial consequences related to construction and operation of the leachate treatment at the Site throughout the project lifecycle. Financial risks may alter the total cost of the project throughout its lifecycle. It is desirable to minimize financial risk associated with the project.

Table 4 provides an outline of the risk likelihood criteria for scoring. Different types of risks have different likelihoods of risks. For example, an operational risk is best measured by the frequency of its expected occurrence. However, a construction or capital expenditure risk is better measured by the probability or likelihood of occurrence.

Table 4: Likelihood of Risks

Score	Descriptor	Probability	Frequency	Likelihood
1	Remote	0% - ≤ 20%	May occur less than once in 35 years	May happen in only exceptional circumstances
2	Unlikely	> 20% - ≤ 40%	May occur once in 25 to 35 years	Could happen sometimes, but not likely
3	Possible	> 40% - ≤ 60%	May occur once in 15 to 25 years	Might occur
4	Likely	> 60% - ≤ 80%	May occur once in 5 to 15 years	Likely to occur
5	Almost Certain to Occur	> 80% - ≤ 100%	May occur once in 1 to 5 years	Expected to occur

Table 5 provides a summary of the magnitude of risks. Different types of risks are best measured by different parameters. As result, financial risks are broken down into operational and capital losses. Financial risk is the only parameter considered for the magnitude of risks in this case. However, interruption of activities or non-compliances have financial consequences for the Site such as fines or lost revenue. All risks are classified as either operational or capital risks. Capital risks include major replacements expected throughout the lifecycle of the facility.

Table 5: Magnitude of Risks

Score	Descriptor	Financial Loss (Capital)	Financial Loss (Operational)
1	Low	≤ $ 200K	≤ $ 2K
2	Moderate	>$ 200K - ≤ $1.5M	>$ 2K - ≤ $15K
3	Significant	>$1.5M - ≤ $5M	>$15K - ≤ $50K
4	Serious	>$5M - ≤ $10M	>$50K - ≤ $100K
5	Severe	> $10M	> $100K

Leachate treatment risks are summarized in **Table6**, using the scoring criteria outlined in **Table 4** and **Table 5**. Individual risks are scored by multiplying the likelihood by the magnitude – called individual risk score. The total risk score for each alternative is tabulated by summing the individual risk scores for each risk. For each alternative, a minimum total risk score and a maximum total risk score are tabulated. The minimum total risk score is equal to the number of risks multiplied by the minimum possible individual risk score, which is “1”. The minimum total risk scores for each alternative are:

- **Aerated Lagoon and WTA**: 7 (7 risks, and minimum individual risk score of 1);
- **Pre- treatment and haul to the City’s WWTP**: 5 (5 risks, and minimum individual risk score of 1); and
- **On-site mechanical treatment**: 5 (5 risks, and minimum individual risk score of 1).

The maximum possible total risk score is equal to the number of risks multiplied by the maximum individual risk score, which is “25”. The individual maximums for each risk are:

- **Aerated Lagoon and WTA**: 175 (7 risks, and maximum individual risk score of 25);
- **Pre- treatment and haul to the City’s WWTP**: 125 (5 risks, and maximum individual risk score of 25); and
- **On-site mechanical treatment**: 125 (5 risks, and maximum individual risk score of 25).

Using the range of potential risk scores established for each alternative, a qualitative descriptor of risk is used for each alternative. These descriptors are low, low-medium, medium, medium-high and high. Qualitative classifications are based on quintiles identified in the ranges. For example, risks scores in the lowest quintile are classified as low risk.

Based on the risk scoring criteria outlined above, points will be allocated for the financial risk component of the triple bottom line assessment. Allocated points correspond with the qualitative descriptions where lower risk is identified, as preferable. For example, a low risk alternative would be allocated the maximum score of 5 points.

Table 6: Construction and Operation Risks associated with Leachate Treatment

Option	Risk	Risk Type	Likelihood	Magnitude	Description	Score
Aerated Lagoon and WTA	Availability of raw construction materials (engineered liner, suitable gravels)	Capital	3	2	Certain materials required for construction may not be available or difficult to find in the area. The inability to find suitable materials in the local area may increase capital costs associated with construction. It is possible these materials are located in the area; therefore, it is expected materials will need to be procured from other regions.	**6**
	Availability of suitable contractors	Capital	2	2	Finding suitable contractors for this type of specialized project may require a search beyond the local area, which could moderately increase the financial costs of construction. While it is possible these contractors may not be available, it is unlikely to happen.	**4**
	Ability to encourage and sustain suitable plant growth in the WTA	Operation	4	4	The performance of plant growth can be difficult to accurately predict. It is estimated that it would take at least 3 to 4 years for plant growth to be at a level where treatment performance would be accepted. This may result in levels of service interruption which could have serious financial consequences including stalled operations, and non-compliance fines or litigation. It is anticipated this is likely to occur at some point in the project lifecycle.	**16**
	Ability to find suitable terrain/constructability around existing contours	Capital	3	1	Inability to find suitable terrain for construction may result in revisions to studies and project planning to revise the design of the project to consider an alternative leachate treatment system. If this alternative is pursued, it will remain possible that the terrain is not suitable. If the terrain is not suitable, additional engineering costs would be required to design a new treatment alternative.	**3**
	Difficulty in managing phases/expansions of treatment system to accommodate landfill growth	Capital	3	2	Based on the size of the leachate treatment footprint and other physical constraints at the Site, it is possible the management of leachate will result in larger than expected financial costs associated with phasing and expansion. Moderate consequences, including capital costs and non-compliance, may result from these issues.	**6**
	Ability to consistently meet wastewater discharge parameters	Operation	5	4	While lagoons and WTA have a long history in treating municipal wastewaters across northern and southern Canada, their track record related to industrial or leachate treatment is very limited. Constituents in the raw leachate (e.g., metals, salinity, ammonia) may inhibit plant growth and significantly hinder performance. It is likely the aerated lagoon would experience these consequences once every 1 to 5 years. Non-compliance would be a major regulatory breach and would be likely to result in ligation or major service interruption. These breaches could result in fines and other legal costs impacting the operation of the Site.	**16**
	Ability to identify a central point of compliance and satisfy regulators, acknowledging nature of land treatment	Operation	2	2	Aerated lagoon and WTAs in the north have issues identifying a central point for monitoring the compliance of effluent from the Site. It is unlikely this would occur and would only result in minor non-compliance issues. The non-compliance issues may have a negative impact on operations leading to moderate financial losses	**4**
Pre-treatment and Hauling to the City's WWTP	Availability of raw materials	Capital	4	2	Certain materials required for construction may not be available or difficult to find in the area. The inability to find suitable materials in the local area may increase capital costs associated with construction. It is likely there will be additional costs associated with the availability of raw materials and this could result in moderate additional financial costs.	**8**
	Availability of suitable contractors	Capital	3	2	Finding suitable contractors for this type of specialized project may require a search beyond the local area, which could increase the financial costs of construction. The availability of these contractors within the expected costs for the project is possible and the magnitude could be moderate additional financial costs.	**6**
	Difficulty in managing phases/expansions of treatment system to accommodate landfill growth	Capital	3	2	Significant capital costs may be associated with difficulty managing the expansion of the WWTP, as it is expected the City's current WWTP will need major upgrades during the project lifecycle based on population growth projections. It is possible this will result in financial costs, which would be classified as moderate.	**6**
	Requires that City WWTP is willing/able to accept leachate over the life of the landfill	Operation	3	5	The City's WWTP may not be willing to accept leachate. This would create an immediate disruption to landfill operations, and likely carry with it serious capital and regulatory issues. It is possible this would occur, and it will result in significant financial costs associated with stalled operations and operational costs.	**15**
	Availability of annual chemical supply/shipment	Operation	3	5	Pre-treatment will require some type of chemical treatment. These chemicals will need to be shipped to the Site and stockpiled for annual use. If the chemical supply was ever interrupted, treatment would not meet requirements. It is possible this would occur based on transport within the region. If this occurs, the service interruption would be likely to exceed one month, which carries financial consequences including potential regulatory issues and operational costs.	**15**

Option	Risk	Risk Type	Likelihood	Magnitude	Description	Score
On-Site Mechanical Treatment	Availability of raw materials	Capital	3	2	Certain materials required for construction may not be available or difficult to find in the area. The inability to find suitable materials in the local area may increase capital costs associated with construction. It is possible these materials will not be located within the expected cost limitations for the project. Additional costs would be anticipated to be moderate.	**6**
	Availability of suitable contractors	Capital	4	2	Finding suitable contractors for this type of specialized project may require a search beyond the local area, which could increase the financial costs of construction. The availability of these contractors within the expected costs for the project is possible and the magnitude could be moderate additional costs.	**8**
	Optimizing treatment process for short-term (summer) operation	Operation	3	5	As part of the full on-site treatment process, some level of biological treatment is anticipated. It can take time (days to months) to establish suitable biomass that will achieve the desired treatment performance. Depending on the process, this may be difficult in the Nunavut climate. It is possible suitable biomass may not be established. If it is not established, the result will be serious non-compliance and associated financial costs.	**15**
	Difficulty in managing phases/expansions of treatment system to accommodate landfill growth	Capital	3	2	Significant capital costs may be associated with difficulty managing the expansion of the WWTP at the Site, as the mechanical treatment plant will require various upgrades and expansions at significant capital costs. These changes may alter the lifecycle capital cost. Based on the scale and nature of the plant, the operational burden is likely to be moderate, if the expansion is managed incorrectly.	**6**
	Availability of annual chemical supply/shipment	Operation	3	5	Pre-treatment will require some type of chemical addition. These chemicals will need to be shipped to the Site and stockpiled for annual use. If the chemical supply was ever interrupted, treatment would not meet requirements. It is possible this would occur based on transport within the region. If this occurs, the service interruption would be likely to exceed one month, which carries financial consequences.	**15**

Based on **Table 6**, each leachate treatment alternative would result in financial risk associated with construction and operation of the Site. The risk scores and their associated ranges include:

- **Aerated Lagoon and WTA**: 60 (range of 1 - 175);
- **Pre- treatment and haul to the City's WWTP**: 50 (range of 1 - 125); and
- **On-site mechanical treatment**: 50 (range of 1 - 125).

As result, all alternatives are determined to have low to medium risk. The aerated lagoon and WTA alternative has the most risks associated with it but these tend to have lower individual risks cores. While the pre-treatment and haul to the City's WWTP alternative and on-site mechanical treatment alternative have fewer risks, they have higher individual risk scores.

1.3.5 Summary of Financial Costs

Table 7 presents a summary of the financial costs and risks associated with the project. The aerated lagoon and WTA alternative is financially preferable, as costs are approximately one third and one quarter of the cost of the pre-treatment and haul to the City's WWTP alternative and on-site mechanical alternative, respectively. All alternatives are anticipated to carry low to medium financial risk.

Table 7: Summary of Financial Costs and Benefits

Criteria	Aerated Lagoon and WTA	Utilizing the existing City WWTP	Mechanical Treatment Plant at the Landfill
Construction Cost ($ million)	3.44	2.18	4.85
Operation Cost ($ million)	20.99	72.98	95.97
Total Cost	24.43	75.16	100.82
Financial Score (out of 25)	25	8.1	6.1
Risk Classification	Low to medium	Low to medium	Low to medium
Risk Score (out of 5)	4	4	4
Total Financial Score (out of 30)	29	12	10

Note:

1. The financial score is equal to the lowest cost alternative over the cost of the alternative multiplied by the number of available points (25). Therefore, the alternative with the lowest financial cost score 25 points and all other scores are relative to that. The remaining 5 points are awarded based on the project's financial risk.

2. Scores were round to the nearest whole number.

1.4 Environmental

The leachate treatment alternatives will have differing environmental impacts. Areas in which the leachate alternative may impact the environment include:

- Materials;
- Energy;
- Water;
- Biodiversity;

- Emissions; and
- Transport.

The potential impacts to environmental factors based the leachate treatment method are provided below.

1.4.1 Materials

Environmental impacts related to materials used in each of the treatment alternatives considered:

- Depletion of natural resources (e.g., quantity of new materials required for construction and operation); and
- Impacts of these materials on environment (e.g., hazardous nature of materials, emissions, potential for spills).

Environmental impacts related to materials were evaluated out of a possible three points. The materials considered are categorized into chemical and physical materials, including those required to treat the leachate and those required to construct treatment plants and retention structures on-site. Two points were allocated to chemical materials and one to physical materials.

Chemical materials refer to any manufactured chemicals used during treatment of leachate or effluent. The aerated lagoon and WTA alternative does not require chemicals to treat leachate, as this method makes use of natural biological activity to treat leachate to acceptable levels for discharge into the environment. In order to prepare leachate to be transported to the WWTP, as in the pre-treatment and haul to the City's WWTP alternative, both physical and chemical treatment of the leachate is required. The risk to environmental and natural systems includes leaking of treatment chemicals into downstream surface environments and groundwater systems. Surface water on the Site is transported into a stream that flows into Carney Creak and an unnamed lake, just west of the Site. The Site and its environs are home to several species of wildlife, including arctic char and lemming, which are a major food source for arctic predators. A leak of treatment chemicals could travel overland and potentially into subsurface channels, negatively impacting humans, plants and wildlife utilizing the Site.

Physical materials considerations should include construction requirements for each of the alternatives. In the aerated lagoon and WTA alternative, the treatment lagoon will need to be lined with either compacted clay, geosynthetic liner (bentonite-infused fabric), or geomembrane (HDPE) materials and then populated with natural plant life capable of removing contaminants from incoming leachate. Although HDPE is a fossil-fuel derivative with a high embodied energy coefficient, it is designed to be long-lasting and should not need to be replaced for the lifetime of the lagoon. The construction of a treatment plant - either the pre-treatment and haul to the City's WWTP alternative or the on-site mechanical treatment alternative, would require the use and transportation of all materials normally associated with building construction.

1.4.2 Energy

Energy use for each of the leachate treatment alternatives are evaluated based on electricity and fuel use. A total of 5 points is allocated to energy considerations. This is an important metric for the City; electricity costs in Nunavut are the highest in the country and fuel is imported from neighbouring provinces during certain times of the year, when roads are usable. Efficiency and low energy use are of a high priority under these conditions. Based on the design stage, qualitative estimates of energy consumption were used. Energy use was considered relative to other options, as the purpose of the assessment is to compare alternatives relative to each other.

The aerated lagoon and WTA alternative would require the least amount of energy consumption. This plan consists of pumping systems to move leachate from the landfill to the lagoon, and from the lagoon to the wetland downstream, as well as an aeration system for the lagoon (and possibly wetland). The equipment required for both the pumping system and the aeration system consume minimal electricity compared to more complex systems (i.e., the other two treatment options). For reference, a lagoon would use less energy daily than a typical household.

In the pre-treatment and haul to the City's WWTP alternative, pre-treatment requires both physical and biochemical treatment. Leachate would need to be pumped from the landfill into the treatment facility, moved around within the facility to different forms of treatment and then pumped into retention structures awaiting transportation to the City's WWTP. The pumping and treatment systems (depending on the types of systems selected) may consume as much electricity as a typical household in a day. However, as personnel would be required to run the pre-treatment site, the building will require space heating, using diesel fuel.

For the on-site mechanical treatment alternative, the complexity of the multiple processes would result in higher electricity consumption levels than either of the other two alternatives. Systems needed for operating the plant include pumps, blowers, control systems, gear boxes, motors, etc. Additionally, this building would be regularly staffed during the summer months and possible shoulder months; therefore, would consume fuel to maintain reasonable interior temperature conditions (likely higher fuel consumption than the smaller pre-treatment facility).

1.4.3 Water

Water is an essential natural resource that should be conserved, where appropriate. Treatment options are evaluated based on their consumption and use of water throughout the treatment cycles. A total of 3 points are available for each leachate treatment alternative.

The aerated lagoon and WTA alternative does not require the use of any additional water in treatment – precipitation and leachate is anticipated to adequately fill the lagoon. Both of the other leachate treatment alternatives are expected to require little water, in the range of about 1000 L/day (for reference, the average water use per person in Canada was 466 L/day in 2013). The water will be used as part of the operation of the treatment plants for each alternative. However, for the pre-treatment and haul to the City's WWTP alternative, it is reasonable to account for water used by the haulers to clean out the trucks used for leachate transportation, which would increase total water usage for this option.

1.4.4 Biodiversity

Biodiversity, or biologic diversity, refers to the variability among species/organisms in an ecosystem, from all sources. Many interactions occur among species within an ecosystem, which all play an important role in ecosystem function; loss of biodiversity can significantly impact the ecosystem's capacity to support and promote life of all flora and fauna within. Each of the leachate treatment alternatives are scored out of 5 points for their impacts to biodiversity, which include risks to the Site's current plant and animal life (3 points), as well as potential loss of biodiversity (2 points).

Leachate is generally characterized by high chemical oxygen demand, biological oxygen demand, pH, ammonia nitrogen and heavy metals, but varies depending on landfill composition. According to a review study completed in 2018 (Bederma et al, 2019), leachate is toxic, mutagenic, genotoxic and estrogenic, even at low concentrations. It poses a risk to both humans and plants/wildlife. Additionally, some contaminants contained within leachate can bioaccumulate up the food chain, posing long-term risks to apex species.

The Site is currently home to 23 plant species and 11 wildlife species. Each treatment alternative will have a potential impact on these species in varying ways.

The aerated lagoon will require management of introduced plant life, in order to build up capacity to properly treat leachate. It is estimated that it would take at least 3 to 4 years for plant growth to be at a level where treatment performance would be accepted; however, the lagoon is not likely to fill to capacity during that period of time. The nature of developing a lagoon and wetland on-site allowss the continued diversity of plant life within this ecosystem. Although, it may require the removal of an area of approximately 2.5 ha of existing, untouched land, occupied by native plant and wildlife species in a well-established ecosystem. An additional possible risk to the environment that exists for this option is the potential for insufficiently treated effluent to overflow into the WTA, during extreme weather events.

The construction of a pre-treatment plant on-site would have a project footprint of approximately 0.5 ha, including the pre-treated leachate retention structures. Trucks would require access to retention structures and the pre-treatment site; therefore, additional road allowances may need to be constructed. All of these activities - treatment site construction, trucking, and retention structure creation and use - will have an impact to the biodiversity of the Site. In addition, potential upset conditions, such as oil and gas leaks from truck traffic, a spill of untreated leachate during transfer or from retention structures into the environment could harm existing plant and wildlife, and/or result in habitat loss or degradation.

The on-site mechanical treatment alternative would also require the construction of a treatment plant at this location. An area of approximately 0.8 ha may be required and may require external retention structures. In terms of biodiversity loss due to land disturbance, this alternative is the least impactful. Additionally, the risks of leachate leaking from the building's treatment systems are minimal and can be mitigated.

1.4.5 Emissions

1.4.5.1 Waste

Waste generation resulting from leachate treatment can be categorized into chemical waste, biological/hazardous waste and construction waste. Each is evaluated out of 1 point.

Chemical waste refers to unused or spilled chemicals required for treatment. In the lagoon treatment option, there will be no chemical usage; therefore, no chemical waste. The pre-treatment and haul to the City's WWTP alternative will involve chemical, physical and biological treatment of waste prior to hauling it to the WWTP; therefore, there is a possibility of chemical waste. The mechanical treatment plant alternative would have the highest potential chemical waste, as this alternative is the most chemical intense.

Biological/hazardous waste refers to the residual solid components of treatment (i.e., sludge) that may need to be disposed of as hazardous waste due to the chemical and biological components contained within. Sludge can often be applied to land as a soil enhancer (after being treated for bacteria like e.coli). However, with leachate treatment, when heavy metals and other inorganic chemicals are potential contaminants, this sludge would likely need to be treated as hazardous waste. Sludge would be generated through processing in all three leachate treatment alternatives, although timing and frequency of need for sludge disposal may be vastly different. For instance, lagoons need to be dredged after a certain period, as they accumulate solids. The pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative both require preliminary solids removal and primary treatment to reduce total suspended solids, generating sludge that would require safe disposal. The frequency of need for solid waste disposal from both treatment facilities would be similar, as sludge is developed during the first stage of treatment.

As a result of construction of either the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative, construction waste would be generated on-site. The larger the structure, the more construction waste is likely to be generated (depending upon the type of buildings being constructed and whether or not pre-fabrication is considered).

1.4.5.2 Water

Water emissions refer to the quantity and quality of treated leachate discharged into the local environment from on-site activities. Contaminants within untreated leachate can be toxic to living organisms and cause long-term damage to ecosystems.

Natural discharge and dispersion are the methods of release for treated leachate from the lagoon and WTA alternative. No on-site water discharge is anticipated for the pre-treatment and haul to the City's WWTP alternative; treated leachate is discharged with the City's treated wastewater. The on-site mechanical treatment alternative involves treated water discharge, in line with best practice through natural dispersion.

1.4.5.3 GHGs

Climate is characterized by the seasonal weather conditions of a region over an extended period of time, which can include temperature, humidity, precipitation, sunshine, cloudiness and winds. It is understood that GHG releases on a global scale from both natural processes/sources and human activities are increasing global concentrations of GHGs in the atmosphere, and they contribute to climate change. Project-based releases of GHGs, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), are typically used establish a project's contribution to climate change.

Releases of GHGs and their accumulation in the atmosphere influence global climate and may affect emission reduction targets for GHGs that have been set or are being developed federally and provincially/territorially.

An aerated lagoon and WTA has the potential for generating CH_4 (a potent GHG),emitted from the soil, as organic matter that is present in the soil and overburden decays. The potential for GHG emissions to occur from organic decay increases with increasing temperature, and given the location and cooler climate of the region, it is likely that the potential for GHG emissions is fairly mitigated due to an overall expected low rate of generation of CH_4. There would also be minor indirect GHG emissions from energy consumed in the aerators in the lagoon and associated pumping. Otherwise, this alternative does not require any substantive energy use compared to other alternatives, and apart from CH_4 generation due to organic matter decay, assuming there are no pumping needs between the lagoon and the wetland, it would be expected to have fairly minimal direct GHG emissions.

Conversely, the presence of an engineered wetland and the bacteria contained in its soils may serve to fix carbon dioxide into the soils, thereby acting as a carbon dioxide sink. However, because the CH_4 that would be generated in the wetland as a result of organic decay is a 21 times more potent GHG than the carbon dioxide the wetland might absorb/fix, it is likely that an aerated lagoon and WTA alternative would be a net emitter of GHG, as opposed to a net GHG sink.

The pre-treatment and haul to the City's WWTP alternative would require additional electrical consumption due to the presence of a pre-treatment plant; hence, increase indirect GHG from energy use, as compared to other alternatives.

The on-site mechanical treatment alternative would require additional electrical consumption beyond that required for the other two alternatives (given the likely size and complexity of the mechanical plant process); hence, increase indirect GHGs from energy use, as compared to other alternatives. In addition, potential fugitive emissions of GHGs such as CH_4 may occur from organic matter in the treatment process itself.

1.4.5.4 Noise and Air Emissions

Air Quality

Air quality has an intrinsic or natural value because the atmosphere helps maintain the health and well-being of humans, wildlife, vegetation, and other biota. Emissions from the project to the air (including odour) may cause adverse environmental effects through the various transport, dispersion, deposition, and transformation processes that occur in the atmosphere. Project effects on air quality include emissions of contaminants (including odour) to the atmosphere during construction and operation of the project, which may present a pathway for humans and biota to be exposed to air contaminants.

The Environmental Guideline for Ambient Air Quality issued by the Government of Nunavut Department of Environment set standards for the maximum permissible concentrations for five air pollutants, namely: total suspended particulate (TSP), fine particulate matter, sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and ozone (O_3).

Given the passive nature of the treatment process used by the aerated lagoon and WTA alternative, this alternative is expected to produce limited on-site emissions of the regulated air contaminants. Minor direct and indirect emissions of air contaminants would be expected as a result of energy use in the aerators for the lagoon.

The pre-treatment and haul to the City's WWTP alternative would require additional electrical consumption to operate the pre-treatment plant. Therefore, indirect emissions would arise from this energy use.

The third alternative of an on-site mechanical treatment plant would require additional electrical consumption that presumably exceeds that of the other alternatives given the larger size and likely complexity of the treatment process; hence, indirect emissions arising from this energy use.

Odour

Odour is another consideration with respect to air quality. Odour can be related to a variety of factors, sources and compounds. Odour is not necessarily related to one specific compound (and often is not or cannot be addressed from a regulatory or health limit basis for a specific compound). Its effect is relative to an individual's perceptible limit and tolerances, and because of this inherent subjectivity, odour is therefore more frequently treated as a nuisance issue. There is potential for odour for each potential treatment alternative, and odour generation and detection may vary depending on the process and/or meteorological conditions. There is potential for odour to be perceived at locations beyond the facility property during specific meteorological conditions, for any alternative.

For the aerated lagoon and WTA alternative, there are typically two primary compounds that contribute to odour as a result of fugitive gas releases from wetlands: reduced sulphur compounds and CH_4 (both from organic decay processes). Like with GHGs, the potential for odour emissions to occur from organic decay increases with increasing temperature, and given the location and cooler climate of the region, it is likely that the potential for odour emissions is fairly mitigated due to an overall expected low rate of generation of odourous compounds. Recreational use is primarily to the west and southwest of the Site, and since the dominant wind direction is from the northwest, the potential for odour to affect the enjoyment of recreational activities in the area is further reduced due to a lack of receptors in the prevailing downwind direction from the Site.

For the pre-treatment and haul to the City's WWTP alternative, odours potentially arising from the treatment of leachate from the Landfill would not be expected to be distinguishable from odours generated by the treatment of other wastes at the WWTP. There is potential for odour emissions from pre-treatment at the Site; however, the potential for odour emissions increases with increasing temperature, and given the cooler climate of the region, it is anticipated that the probability of significant odour incidents is low.

The third alternative of an on-site mechanical treatment plant at the landfill would have the potential for fugitive emissions; hence, odours from the treatment process itself. The dominant wind direction is from the northwest; therefore, receptors to the southwest would have a higher potential to experience odours more frequently, if odours were present. Recreational use is primarily to the west and southwest of the Site; as such, the potential for odour to impact the enjoyment of recreational activities in the area is further reduced due to a lack of receptors in the prevailing downwind direction from the Site.

Noise

The type, frequency, intensity and duration of noise (unwanted sound) all contribute to the effect on a recipient in the outdoor environment. For certain industrial processes that generate significant noise, it may be treated as a health and safety issue in close proximity to these operations. In the surrounding environment, noise is often treated as a nuisance issue. There are no regulatory criteria established for noise by the Government of Nunavut.

For the aerated lagoon and WTA alternative, there is potential for noise from the aeration at the lagoon, as well as from pumping; however, it is not anticipated to be significant nor perceived as a nuisance effect on the enjoyment of nearby recreational areas. Given the passive nature of a wetland, a WTA is not expected to have any substantive sources of noise.

For the pre-treatment and haul to the City's WWTP alternative, there is potential for noise from the pre-treatment process on-site; however, it is not anticipated to be significant nor perceived as a nuisance effect on the enjoyment of nearby recreational areas.

The third alternative of an on-site mechanical treatment plant at the landfill has the potential for noise from various parts of the process; however, it is not anticipated to be significant nor perceived as a nuisance effect on the enjoyment of nearby recreational areas.

1.4.6 Transport

All three alternatives would likely have GHG, air contaminant and noise emissions associated with transporting goods and service providers to the Site, including depending on the alternative, raw materials, prefabricated structures, contractors, machinery and supplies.

The pre-treatment and haul to the City's WWTP alternative will result in increased trucking traffic; therefore, an increase in direct GHG emissions. The GHG emissions arising from trucking activity would be expected to far exceed GHG emissions from any other alternative. This alternative will result in increased trucking traffic; therefore, an increase in direct emissions of air contaminants from fuel combustion. Powering the pre-treatment process would result in indirect emissions of regulated air contaminants. The increased trucking traffic would result in increased noise associated with vehicle traffic along the haul route.

During operation, no transport is required for the aerated lagoon and WTA alternative, nor the on-site mechanical treatment.

1.4.7 Summary of Environmental Impacts

Table 8 presents a summary of the environmental impacts. These costs and benefits include:

- **Materials**
  - The use of chemicals for leachate treatment at the Site is apparent in the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical alternative. Chemical leakage has the potential to harm humans, plants and wildlife near the Site. Therefore, the pre-treatment and haul to the City's WWTP alternative is allocated zero (0) points. As the aerated lagoon and WTA alternative and the on-site mechanical treatment option have no chemicals or easily mitigated chemical risks, they are allocated 2 points.
  - The aerated lagoon and WTA alternative is allocated 1 point, as the physical materials associated with the leachate materials may be derived from fossil fuels but are durable throughout the lifecycle of the Site. The pre-treatment and haul to the City's WWTP

alternative and the on-site mechanical treatment alternative will produce a significant amount of construction waste, and as result, are allocated zero (0) points.

- **Energy** – The aerated lagoon and WTA alternative is anticipated to use the least electricity, less than a typical household daily. As result, this alternative is allocated 5 points. The pre-treatment and haul to the City's WWTP alternative is likely to consume electricity similar to a typical household. As result, 3 points are allocated to this alternative. The on-site mechanical treatment is allocated 1 point, as it is likely to consume the most energy.
- **Water**– Both the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative would require water approximately equivalent to two days of use for the average Canadian. Additional water would be used to in the pre-treatment process to clean the haul trucks. As result, this option is allocated 1 point, while the full treatment plant is allocated 2 points. No additional water is required for the aerated lagoon and WTA option. Therefore, the maximum 3 points is allocated to this alternative.
- **Biodiversity** – The aerated lagoon and WTA is allocated 2 points for biodiversity, as it will support continued diversity of plant life on-site. However, some biodiversity loss will also occur as an area of approximately 2.5 ha of the Site is disturbed from use by native plants and wildlife. The pre-treatment and haul to the City's WWTP alternative treatment site construction will have some biodiversity loss as an area of approximately 0.5 ha of the Site are disturbed from use by native plants and wildlife. In addition, potential for upset conditions (e.g., spills) related to trucking and retention structure may impact the biodiversity of the Site. Due to the risks to the Site's biodiversity associated with these activities, the pre-treatment and haul to the City's WWTP alternative has been allocated 2 points. The on-site mechanical treatment alternative is allocated 4 points, as it is anticipated to be least impactful to biodiversity.
- **Emissions, Waste and Effluent**
    - Each type of waste (chemical waste, biological/hazardous waste, and construction waste) may occur depending on the leachate treatment alternative. The aerated lagoon and WTA alternative is allocated 2 points, as it may result in biological/hazardous waste in the form of sludge. The pre-treatment and haul to the City's WWTP alternative is allocated zero (0) points, as it may result in chemical, biological/hazardous waste and construction waste. The on-site mechanical treatment alternative is allocated zero (0) points, as it may result in chemical, biological/hazardous waste and construction.
    - Four (4) points are allocated to the water discharge associated with the aerated lagoon and WTA, as there is a small risk of insufficiently treated leachate being released accidentally during extreme weather events. The maximum 5 points are allocated to the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative, as water discharged is fully treated and safe for release.
    - Emissions of GHGs are associated with all three alternatives. The aerated lagoon and WTA would be a net carbon emitter but its emissions are anticipated to be less than the other alternatives. Therefore, it is allocated 3 points. The pre-treatment and haul to the City's WWTP alternative would result in emissions associated with electricity

consumption and is allocated 2 points. The on-site mechanical treatment alternative would result in the most emissions associated with electricity consumption and treatment of organic materials. This alternative is allocated 1 point.

- Noise and air emissions are associated with all three alternatives. The aerated lagoon and WTA is expected to have minimal noise, air contaminant and odour emissions. As result, this alternative is allocated 4 points. Noise and air contaminant emissions would result from the operation of the pre-treatment plant or the on-site mechanical treatment plant. The mechanical treatment plant may also have odour emissions. As result, the pre-treatment and haul to the City's WWTP alternative and the on-site mechanical treatment alternative is allocated 3 and 2 points, respectively.

- **Transport** – The transportation of the goods and services for constructing the leachate treatment methods at the Site would result in GHG, air contaminant and noise emissions. Transportation is only required during operations for the pre-treatment and hauling to the City's WWTP alternative. Therefore, 2 points are allocated to the pre-treatment and hauling to the City's WWTP alternative. As no transportation is associated with the operation of the other alternatives, they are allocated 4 points.

Based on the environmental criteria, the aerated lagoon and WTA alternative is most preferred by a wide margin (9 points). With the exception of biodiversity, this alternative is the most preferred for all environmental criteria. In the case of biodiversity, the aerated lagoon and WTA alternative is second most preferred. These results are carried forward to **Section 1.6**.

Table 8: Summary of Environmental Costs and Benefits

Criteria	Lagoon and WTA	Utilizing the existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Materials (out of 3)	3	0	2
Energy (out of 5)	5	3	1
Water (out of 3)	3	1	2
Biodiversity (out of 5)	2	2	4
Emissions, effluent, waste (out of 19)	13	10	8
Transport (out of 5)	4	2	4
Total Environmental Score (out of 40)	30	18	21

1.5 Socio-economic

The leachate treatment alternatives have differing socio-economic impacts. Potentially effected socio-economic conditions include:

- Socio-community;
- Land uses;
- Local economy;

- Human health;
- Indigenous Rights and Interests; and
- Cultural resources.

The potential impacts to the socio-economic environment based the leachate treatment method are provided below.

1.5.1 Socio-community

Changes to the socio-community, as result of leachate treatment, is tied to the environmental changes and land use disturbances associated with the Site. While the leachate treatment is not anticipated to negatively impact the community well-being or the enjoyment of the community directly, nuisance effects may indirectly negatively impact the environmental conditions of areas surrounding the Site utilized by community members. Nuisance effects, for this assessment, are considered to be noticeable and beyond historical conditions at the Site. The assessment is anticipated to be binary. If the change is not anticipated to be noticeable and beyond historical conditions, the alternative receives a score of 1.5. A total of 6 points are available, 1.5 points for each potential nuisance identified as potentially altering community enjoyment associated with the leachate treatment alternative.

Water Quality

All three leachate treatment alternatives are not likely to result in nuisance effects on the socio-community and land users based on potential changes to water quality.

Further information on potential impacts to water quality is provided in **Sections 1.4.5.1**.

Air Quality

Given the passive nature of the treatment process used by an aerated lagoon and WTA, this alternative is not expected to have any substantive on-site emissions of the regulated air contaminants. The pre-treatment and haul to the City's WWTP alternative will result in increased trucking traffic; therefore, an increase in direct emissions of air contaminants from fuel combustion. Air quality is not expected to be a nuisance regardless of leachate treatment method.

Further information on air quality is provided in **Sections 1.4.5** and **1.4.6**.

Odour

For the aerated lagoon and WTA alternative, it is likely that the potential for odour emissions due to organic decay is fairly mitigated due to cooler temperatures and an overall expected low rate of generation of odourous compounds. For the pre-treatment and haul to the City's WWTP alternative, there is potential for odour emissions from pre-treatment at the Site. However, it is anticipated that the probability of significant odour incidents is low. The on-site mechanical alternative would have the potential for fugitive emissions; hence, odours from the treatment process itself.

For all alternatives, the dominant wind direction is from the northwest; therefore, receptors to the southwest would have a higher potential to experience more frequently, if odours were present. Recreational use is primarily to the west and southwest of the Site; as such, the potential for odour to affect the enjoyment of recreational activities in the area is further reduced due to a lack of receptors in the prevailing downwind direction from the Site.

Further information on odour is provided in **Sections 1.4.5**.

Noise

For the aerated lagoon and WTA alternative, there is potential for noise from the aeration at the lagoon, as well as from pumping. The pre-treatment and haul to the City's WWTP alternative will result in increased trucking traffic; therefore, an increase noise associated with increased vehicle traffic along the haul route. There is potential for noise from the pre-treatment process on-site. The on-site mechanical treatment alternative has the potential for noise from various parts of the process. In all cases, it is not anticipated to be significant nor perceived as a nuisance effect on the enjoyment of nearby recreational areas.

Further information on noise is provided in **Sections 1.4.5** and **1.4.6**.

Summary

Each alternative is anticipated to result in varying nuisance effects for community members due to anticipated changes in environmental conditions associated with leachate treatment. Changes to environmental conditions are unlikely to be perceived by community members and are not anticipated impact the enjoyment of the use of lands near the Site for various activities. The exception is odour, which may have an impact to land users and community members.

1.5.2 Land Uses

Changes to land use are associated with the physical project footprint of the leachate treatment method and the visual nuisance effects associated with the treatment method. These changes are likely to influence land users. Land uses in the project area are defined by four separate anticipated changes to the land use environment, which may change as result of the preferred leachate treatment method: protected areas, recreation, industry and visual changes. Each of these four changes has 2 points associated with it. The magnitude of anticipated effect associated with each alternative is reflected in the scoring with lower impact magnitudes being desirable.

Protected Areas

Three designated and protected areas overlap or are in proximity to the Site according to the EXP report (2018). These include an arctic char area of abundance, a water management area and Sylvia Grinnell Territorial Park. These areas were identified as Valued Socio-Economic Components for the Site. The leachate treatment alternative has the potential to impact these land uses.

Arctic char areas of abundance are identified by the Department of Fisheries and Oceans where arctic char are commonly found (EXP 2018). Char are an anadromous species; therefore, these areas include marine areas and adjacent fresh water rivers and streams. Arctic char are known to migrate up the Sylvia Grinnell River to spawn within the river and connecting inland lakes (EXP 2018). Leachate treatment associated with all three alternatives is unlikely to impact water areas used for spawning by arctic char.

The Site falls within the Frobisher Bay water management area (EXP 2018). Water management areas correspond with watersheds in Nunavut. These areas are expected to be an important component of future generations because of the inter-connectivity between land and water throughout Nunavut (EXP 2018). The leachate treatment method is not anticipated to alter water management within the Frobisher Bay water management area.

Sylvia Grinnell Territorial Park is located 2 km west of Site (EXP 2018). Primary features of the park include recreation and cultural features (Travel Nunavut N.d.). A variety of archaeological features exist related to settlement of the lands by a variety of cultures predated and including the Inuit. Fishing, hiking and camping are identified as common activities within the park (Travel Nunavut N.d.). Nuisance effects or disturbances from the leachate treatment alternative are not anticipated to impact the use of the land by tourists and recreationalists viewing cultural heritage sites or undertaking recreation activities.

Overall, the leachate treatment alternative is not anticipated to alter the use of protected areas. Discharge from the leachate treatment is not anticipated to have an impact on surrounding water quality. Sylvia Grinnell Territorial Park is too far west of the Site to be impacted by nuisance effects.

Recreation

EXP identified lands adjacent to the Site used for recreational use, including ski trails used by the Aniirajak Ski and Adventure Club in Iqaluit occur on the Site (EXP 2018). All three leachate treatment alternatives are likely to displace a portion of the existing trail used by the club. However, the aerated lagoon and WTA alternative is likely to displace more of the existing trail, as the trail runs through the proposed treatment area.

An unnamed lake west of the Site is used for camping and fishing by local community members (EXP 2018). A trail to the west of the Site is used by locals to access fishing and hunting areas north of the Site (EXP 2018). The Site is used for berry picking, dog walking, picnicking and camping. Campers occasionally drink water from Carney Creek south of the Site (EXP 2018). Some of these activities are likely to be displaced due to the presence of leachate treatment alternatives on the Site. Additionally, the leachate treatment alternative may alter existing access features, including an ATV trail used to access these activities (EXP 2018).

Camping was observed with a fire pit identified on the Site (EXP 2018). All three leachate treatment methods are anticipated to remove the camping area on the Site, where the fire pit was observed.

Industry

A Proposed Transportation Corridor runs through the Site to an area of high mineral potential. A Proposed Transportation Corridor is defined as a corridor through which an application to construct has been submitted but not yet approved (EXP 2018). The width of this corridor is much larger than the Site and provides the proponent the opportunity to construct their infrastructure in other areas of the corridor. According to the Draft Nunavut Land Use Plan, this corridor is still designated as a Proposed Transportation Corridor as of April 2017. No other industrial land uses or access features are identified on the site area (Government of Nunavut 2017).

Visual

An aerated lagoon would be a visual disturbance on the existing viewscape relative to existing conditions. The lagoon would have a project footprint of an estimated 2.5 ha. The lagoon would appear as a wetland and plant native plant growth would be encouraged. However, fencing and signage would surround the Site, which would reduce the natural look of the leachate treatment area.

The pre-treatment and haul to the City's WWTP alternative would have a prefabricated building, and a small holding tank or pond. The treatment plant would have a visual contrast relative to the existing landscape. The contrast would be noticeable and may present a nuisance beyond historical norms for land users in the area.

A mechanical treatment plant would represent the largest visual disturbance on the landscape, as it is most likely to be visible from the furthest distance and will be in contrast to the existing landscape. This is due to the prefabricated building, which is expected to be larger than pre-treatment building identified in the pre-treatment and haul to the City's WWTP alternative. The contrast would be noticeable and may present a nuisance beyond historical norms for land users in the area.

1.5.3 Economic

The construction and operation of a leachate treatment alternative for the project results in changes to the local economy associated with the procurement of goods and services. These benefits will take place over the course of the project lifecycle. Economic benefits will include jobs and spending directly associated with the Site that may have indirect and induced economic benefits for the community. The primary benefit would be the magnitude of the economic activity. However, additional weight is also being given to the presence of long-term opportunities associated with direct spending from the Site, including jobs and procurement. Preference is also being given to alternatives that rely on local procurement of goods and services for the construction and operation of the Site.

For all alternatives, a part-time operator is anticipated during the winter months, where leachate production is expected to be limited. This operator would be responsible for conducting routing checks of the system and preparing the selected treatment system for summer operation. During the treatment season (July to September), operator attention would increase for all three alternatives. In addition, approximately 15 days would be required for preparing and shutting down the system before and after the treatment season. Therefore, there would be a total of four months of increased operator attention.

Capital costs and labour associated with the aerated lagoon and WTA alternative are anticipated to be $3.44 million. These costs are likely to include capital and labour costs associated with earthworks and imported liner materials associated with the lagoon construction. The aerated lagoon and WTA is most likely to utilize a local contractor for construction of the lagoon and local materials in the construction. This will aid in reducing leakage from the local economy. Leachate treatment through an aerated lagoon is likely to have the least operational costs and labour required associated with the leachate treatment. Operational costs are expected to be $0.11 million (2018 dollars) annually over the 75 year lifecycle. These costs are likely to include one additional part-time operator for the summer months, fuel, maintenance and other miscellaneous costs. In addition, major capital replacements valued at $0.25 million (2018 dollars) are anticipated at years 25, 50 and 75.

Capital costs associated with the pump and hauling of leachate to the City's WWTP would initially include a pre-treatment plant, a retention structure, and vehicles for the hauling of waste. Total capital costs are anticipated to be $2.18 million. Capital costs are likely to be spent beyond the local economy, as the manufacturing required for these buildings does not take place in Iqaluit. Operational costs are likely to include the maintenance of existing equipment, chemical consumption, labour and fuel. The anticipated labour associated with pre-treatment and hauling of leachate is expected to include one full-time operator and two truck drivers during the summer months. Operational costs are anticipated to be $0.41 million (2018 dollars) annually. In addition, major capital replacements valued at $0.50 million (2018 dollars) are expected to occur in years 20, 40 and 60.

A mechanized treatment plant is anticipated to cost $4.85 million. This includes earthworks, liner, a biological treatment system, a metals treatment system, treatment building and pumping systems. Capital costs are likely to be spent beyond the local economy, as the manufacturing required for these buildings does not take place in Iqaluit. Operational costs associated with the Site would include maintenance, energy, labour and chemicals. In addition to the part-time operator during the winter months, a full-time operator will be required for the summer months. Annually, these costs are anticipated to be $0.51 million (2018 dollars). The operator required for the Site will require specialized skills and is unlikely to be found from beyond the local economy. As this is a seasonal opportunity, it is not certain the operator will permanently relocate to the area and leakage may result as the consumption from this employee could occur externally. Also, major capital replacements valued at $1.20 million (2018 dollars) are expected to occur in years 20, 40 and 60.

As described above the capital and operational costs associated with each alternative will generate economic activity within the local economy. However, the capital and operational costs will vary based on the chosen leachate treatment alternative. Each alternative has varying labour and capital requirements in all phases. Each is also likely to vary in its local content and resulting leakage associated with procuring services and materials from beyond the local economy.

1.5.4 Human Health

Impacts to human health include exposure to untreated leachate (skin/lung/eye exposure and inhalation exposure of possible emissions associated with the leachate treatment), as well as exposure to chemicals used as part of the treatment alternatives. As these two issues represent the primary human health risk associated with leachate treatment, 2 points are allocated to each, with minimizing risks to human health being considered preferable.

The risk to physical exposure of untreated leachate is similar in all treatment alternatives. In each scenario, leachate is pumped from the landfill into a receptacle (whether that is a lagoon or retention structure) and retained for a certain period of time. Human intervention is required to ensure that the pumping system is functioning properly and that the retention structures are holding up. As such, there is the risk of exposure to on-site staff if there are leaks detected. More time is required of staff to ensure proper working condition of equipment for both treatment facility alternatives, thereby increasing the small risk of exposure to untreated leachate. Risks of exposure may be elevated in the pre-treatment approach, due to transfer of leachate from the pre-treatment facility to the municipal WWTP.

Operationally, the use and storage of chemicals poses risks to human health, for those within the exposure zones. Chemical treatment is unnecessary for the lagoon and WTA alternative; therefore, this risk is limited. The pre-treatment facility will use both physical and biological/chemical treatment to prepare leachate for transport to the WWTP. In this scenario, there is a risk related to chemical exposure to staff in the facility. A slightly elevated risk exists for staff operating the full treatment plant, as treatment of leachate is more complex and requires more chemicals.

1.5.5 Indigenous Rights and Interests

Indigenous Rights and Interests may be disturbed by the preferred leachate treatment method, as it will have a physical disturbance on the land. Project lands are identified as lands used for traditional activities. As a result, the presence of leachate treatment will displace areas with the potential for traditional activities.

The physical project footprint of leachate treatment alternatives will remove lands from traditional use. The aerated lagoon and WTA alternative would have the largest project footprint of approximately 2.5 ha. The pre-treatment and haul to the City's WWTP alternative would require approximately 0.5 ha. The on-site mechanical treatment alternative would have a physical project footprint of approximately 0.8 ha.

In addition, nuisance effects near the Site may negatively impact the environmental conditions for traditional activities near the Site. Perceptions of value for these activities could be impacted by these nuisances and disturbances.

1.5.6 Cultural Resources

According to the EXP Physical and Biological Assessment for the Proposed New Landfill Site (2018), "there are no culturally designated or significant heritage features currently identified within the Site. No existing records for archaeological, paleontological or place name records occur on the Site." As a result, the leachate treatment for the project is not anticipated to result in any disruption of cultural heritage resources.

1.5.7 Summary of Socio-economic Impacts

Table 9 presents a summary of the socio-economic costs and benefits. These costs and benefits include:

- **Socio Community**
  - It is unlikely the three leachate treatment alternatives would impact water quality. The aerated lagoon and WTA alternative has the potential to impact water near the Site but it is unlikely to occur. The other alternatives will not impact water quality near the Site. Therefore, 1.5 points are allocated to each alternative.
  - No noticeable air emissions that would qualify as a nuisance are expected from any alternative considered. Therefore, 1.5 points are allocated to each alternative.
  - Odour emissions from the aerated lagoon and WTA alternative and on-site mechanical treatment alternative may be a nuisance to land users southwest of the Site. No noticeable odour emissions that would qualify as a nuisance are expected from the pre-treatment and haul to the City's WWTP alternative. Therefore, 1.5 points are only allocated to the pre-treatment and haul to the City's WWTP alternative.
  - No noticeable noise emissions that would qualify as a nuisance are expected from any alternative considered. Therefore, 1.5 points are allocated to each alternative.
- **Land Uses**
  - None of the alternatives are expected to alter protected areas so each are allocated 2 points.
  - All three alternatives are expected to remove recreation features though the aerated lagoon and WTA is expected to remove more of the existing ski trail. As result, mechanized treatment and pre-treatment and hauling to the City's WWTP receive 1 point, while the aerated lagoon and WTA receives zero (0) points.
  - All three alternatives are located within the proposed transit corridor area. However, the presence of the Site would likely remove this area as accessible for a transit corridor regardless. The corridor is wide and provides other opportunities for the proponent to locate their infrastructure. As result, all three alternatives are awarded 2 points.

    - The visual changes would be most severe in the case of a mechanical treatment plant (0) compared to an aerated lagoon (1 point) or a smaller pre-treatment plant associated with hauling leachate to the City's WWTP (1 point).
- **Economic** – Economic scoring is based on a combination of capital costs, operational spending, labour force requirements and local content. The aerated lagoon and WTA alternative is allocated 2 points, as it is most likely to use local raw materials and contractors, is likely to have some local labour, and a high capital cost. Pre-treatment and hauling to the City's WWTP receives a score of 3 points ,as it will require high operating costs and local labour for the operation of the Site. In addition, some capital costs will be associated with the pre-treatment plant. Mechanical treatment receives 2 points, as it is expected to have a high capital cost and high operations costs. However, the operator is unlikely to be locally sourced based on the skills required and little labour is required for operating the plant. Furthermore, most of significant operating costs, such as chemical and major replacements, are likely to be procured beyond the local area.
- **Human Health** – Impacts to human health include exposure to untreated leachate (skin/lung/eye exposure and inhalation exposure of possible emissions associated with the leachate treatment), as well as exposure to chemicals used as part of the treatment alternatives.
    - Exposure to untreated leachate is a baseline risk in all three of the treatment alternatives, as they all require pumping from the landfill into a retention structure. The nature of treatment for the pre-treatment alternative likely poses the highest risk of all three alternatives, due to the added transportation requirement of partially-treated leachate. Therefore, the lagoon and WTA, and the full treatment alternatives are allocated 2 points each, while the pre-treatment alternative is allocated 1 point.
    - Exposure to chemicals during treatment is a risk to those operating the treatment plants. The lagoon and WTA alterative requires no chemical treatment; therefore, it receives a score of 2 points. The pre-treatment alternative receives a score of 1 point resulting from potential chemical exposure during pre-treatment, while the full treatment alternative receives a score of zero (0) for added risk of chemical exposure due to a more operationally-intense process.
- **Indigenous Rights and Interests** – All three as are equally preferable receiving 4 points as they will remove small areas of territory used for traditional activities and one campsite that could have been used for traditional activities. As the three alternatives remove small portions of territory and only one site (which has not specifically been identified for traditional use), only 1 point is deducted from the maximum of 5 points.
- **Cultural Resources** – All alternatives are equally preferable as no cultural heritage resources are identified in the vicinity. Therefore, no cultural heritage resources will be impacted. Since no cultural heritage impacts are expected to occur, all alternatives are allocated the maximum 3 points.

The overall scoring for the socio-economic is relatively similar. Therefore, considering socio-economic factors, the pre-treatment and haul to the City's WWTP alternative would be the preferable leachate treatment alternative. However, the variance in allocated points is low (range of 3.5). The pre-treatment and haul to the City's WWTP alternative is the most preferred for all socio-economic criteria, except for human health. These results are carried forward to **Section 1.6**.

Table 9: Summary of Socio-economic Costs and Benefits

Criteria	Aerated Lagoon and WTA	Utilizing the existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Socio-community (out of 6)	4.5	6	4.5
Land Uses (out of 8)	5	6	5
Economic (out of 4)	2	3	2
Human Health (out of 4)	4	2	2
Indigenous Rights and Interests (out of 5)	4	4	4
Cultural Resources (out of 3)	3	3	3
Total Socio-economic Score (out of 30)	22.5	24	20.5

1.6 Triple Bottom Line Assessment

The Triple Bottom Line Assessment provides the assessment of the environmental, social and financial trade-offs between the three alternatives. This section arbitrates between alternatives by providing overall scores for each alternative. A shown in **Table 10**, *the aerated lagoon and WTA alternative was identified as most preferred based on the financial costs and the environmental criteria*. While this option was not the most preferred socio-economic option, the variance in socio-economic impact dependent on leachate treatment alternative is minor. Considering all criteria, the aerated lagoon and WTA alternative was most preferred for:

- Financial Cost;
- Materials;
- Energy;
- Water;
- Emissions, effluent, waste;
- Transport;
- Human health;
- Indigenous Rights and Interests; and
- Cultural resources.

Table 10: Triple Bottom Line Assessment

Criteria	Aerated Lagoon and WTA	Utilizing the existing City of Iqaluit WWTP	Mechanical Treatment Plant at the Landfill
Life Cycle Cost ($ million)	24.43	75.16	100.82
Annual Financial Benefits (30%)	29	12	10
Environmental Cost/Benefit Score (40%)	30	18	21
Socio-economic Cost/Benefit Score (30%)	22.5	24	20.5
Overall Score[1]	81.5	54	51.5

Note:

1. The overall score is the sum of the financial, environmental and socio-economic scores.

Conclusion - Dillon recommends the City use an aerated lagoon and WTA leachate treatment system for the Site based on the Triple Bottom Line Assessment for Leachate Treatment Alternatives.

References

Bank of Canada. 2019. Inflation. Available at https://www.bankofcanada.ca/core-functions/monetary-policy/inflation/. Accessed May 1, 2019.

Bederma et al, Investigating landfill leachate toxicity in vitro: A review of cell models and endpoints; Environment International; 122: Jan, 2019.

Government of Nunavut. 2017. Draft land Use Plan. Available at http://www.arcgis.com/home/webmap/viewer.html?webmap=e4c417e928794a2f95c2d4515542ebd4&extent=-180,37.2031,180,88.4809. Accessed May 1, 2019.

Statistics Canada. 2017. Iqaluit, CY [Census subdivision], Nunavut and Baffin, REG [Census division], Nunavut (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.

https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed May 2, 2019).

Sullivan, Grant. 2017. Diverging From Diesel: The True Cost of Diesel Power in the Canadian North. Available atI . Accessed May 1, 2019.

Travel Nunavut. N.d. Sylvia Grinnell territorial Park. Available at https://www.nunavuttourism.com/things-to-see-do/parks-special-places/sylvia-grinnell-territorial-park/. Accessed May 1, 2019.

Appendix E

Design and Construction Options Technical Brief

MEMO

TO: File
FROM: Dillon Consulting Limited
DATE: May 31, 2019
SUBJECT: Design and Construction Options Technical Brief
OUR FILE: 19-9543

Introduction

The City of Iqaluit (City) is in the process of implementing its Solid Waste Management Strategy to service their near and long-term (75 years) municipal solid waste (MSW) disposal requirements. Founded on a previously completed conceptual design and facility siting exercise, key elements of the project include a solid waste transfer station (WTS) within the immediate urban area of the City, where residential and commercial waste will be hauled to, processed, and compacted in bales or in the case of waste wood and cardboard, shredded and pelletized for use as a fuel source for an on-site biomass boiler. Tires, metal and some construction and demolition (C&D) wastes will also be shredded and or baled for landfilling or transported south for recycling. The resulting solid waste bales and possibly a smaller amount of unbaled C&D waste will be trucked to an engineered balefill landfill site located approximately 6 km from the WTS. The vehicles transferring the waste bales will access the road leading to the landfill site from the WTS to avoid having the transfer vehicle travel through the City.

Other planned features of the WTS include a public drop off area for household hazardous wastes (HHW) and a vehicle logger/compactor unit; in both instances allowing for the preparation of waste materials prior to shipping to approved management facilities in the south.

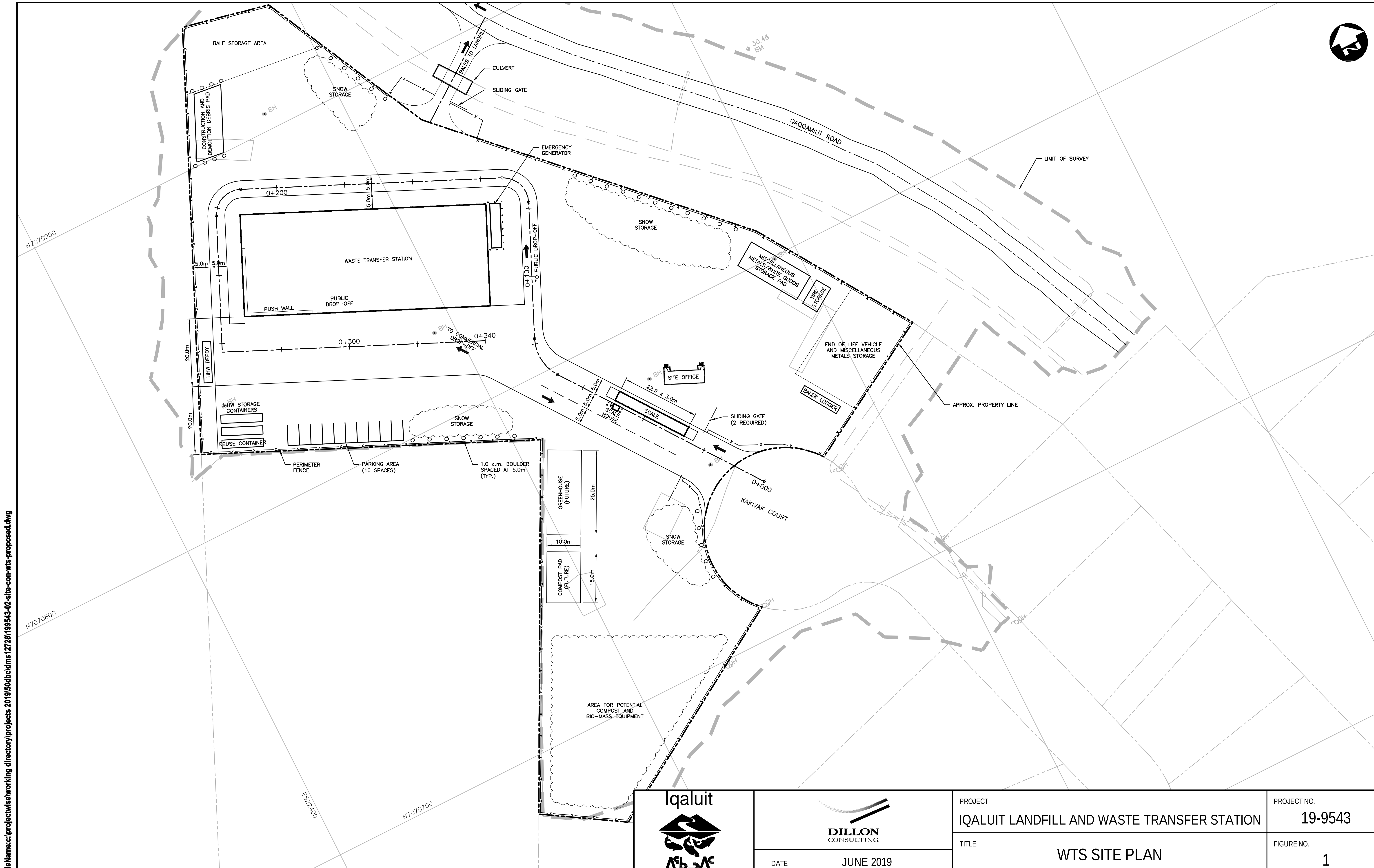
There are no specific landfill standards for MSW disposal facilities in Nunavut. The documents “Guidelines for the Planning, Design, Operations and Maintenance of Modified Solid Waste Sites in the Northwest Territories, April 2003”, “Solid Waste management for Northern and Remote Communities Planning and Technical Guidance Document, Environment and Climate Change Canada, March 2017”, and “Nunavut Solid Waste Management Plan, October 2014” have been utilized as a representative for this project.

Waste Transfer Station

The WTS will receive municipal waste from residential, commercial and institutional sources. The WTS is located off of Kakivak Court on approximately 2.2 ha of land owned by the City. Figure 1 identifies the property and the general layout of the site. Arriving municipal waste vehicles will be directed to the weight scale. Signage at the site entrance will identify acceptable and unacceptable materials, along with hours of operation, contact names and phone numbers. To control access to the site, a chain link fence will be located at the property line with two horizontal electrical gates control by a security card. The first gate will be for public usage, with the second gate providing exit and entrance for the bale haulage truck.

Depending on the material on the vehicle, visitors will be directed to one of the following:

- Tipping floor of the WTS
- Public drop off
- C&D debris pad
- Miscellaneous metals and white goods pad
- HHW depot
- Reuse depot



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DILLON CONSULTING

DATE JUNE 2019	PROJECT IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO. 19-9543
	TITLE WTS SITE PLAN	FIGURE NO. 1

Site Development

The site is currently a gravel property. Additional granular material will be placed (as required) for site development/fill, to establish elevation for the WTS building and to promote drainage. Site lighting will be provided by LED dark sky friendly compliant fixtures complete with photo cell control. The fixtures will be mounted on 6 m galvanized steel poles. The lighting will be designed to illuminate the site with an average of 10 lux.

Weigh Scale

All vehicles carrying MSW will be required to use the scale to enter the site. The portable scale will be approximately 3 m x 23 m, with a steel deck and digital load cells. The scale will be raised off of the ground approximately 500 mm to allow access under the scale. This will also require the installation of inbound and outbound asphalted ramps. For the scale to be used for commercial purposes, the scale must be calibrated to the requirements of Measurement Canada, requiring the shipment of 10 tonnes of weight. Digital load cells can be calibrated prior to shipment and checked during installation. To record transactions, a terminal and software on a computer in the scale kiosk will record the weight of the vehicle and if they have a registration number. If a tare weight is not available for a vehicle, either a fixed amount (e.g., $10.00 for 100 Kg) can be charged or the vehicle would be instructed to exist the site by travelling over the scale, where the difference in weight can be determined. The scale is not contained in a building.

Scale Kiosk

A building, raised off of the ground, will be located near the end of the scale, where the Scale House Operator could interact with all vehicles entering the site. The building, approximately 1.5 m x 2.0 m, would have windows on all four sides, such that the Operator could view incoming and outgoing vehicles. Security bars and a viewing monitor would allow the Operator to observe the tipping floor and a two-way radio to keep in contact with staff at the WTS.

The building will be serviced with a 100 amp, 120/240 VAC single phase power supply from the main distribution, located in the WTS electrical room. The service will be by direct buried teck cables. The 120/240 VAC panel board will contain circuit breakers for the building loads. Interior lighting will be LED. A dark sky friendly LED exterior fixture will be installed over the main door and controlled via an integral photocell.

Telephone and data will be provided to the building with buried telephone cable and fibre optic cable. Phone and data jacks will be located at the workstation location. A standalone security consisting of door contacts, motion detectors, entry keypad and autodialler will be installed.

Controls for red and green traffic lights located at each end of the truck scale will be provided. A remote scale display will be mounted on the exterior in view of the vehicle operator. An intercom system will be provided on the driver's side of the truck scale when exiting to enable communication between the Scale Operator and the vehicle operator.

Site Office

The site office will be remote from the WTS to minimize the potential for dust and mold to be present. The building will be approximately 4 m x 12 m, sit on a gravel pad with blocking, tie downs and ventilated skirt. The building roof panel will be 24 gauge and insulated with R-40 fiberglass batt insulation. Exterior wall panels will be 26 gauge 38 mm profile insulated with fiberglass batt insulation, and completed with vapor barrier and drywall. The floor shall be insulation with R-11 fiberglass insulation.

This building will contain the office for the Facility Supervisor, unisex barrier free washroom, locker room (nine lockers), lunchroom and maintenance closet. Heating will be electric baseboard and roof mounted cooling with LED lighting. Water and sanitary services are remote; therefore, the water supply will be a 250 gallon storage tank within the building and the heated septic tank will be located in the crawlspace.

The building will be serviced with a 100 amp, 120/208 VAC 3 phase power supply from the main distribution, located in the WTS electrical room. The service will be provided through direct buried teck cables. The 120/208 VAC panel board will contain circuit breakers for the office trailer building loads. Interior lighting will be LED. A dark sky friendly LED exterior fixture will be installed over the mandoors and controlled via an integral photocell.

Telephone and data will be provided to the building with buried telephone cable and fibre optic cable. Phone and data jacks will be located in the office and lunchroom locations. A standalone security consisting of door contacts, motion detectors, entry keypad and autodialler will be installed.

Waste Transfer Station

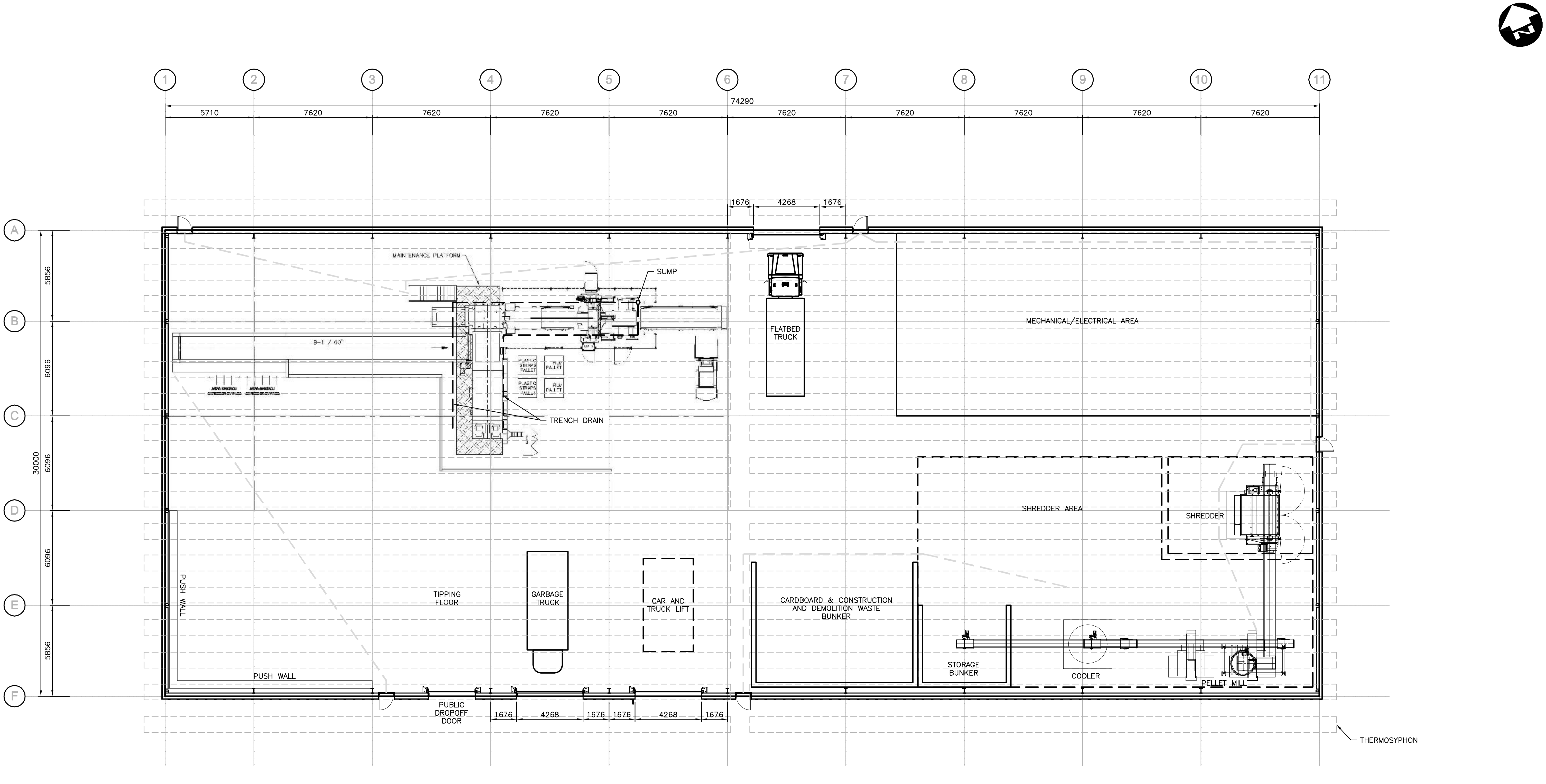
Commercial vehicles delivering MSW will exit the weigh scale, turn to the left and proceed to the tipping floor, located in the western portion of the building. The overhead door (4.3 m W x 5.2 m H), normally closed, will be raised and vehicles will back into the building to deposit the material into the tipping floor. Vehicles will then drive out of the building, turn to the right and exit the site. Private vehicles will exit the weigh scale and drive straight, circling the building. On the southern side of the building, just before the commercial overhead doors (3.0 m W x 3.0 m H) will function as public drop off, allowing the general public to exit their vehicle and place material on the tipping floor. Figure 2 depicts the WTS.

On the tipping floor, a wheel loader with a bucket thumb (approximately 110-120 Hp) will sort the material into MSW for baling, and clean wood/cardboard for shredding. Tires delivered to the site will be stockpiled near the metal storage and until a sufficient volume is achieved to be shredded.

The MSW will be placed onto the two ram baler in-feed steel belt conveyor, and the material baled and wrapped. A forklift with a material handling clamp will collect the wrapped bale and place the bale on a flatbed truck, normally parked in the building. The deck of the truck will consist of a series or angles welded to the bed of the truck, to allow the bales to be removed from the truck at the landfill by the wheel loader equipped with forklifts.

Clean C&D wood waste and cardboard will be separately stockpiled on the tipping floor. The wheel loader will remove the material from the stockpile and place the material into the in-feed hopper for the shredder.

The shredder, approximately 330 HP and a capacity of 6 tonnes/hour, will shred the material and send the shredded material to the pelletizer via a conveyor. The pelletizer will produce pellets that will be conveyed to the cooler for cooling, stockpiled, and then directed to the biomass boiler.



FLOOR PLAN
1:125

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DILLON CONSULTING

DATE JUNE 2019

PROJECT
IQALUIT LANDFILL AND WASTE TRANSFER STATION

PROJECT NO.
19-9543

TITLE
WTS BUILDING PLAN

FIGURE NO.
2

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Structural

The WTS building will be a pre-engineer rigid-frame steel building of 30.0 m x 74.3 m, with an 8.5 m eave height. The building will be gable frame. The building roof panel will be 24 gauge standing seam with galvalume finish, completed with concealed fasteners to provide a weather-tight system. The roof will be insulated with R40 semi-rigid insulation or fiberglass batt insulation, and completed with 26 gauge liner. Exterior wall panels will be 26 gauge 38 mm profile insulated with R19 semi-rigid insulation or fiberglass batt insulation, and completed with vapor barrier and 16 mm profile metal liner. Rainwater gutters and downspouts will be pre-finished with color matching the exterior wall. The building will be designed in accordance with the National Building Code 2015.

Push walls (3.5 m) will be located along the southwest corner of the building. The push walls will be designed to withstand a point load from the application of the loader, a uniform distributed load from the application of the loader and the active stockpile pressure. The design will be based on CSA-S6-14: Canadian Highway Bridge Design Code; CSA A23.3-14: Design of Concrete Structures.

The building will be supported on a concrete mat foundation, as specified in the geotechnical report , over 10 mil poly on a 150 mm extruded polystyrene insulation with maximum compressive strength of 415 kPa , thermal resistance (typical 5-year aged R value) of 0.87 per 25 mm, and maximum water absorption by volume of 0.7%. The insulation will be over 300 mm well graded granular, as specified in the geotechnical report, “City of Iqaluit Geotechnical Investigation Proposed Waste Transfer Station Lots 3586 228/17/18/20 and 3480 220 1 Iqaluit, Nunavut, October 2018.” A 100 mm layer of sand compacted to 98% Standard Proctor Modified Dry Density will be placed under the granular.

Thermosyphon

Flat loop thermosyphon evaporator will be placed within this sand layer. The thermosyphon will be designed based on the geotechnical investigation and a thermal analysis “Geothermal Modelling and Geotechnical Recommendations Transfer Station and Landfill in Iqaluit, Nunavut May 2019”, and will be designed in accordance with the CAN/CSA-S500-14: National Standard of Canada for Thermosyphon foundations for buildings in permafrost regions. According to the thermal analysis, the temperature at permafrost elevation would remain at -2 °C, after the first year of operation.

The thermosyphon will be designed to have redundancy (i.e., if one fails) so the system remains functioning. During operation, thermosyphon temperature will need to be measured to protect against leakage and that the system functions as designed.

Electrical

The main electrical service for the WTS will be located in the dedicated electrical room of the building. The service will be a 1,200 amp, 347/600 VAC 3 phase supply from the utility. The owner of the oil filled pad mounted transformer will be either the utility or the City. This will be determined by the utility during detailed design. Cost for the transformer is not carried in the 30% submission. The main switchgear will have breakers for supplying power to the other buildings on-site. Dry type transformers and 120/208 VAC panel boards will be located in the electrical room.

A diesel generator will be designed to enable the facility to continue operations in the event of a utility power failure. A 1.2MW generator located in a pre-manufactured walk-in enclosure will be located near the building. An open transition automatic transfer switch will provide automatic switching between the utility and generator. The generator will be specified with a 24 hour sub-base double walled fuel tank.

Interior lighting will be LED. Dark sky friendly LED exterior fixtures will be installed over the exterior doors and controlled via an integral photocell. A fire alarm system will monitor the sprinkler system and provide notification to the community fire station. Wiring to the fixed equipment will be installed in conduits cast into the floor slab. Lighting and other power distribution will utilize a combination of armoured teck cable and emt conduit.

Telephone and data will be provided to the building with buried telephone cable and fibre optic cable. Phone and data jacks will be located in the electrical and fire pump rooms. A standalone security consisting of door contacts, motion detectors, entry keypad and autodialler will be installed.

Mechanical

Sprinkler System
Based on the current National Building Code of Canada, the WTS building will need an automatic sprinkler system throughout as part of its fire protection. As none of the City's water mains are located near the WTS, the sprinkler system will need to have its own on-site water storage system and associated fire pump with dual power sources. The water storage tank for the sprinkler system will be located in its own fire-rated room. The fire pump will be located in this room as well, complete with back up power provided by the on-site generator. The sprinkler system will be considered a wet system charged with water throughout.

Heating System
The heating system for the WTS will consist of a combination of biomass and oil-fired hydronic boilers, as its central plant in the mechanical room. Both the biomass boiler system and the oil-fired boiler will each be sized for approximately 75% of the capacity of the building's designed heating load. The boilers will operate in a lead/lag sequence with the biomass boilers leading to fully utilize the base-loading characteristics of the biomass boilers and maximize biomass usage. The oil-fired boiler will serve as a back up boiler and to provide for peak heating loads. Hydronic supply and return lines using a glycol solution will be distributed throughout the WTS to provide heating to unit heaters and an air handling unit to heat and ventilate the WTS. The minimum heat loss for the building will be based on the following criteria:

- National Building code Climatic Design Data for the 1% January design temperature in Iqaluit of 41°C.
- Interior winter design temperature of 10°C.
- The overall thermal transmittance of the building assemblies, along with adequate infiltration rates.

The fuel source for the biomass boiler will be provided from the biomass waste stream. Waste stream cardboard, wood, and furniture will be converted into pellets by the on-site shredder and pelletizer system. It is estimated that the biomass boiler system will require approximately 200 tonnes/year of biomass pellets to provide heating to the WTS.

The fuel for the backup oil-fired boiler will be located outside in a double-walled aboveground storage tank close to the proximity of the WTS mechanical room. Fuel oil will be conveyed to the oil-fired boiler via carbon steel piping to a day-tank located inside the mechanical room. It is estimated the oil-fired boiler will require approximately 2500 US gallons/year of fuel oil to provide peak heating to the WTS.

Ventilation System

The WTS will be provided with ventilation during the occupied periods of operation. The ventilation system will be sized to help with the odour control mitigation strategies of the WTS, as well as for ventilation for internal combustion engine vehicles being operated inside the WTS, in accordance with ASHRAE 62.1 standards. Carbon monoxide and nitrogen oxide detectors will be located in the WTS and interlocked with the ventilation system. The ventilation system will consist of an air unit with hydronic preheat and reheat coils, and an exhaust system with heat/energy recovery. The hydronic heating coils will help to temper the outside air, required by code, to make up the air that is exhausted from the WTS. The heat or energy recovery system will help to recover energy lost from the air being exhausted from the WTS.

End-of-Life Vehicles / Miscellaneous Metals /White Goods

A storage area in the eastern area of the site is designated for the storage of vehicles, metals and white goods. Processing of end-of-life vehicles and removal of chlorofluorocarbons in white goods (by a certified staff member) will occur in the WTS building. Portable column lifts will be utilized to raise the vehicles for processing. A portable drip pan will be located under the vehicles to collect drippings. Collected material will be transferred to the HHW depot for bulking and disposal. When not is use, the column lifts and drip pan will be stored in the WTS.

The processed vehicles, along with miscellaneous metals and white goods, will be periodically compacted in a baler/logger vehicle (175 – 220 Hp). A baler/logger allows different metals to be compacted separately (e.g., vehicles, white goods) to maximize sale value. The bales would be stored outside or in a shipping container for transportation.

Snow Storage

Areas for the storage of snow are located throughout the site. The areas are defined by the placement of 1 m^3 boulders in front of the perimeter fence, for fence protection.

Bale Storage

While bales of MSW will be produced daily, weather conditions, staff shortages or bale truck out of service may result in bales not being able to be delivered to the landfill or stored in the WTS. A dedicated storage area is provided in the northern part of the site.

Household Hazardous Waste and Reuse

A modified 8 ft. x 40 ft. shipping container will be used as a HHW depot, with two additional shipping containers used to store HHW prior to removal from the City. Residential generated material will be accepted at the depot. Design of the facility will follow the requirements of the General Management of Hazardous Wastes (2010) and Guideline for Hazardous Waste Management, October 2017.

The HHW Depot will be serviced with a 100 amp, 120/240 VAC single phase power supply from the main distribution located in the WTS electrical room. The electrical service will be direct buried teck cables. The 120/240 VAC panel board will contain circuit breakers for the building loads. Interior lighting will be

LED. A dark sky friendly LED exterior fixture will be installed over the main door and controlled via an integral photocell.

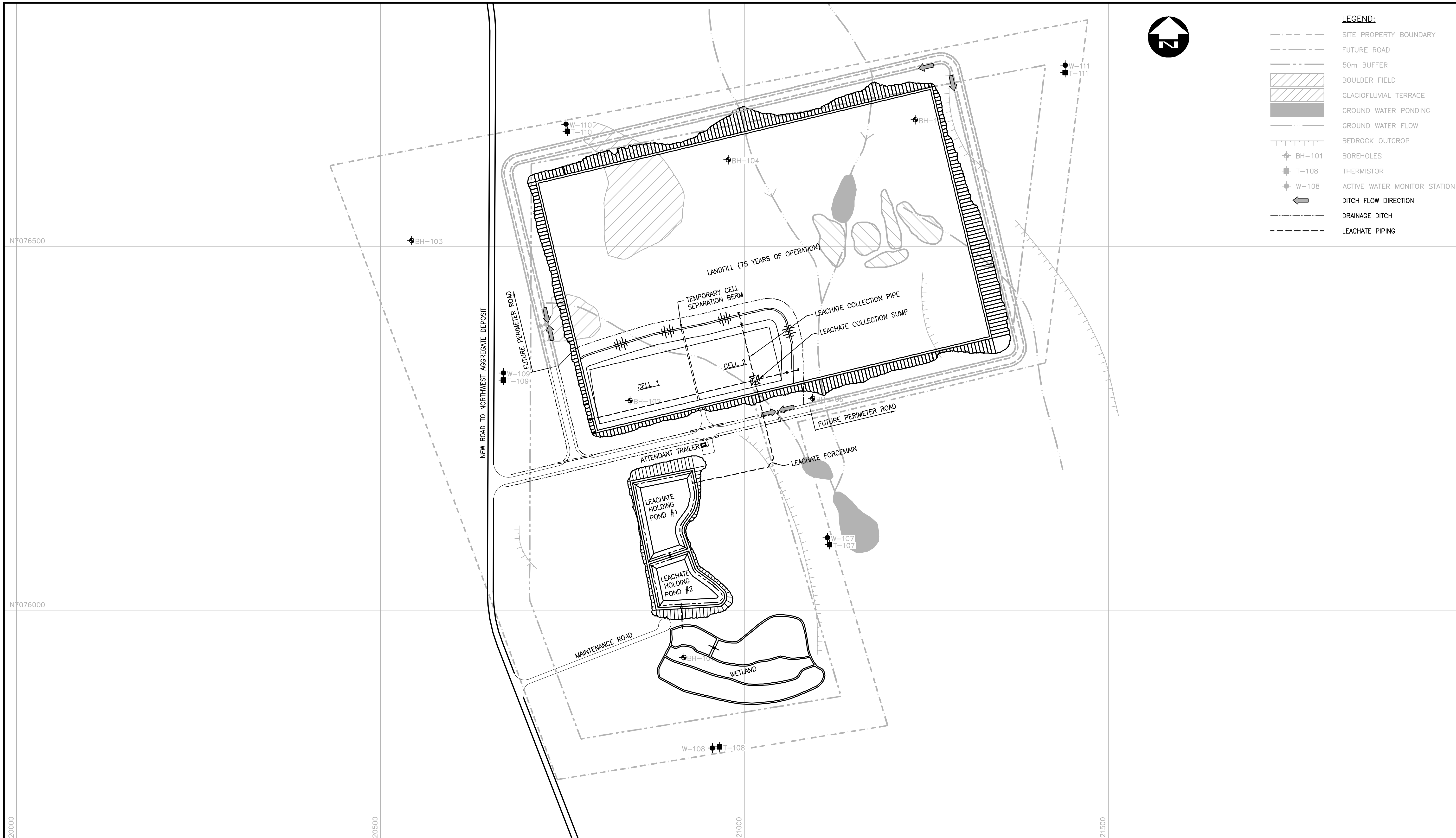
The Reuse Storage Area container will be used to store donated items include windows, doors, paint, hardware, tools, lumber, lighting fixtures, furniture and appliances. The container will not be electrically serviced but will be provided with a solar powered light, with integral photocell.

Drainage and Erosion Control

The proposed WTS is located on a formerly developed site. Construction and operations at the WTS are not expected to significantly impact existing drainage patterns. The site will be graded to drain predominately to the drainage ditch, along the eastern property boundary and Qaqqamiut Road, and to the northern boundary, along the unnamed road. Stormwater management, and erosion prevention and control will be implemented during construction and operation, in accordance with the City's and Government of Nunavut's stormwater management, and control bylaws and guidelines.

Landfill

The landfill is located on approximately 64 ha of land owned by the City, and will accept MSW and C&D debris within the same landfill and cell in the landfill. The MSW will typically be baled and wrapped in plastic. However, the design of the landfill will allow for the placement of unbaled MSW if there are operational issues at the WTS. C&D debris, potentially shredded, will be placed in the landfill to "fill in" areas as the bales are placed, as presented in Figure 3.



Iqaluit

DILLON CONSULTING

DATE JUNE 2019

PROJECT
IQALUIT LANDFILL AND WASTE TRANSFER STATION

PROJECT NO.
19-9543

TITLE
LANDFILL SITE PLAN

FIGURE NO.
3

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The “Geothermal Modelling and Geotechnical Recommendations for the Transfer Station and Landfill in Iqaluit, Nunavut, May 2019” examined the placement of baled waste in the landfill, and the time for freezing of the waste. This report identifies that two or three years after one lift of bales have been placed the soil, under the landfill will be frozen. Also, the bales will continue to freeze and by Year 5 or 6, the bales will be completely frozen.

A monitoring network is proposed between the bottom of the landfill liner and the top of the permafrost to record changes in temperature. A thermistor array, consisting of five thermistor beads on a thermistor cable, is proposed and will remain in situ for the lifetime of the landfill. Two arrays would be required to measure temperature in areas of the landfill that have received and are going to receive waste. Temperature readings will be stored in a solar powered data logger station. Cables would extend from the data logger station, and extend approximately 75 m under Cell 1 and Cell 2.

Liner System

The liner system will consist of a barrier(s) to minimize the migration of generated leachate into the environment, and a leachate collection layer placed above the barrier to intercept and transfer the leachate to a storage or treatment system.

For the landill, the following components of the proposed liner system leachate collection and transfer system are described in the following sections, from the top down. Figure 4 presents the proposed liner for the landfill, with Figure 6 illustrating the proposed liner for the leachate lagoons.

Cushion Layer

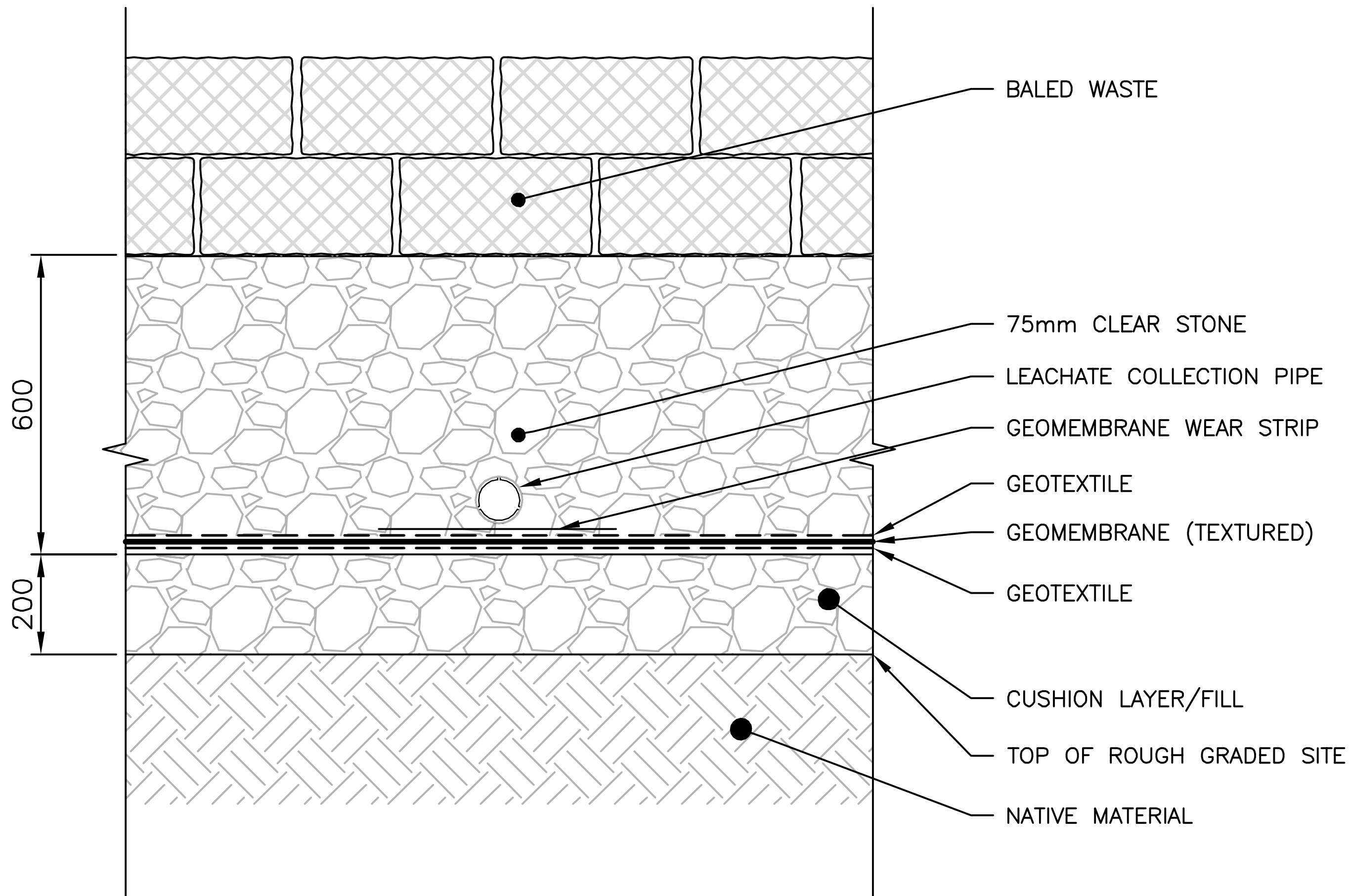
A cushion layer, 300 mm thick and composed of 75 mm clear stone with a hydraulic conductivity of at least 1 x 10^{-2} cm/sec is proposed, immediately below the baled waste. This layer protects the underlying layers of the liner system, while allowing the passage of leachate. A geotextile is not included above this layer, as the baled and wrapped waste is anticipated to mitigate the potential for MSW and C&D waste debris to migrate into the stone.

Leachate Collection Layer

The proposed leachate collection layer comprises a granular layer and piping. Its total thickness is 300 mm, with a hydraulic conductivity of at least 1 x 10^{-2} cm/sec. A geotextile is provided at the bottom of the leachate collection layer and immediately above the barrier, to protect the barrier from damage. A geotextile is not required to separate the cushion layer from the collection layer because of the compatibility of the two layers.

Leachate Collection Pipe

A network of leachate collection piping is placed at the bottom of the leachate collection layer. Where piping is placed, the granular layer extends to the area around the pipe. To protect the underlying barrier a wear strip of high density polyethylene (HDPE) is provided under the collection pipe.



LINER SYSTEM SCHEMATIC

N.T.S.

DILLON CONSULTING	PROJECT IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO. 19-9543
DATE JUNE 2019	TITLE LANDFILL LINER	FIGURE NO. 4

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Geomembrane Barrier
An 80 mil textured HDPE geomembrane liner (geomembrane) is provided under the leachate collection layer, as the primary barrier to leachate migration. A geotextile is positioned above the geomembrane to provide protection during construction and operation. The textured geomembrane is assumed based on the proposed base slopes of the landfill.

Base
The entire liner system is constructed on an engineered base. The native material at the site will be graded and a 200 mm thick granular grading pad will be placed over the native material. The base grades have been selected to minimize the removal of rock, but "knobs" of rock will periodically have to be removed, as cells are developed. Additional compacted soils will be placed at the site, where required for grading. Where possible, a 1.5 m separation distance from the underside of the geomembrane and the seasonal high groundwater table should be achieved.

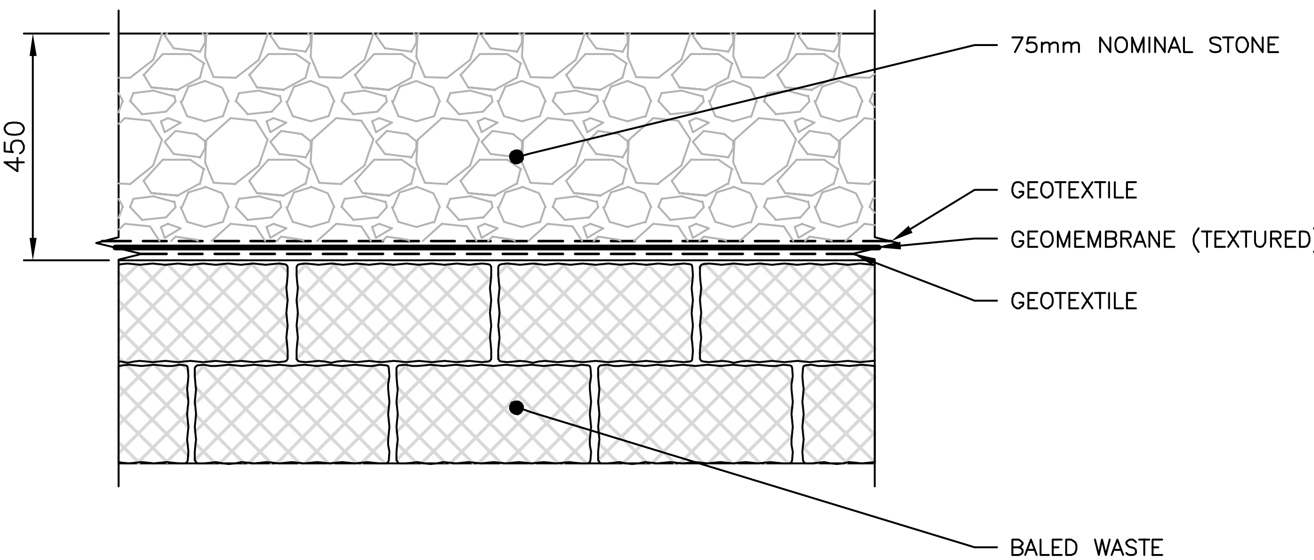
Where soil separation is required, a geotextile will be placed below the base.

Cover

Covering of the placed waste (i.e., bales and C&D material) typically occurs on a daily, intermediate and final basis. The cover material, typically a soil based product, is placed to:

- Reduce wind-blown debris
- Provide a barrier for odour migration
- Control the migration of landfill gas
- Promote surface runoff;
- Minimize the presence of vectors (i.e., insects, birds, rodents)

Daily and Intermediate Cover
The plastic wrapping of the bales function as an alternative cover, eliminating the requirement for a soil based daily or intermediate cover. As such, borrow material stockpile areas are not required. Figure 5 presents the proposed cover.



CAP SYSTEM SCHEMATIC

N.T.S.

DILLON CONSULTING	PROJECT IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO. 19-9543
DATE JUNE 2019	TITLE LANDFILL CAP	FIGURE NO. 5

Final Cover
After the waste reaches the final design elevations, a series of layers that minimize the percolation of precipitation into the waste and promotes the runoff of the precipitation, is placed. Similar to the landfill liner, the following the components of the proposed cover system are described in the following sections, from the top down.

Surface Drainage Layer
This layer protects the underlying layers from erosion, and promotes the interception and transmission of precipitation off of the top and sides of the landfill. A granular layer with nominal particle size of 75 mm permeability and slope stability, will be reviewed for the 50% submission, and approximately 450 mm thick will be placed on the 5% top slope of the landfill. To provide drainage, a geocomposite with 4:1 side slopes will be used.

Geomembrane Barrier
A 60 mil textured Linear Low Density Polyethylene geomembrane liner (geomembrane) is provided under the surface drainage layer, as the primary barrier to leachate migration. A geotextile is positioned above and below the geomembrane to provide protection during construction and closure. The textured geomembrane is assumed based on the proposed slopes of the landfill.

Base
A granular grading layer will be placed between the top of the bales and the barrier.

Leachate Collection System

The leachate collection system consists of:

- Base grades of the landfill
- Collection granulars
- Collection piping
- Sump(s)
- Pumping station
- Forcemain

Base Grades
The general topography of the site dictates that leachate will flow by gravity from the north side to the west side of the site. To direct the leachate toward the sump(s), the top of the grading pad will be based on minimizing the cut of existing material, with the exception that “knobs” will be removed either by excavation or blasting. With the grading required to achieve the required grades, the fill layer under the geomembrane liner will vary in thickness’ from a minimum of approximately 200 mm to 1700 mm.

Collection Piping/Granular Layer
The leachate collection system is located above the 80 mil HDPE geomembrane liner. The system will consist of a series of perforated collection pipes placed in a layer of 75 mm clear stone granular material. As leachate percolates downward through the bales, it will be intercepted by the collection system and removed from the cell area for treatment.

The drainage layer consists of two 300 mm granular layers, which serves to protect the HDPE geomembrane, and transmit and direct the leachate to the collection pipes. The perforated collection pipes consist of 150 mm and 200 mm HDPE. These pipes are connected to a perforated header pipe, which directs the collected leachate to the collection sump. A geomembrane “stormwater” barrier will be included in the cell, to separate areas where baled waste is not placed; hence, not generating leachate. This allows water in these areas to be pumped directly to the environment and to by-pass the lagoons.

At the end of each collection pipe, a non-perforated clean out riser will extend up the inner slope of the perimeter berm. This riser will provide access to the collection pipe for inspection equipment and for cleaning purposes.

We have assumed that the freezing of the bales in the landfill will also result in the freezing of precipitation as it migrates between the bales, and that the granular leachate collection layer under the bales will also freeze by Year 5 or 6. To ensure that leachate can be collected, the bales will be setback from the “Limit of Waste” line on the perimeter berm to provide a corridor to the sump. Lightly compacted C&D material can be placed in the corridor, provided that leachate can reach the granular layer.

Pumping Station/Forcemain

To remove leachate from within each cell a sump(s) and pumps will be utilized. The cells will be graded to direct the flow of leachate toward the collection pipes and toward a sump from which the leachate can be removed from the cell, by using the pumping equipment. By utilizing the pumping system, penetration of the geomembrane are eliminated, as the components of the pumping system rest on top of the liner.

The leachate pump station(s) receives leachate through the leachate collection granular and perforated collection pipes discharging to a sump in the landfill. The pump station, located in the sump, consists of a 2400 mm diameter perforated concrete manhole and two submersible pumps on rails. One pump will be the duty pump with the second a back up. As leachate enters the manhole and reaches a pre-determined level. Floats in the manhole will turn a pump on and the pump will run until the leachate level drops to a set elevation, where a second float will turn the pump off.

The pump station(s) will discharge into a forcemain, which directs flows to the leachate lagoon.

Leachate Treatment System

Introduction

Leachate is water that percolates through solid waste and leaches constituents out of the waste material. The resulting liquid is then considered industrial wastewater and must be managed appropriately. The quality and quantity of leachate produced will vary from site to site, and can even change at the same landfill over the course of months or years. It is strongly influenced by the amount of precipitation the area receives, the nature and placement method of the solid waste material, and landfill design. Leachate will be collected via the landfill’s liner system and then pumped to the ultimate treatment and disposal system.

Design Criteria

Design criteria were established for the 30% stage based on proposed landfill footprint, historical precipitation data, comparison to other municipal landfill sites and discussions with the baler equipment manufacturer. Typically, leachate is characterized as low flow but very high strength, with heavy metals, dissolved/suspended solids and biological demand driving the treatment focus. This can present a both capitally-expensive and operationally-intensive treatment system, often with several levels of treatment to condition the water to a state that is considered non-deleterious to the receiving environment. In some cases, it is partially treated at the landfill site and then hauled to a nearby municipal wastewater treatment facility.

The ultimate size of the landfill is approximately 22 ha at the end of its 75 year anticipated life. Environment Canada meteorological data indicated the area historically has received an average of 404 mm/year of precipitation. It was assumed that 50% of the annual precipitation would become runoff and not contribute to leachate generation, while the other 50% would percolate through the landfill. As the waste bales will be wrapped in several layers of plastic, it was further assumed that only 10% of this infiltration would generate leachate (through perforations or cuts in the bale wraps). This results in an annual leachate generation of approximately 4,400 m^3.

Raw influent quality was developed based on estimated concentrations of biological oxygen demand (BOD), total ammonia nitrogen (NH_3-N), total suspended solids (TSS) and heavy metals. Limited raw leachate data is available for northern landfill sites and even less for northern balefills. The used of plastic-wrapped balefills is not common in North America, so in the absence of in situ data, conservative estimates were applied for the 30% stage.

Discussions with regulators suggested that an appropriate reference material for effluent quality requirements would be the Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities (2011), which provides criteria for process effluents and non-point discharges from industrial facilities. Discussions with the Nunavut Water Board suggested that "non-point source discharges" (NPSD) may be applicable to the City's landfill leachate, which defines NPSD as "non-specific or diffuse source of effluent entering the environment including run-off from an industrial compound or storage yard". These limits were compared to the Canadian Council for Ministers of the Environment (CCME) guidelines for Freshwater Aquatic Life. Estimated influent quality and proposed effluent quality is summarized in Table 1.

Table 1: Estimated Influent and Effluent Quality

Parameter	Influent Design Value[1]	CCME[2]	Government of Nunavut Dept. of Environment[3]	Design Effluent Objective[4]
Carbonaceous BOD (5 day)	100 mg/L	25 mg/L	15 mg/L	15 mg/L
pH	6 – 9	6.5 – 9.0	6 – 10.5	6.5 – 9
Total Ammonia (NH_3-N)	40 mg/L	Varies (10.3 mg/L used)[6]	10 mg/L	10 mg/L
TSS	100 mg/L	Varies (typ. 25 mg/L)	15 mg/L	15mg/L
Total Phosphorus	10 mg/L	-	1.0 mg/L	1.0 mg/L
Chloride	200 mg/l	120 mg/L	-	-
Cadmium[5]	10 ug/L	0.09 ug/L	100 ug/L	100 ug/L
Chromium[5]	50 ug/L	1 – 8.9 ug/L	100 ug/L	100 ug/L

Copper[5]	1000 ug/L	4.0 ug/L	1000 ug/L	1000 ug/L
Iron	20 mg/L	0.3 mg/L	1.0 mg/L	0.3 mg/L
Lead	100 ug/L	7 ug/L	50 ug/L	50 ug/L
Arsenic[5]	10 ug/L	5 ug/L	1000 ug/L	1000 ug/L
Nickel[5]	25 ug/L	25 ug/L	1000 ug/L	1000 ug/L
Zinc	75 ug/L	7.0 ug/L	50 ug/L	50 ug/L

Notes:
1) Estimated based on limited data.
2) CCME Water Quality Guidelines for the Protection of Aquatic Life.
3) Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Treatment Facilities, Table 1.
4) Proposed effluent objective to be confirmed.
5) Preliminary influent quality estimated to be below effluent objectives but impacts to treatment process still considered.
6) Assuming a pH of 7.0 and temperature of 10^{o} C. As temperature and pH increase, the Canadian Council of Ministers of the Environment total ammonia-nitrogen discharge limit decreases due to the relationship between un-ionized and ionized ammonia.

Technology Discussion

Appendix D of the main report presents an introduction and Triple Bottom Line Assessment of the three main treatment options considered:

1. Lined lagoon and wetland treatment area (WTA).
2. Pre-treat and haul to the City's wastewater treatment plant (WWTP).
3. Full-scale onsite mechanical treatment.

An important characteristic of that assessment is that it assumes each of the options is viable and will meet the requirements of the project, in this case providing adequate treatment. Aerated lagoons and wetland treatment for industrial wastewaters is a relatively new and unique concept in northern Canada. While commonly used for municipal wastewater treatment in both Nunavut and the Northwest Territories, the characteristics of leachate often vary significantly compared to municipal wastewater. The performance for parameters, such as heavy metal removals in northern wetlands, would be largely theoretical, as there are limited case studies that have similar conditions.

One of the closest comparisons to Iqaluit would be passive wetland-based treatment systems studied in the Yukon for mining impacted waters. The study found that while passive treatment systems can provide considerable levels of heavy metals removal, they generally require several factors that present challenges for the Iqaluit landfill:

- Constant flow year round
- Liquid carbon sources

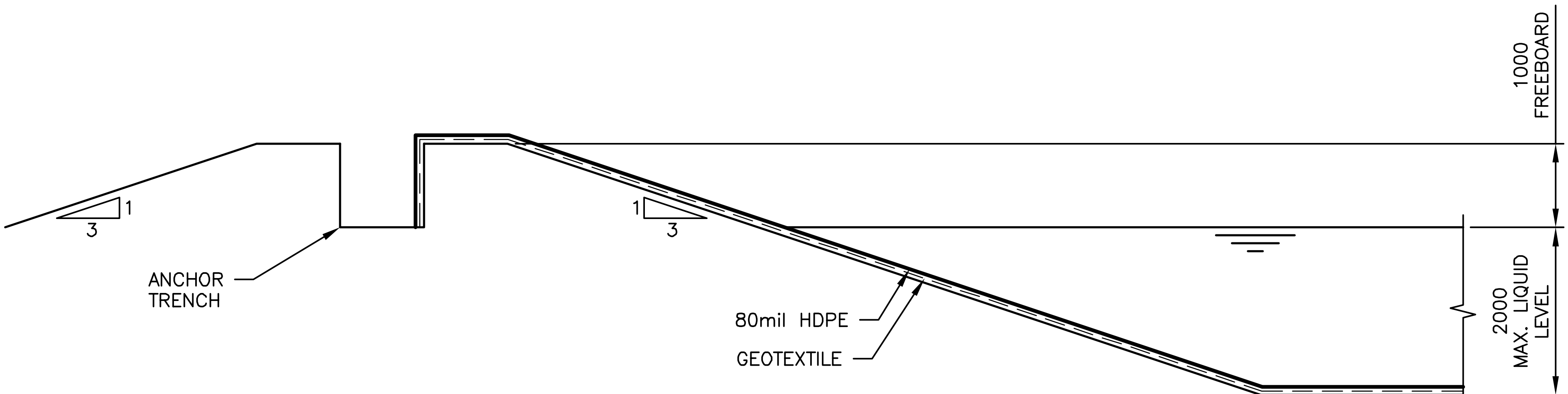
The second issue can be overcome through a chemical feed system or raw-wastewater recycling, but constant flow is not something that is expected since the only wastewater contribution to the treatment system will be precipitation and runoff in the warmer months. However, the raw leachate strength is expected to be relatively weak compared to that from a traditional landfill site due to the plastic bale liners and relatively small footprint of the active landfill cells. As the proposed landfill is several kilometers away from any significant receiving waters, the treated effluent will also likely need to be land applied downstream of the landfill site as well.

Construction Details

Both lagoons will require an engineered liner to prevent them from leaking into the surrounding environment, as no clay or similar materials are readily available in sufficient quantities in Iqaluit. The proposed lagoons are expected to be 3.0 m deep (liquid level), with an additional 1.0 m freeboard and 3:1 side slopes. A berm, approximately 2.0 m in width at a minimum, will be provided around the ponds to allow for installation of aeration equipment and maintenance access. Leachate will be pumped from the landfill sump to the cascade aerator which will then flow by gravity to the first pond, which will has capacity to store approximately 60% of the estimated annual leachate production. The second pond is designed to store approximately 40% of the annual leachate, for a total of 1 years' worth of storage between the two ponds; this will allow for balancing and buffer space during the spring freshet. The primary treatment purpose of the two lagoons will be for preliminary solids removal, BOD reduction and partial oxidation and removal of select metals. At the end of lagoon #2, there will be a level control structure and pump station, which will transfer lagoon effluent to the vertical flow wetland. The vertical flow wetland will be sized for additional BOD and TSS removal, along with ammonia nitrification. The last treatment step will be a WTA that is anticipated to occur naturally over the first few years of the landfill's life. The WTA will be provide general effluent polishing and further reduction of BOD, TSS, ammonia and some metals.

Conclusion

Dillon Consulting Limited's recommendation at the 30% stage is to proceed with an aerated lagoon and wetland treatment system as shown on the 30% drawing set, with provisions for a future mechanical treatment system, if is determined that the lagoon and WTA is inadequate at treating leachate to regulatory requirements. During the first year of operation, the leachate quality and quantity should be monitored, and if necessary, hauled to the City's new WWTP (if effluent standards are not being met), where there is reported short and medium-term capacity. This will help manage potential risks associated with leachate strength and treatment performance, while balancing capital costs and delaying a potentially unnecessary and financially significant investment in a mechanical treatment plant.



TYPICAL LEACHATE HOLDING POND DETAIL

1:75

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PROJECT: IQALUIT LANDFILL AND WASTE TRANSFER STATION		PROJECT NO. 19-9543
DATE: JUNE 2019	TITLE: LAGOON HOLDING POND LINER	FIGURE NO. 6

Drainage and Erosion Control

The drainage area of the proposed landfill site is located to the east of the Sylvia Grinnell River watershed. The site drains predominately to the west and to the south by overland and sheet flow, concentrating to channelized flow. The channelized flow moves south toward the City, ultimately outletting to the Koojesse Inlet of Frobisher Bay.

The proposed landfill site will be approximately 22 ha at completion. Throughout the course of construction, water from two wetland areas will need to be relocated and directed around the facility. Drainage and erosion control on-site will be managed through perimeter ditching and flow control structures per the City's stormwater management guidelines and Government of Nunavut's water protection requirements. Perimeter ditching and roadway culverts will be designed to convey flows associated with major design event storms.

Drawings

Drawings for the Solid Waste Landfill, Waste Transfer Station and Northwest Aggregate Deposit Road – 30% Submission are attached to this memorandum.

Drawings

Iqaluit

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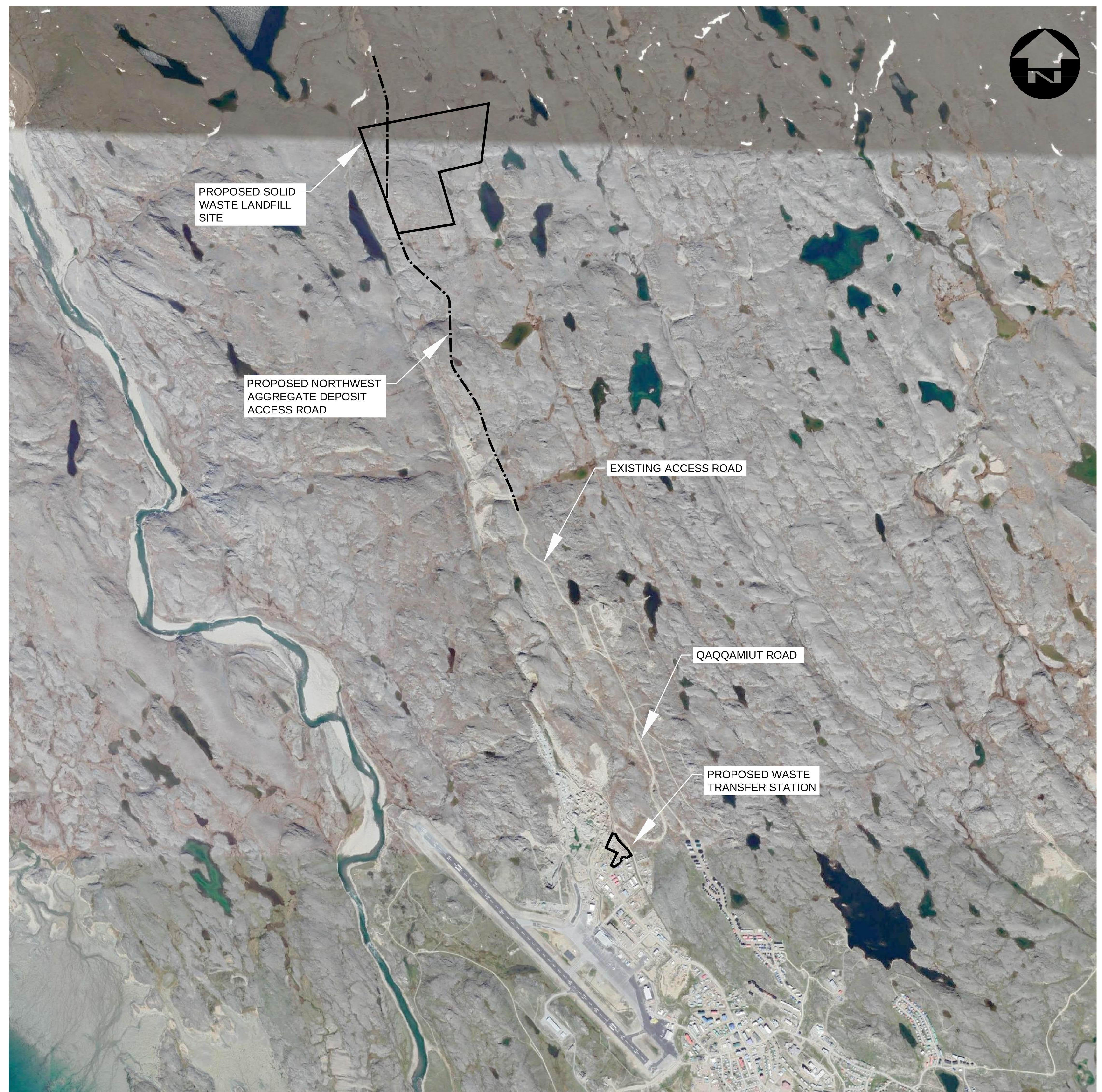
CITY OF IQALUIT

SOLID WASTE LANDFILL, WASTE TRANSFER STATION AND NORTHWEST AGGREGATE DEPOSIT ROAD - 30% SUBMISSION



KEY PLAN

DILLON PROJECT: 19-9543
DATE: JUNE 04, 2019

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CITY OF IQALUIT

SOLID WASTE LANDFILL, WASTE TRANSFER STATION & NORTHWEST AGGREGATE DEPOSIT ROAD

DRAWING INDEX - LANDFILL

DWG.	DESCRIPTION
LF-C01	EXISTING CONDITIONS SITE PLAN
LF-C02	PROPOSED CONDITIONS SITE PLAN
LF-C03	CELL 1 AND 2 - PLAN AND SECTIONS
LF-C04	LEACHATE PROCESS FLOW DIAGRAM
LF-C05	LEACHATE LAGOONS & WETLAND - PLAN & PROFILE
LF-C06	PROPOSED BOTTOM OF LINER SYSTEM
LF-C07	PROPOSED TOP OF FINAL WASTE
LF-C08	LANDFILL SECTIONS 1 TO 3
LF-C09	LANDFILL SECTIONS 4 TO 6
LF-C10	SECTIONS AND DETAILS
LF-C11	LINER DETAILS

DRAWING INDEX - WASTE TRANSFER STATION

DWG.	DESCRIPTION
WTS-C01	EXISTING CONDITIONS SITE PLAN
WTS-C02	PROPOSED CONDITIONS SITE PLAN
WTS-C03	PLAN AND PROFILE
WTS-C04	SITE OFFICE AND SCALE HOUSE
WTS-A01	FLOOR PLAN
WTS-A02	CROSS SECTIONS
WTS-A03	BUILDING ELEVATIONS
WTS-S01	NOTES AND SECTION

INDEX OF INCLUDED DRAWINGS

DRAWING NO.	REVISION	DESCRIPTION
		COVER SHEET
OTT-00219428-A0-LOC-1	3	LOCATION PLAN
OTT-00219428-A0-SP-1	3	SITE PLAN-1
OTT-00219428-A0-SP-2	3	SITE PLAN-2
OTT-00219428-A0-SP-3	3	SITE PLAN-3
OTT-00219428-A0-LP-1	3	LAYOUT PLAN-1
OTT-00219428-A0-LP-2	3	LAYOUT PLAN-2
OTT-00219428-A0-LP-3	3	LAYOUT PLAN-3
OTT-00219428-A0-LP-4	3	LAYOUT PLAN-4
OTT-00219428-A0-LP-5	3	LAYOUT PLAN-5
OTT-00219428-A0-LP-6	3	LAYOUT PLAN-6
OTT-00219428-A0-PP-1	3	PLAN AND PROFILES-1
OTT-00219428-A0-PP-2	3	PLAN AND PROFILES-2
OTT-00219428-A0-PP-3	3	PLAN AND PROFILES-3
OTT-00219428-A0-PP-4	3	PLAN AND PROFILES-4
OTT-00219428-A0-PP-5	3	PLAN AND PROFILES-5
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OTT-00219428-A0-PP-10	3	PLAN AND PROFILES-10
OTT-00219428-A0-PP-11	3	PLAN AND PROFILES-11
OTT-00219428-A0-PP-12	3	PLAN AND PROFILES-12
OTT-00219428-A0-PP-13	3	PLAN AND PROFILES-13
OTT-00219428-A0-PP-14	3	PLAN AND PROFILES-14
OTT-00219428-A0-DET-1	3	ROAD DETAILS
OTT-00219428-A0-DET-2	3	GUIDERAIL DETAILS
OTT-00219428-A0-DET-3	3	MISC. DETAILS

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CHECKED BY: K.B.
DATE: MAY 2019
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CITY OF IQALUIT
SOLID WASTE LANDFILL

EXISTING CONDITIONS SITE PLAN

PROJECT NO. 19-9543

SHEET NO. LF-C01

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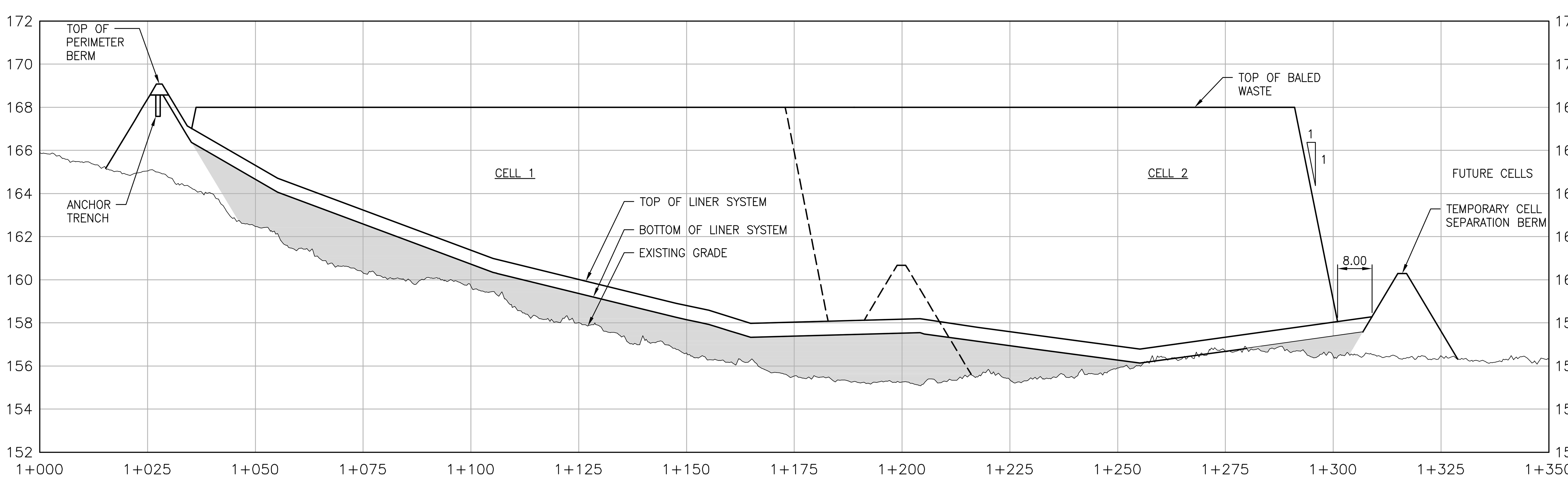
SOLID WASTE LANDFILL

PROPOSED CONDITIONS SITE PLAN

PROJECT NO. 19-9543

SHEET NO. LF-C02



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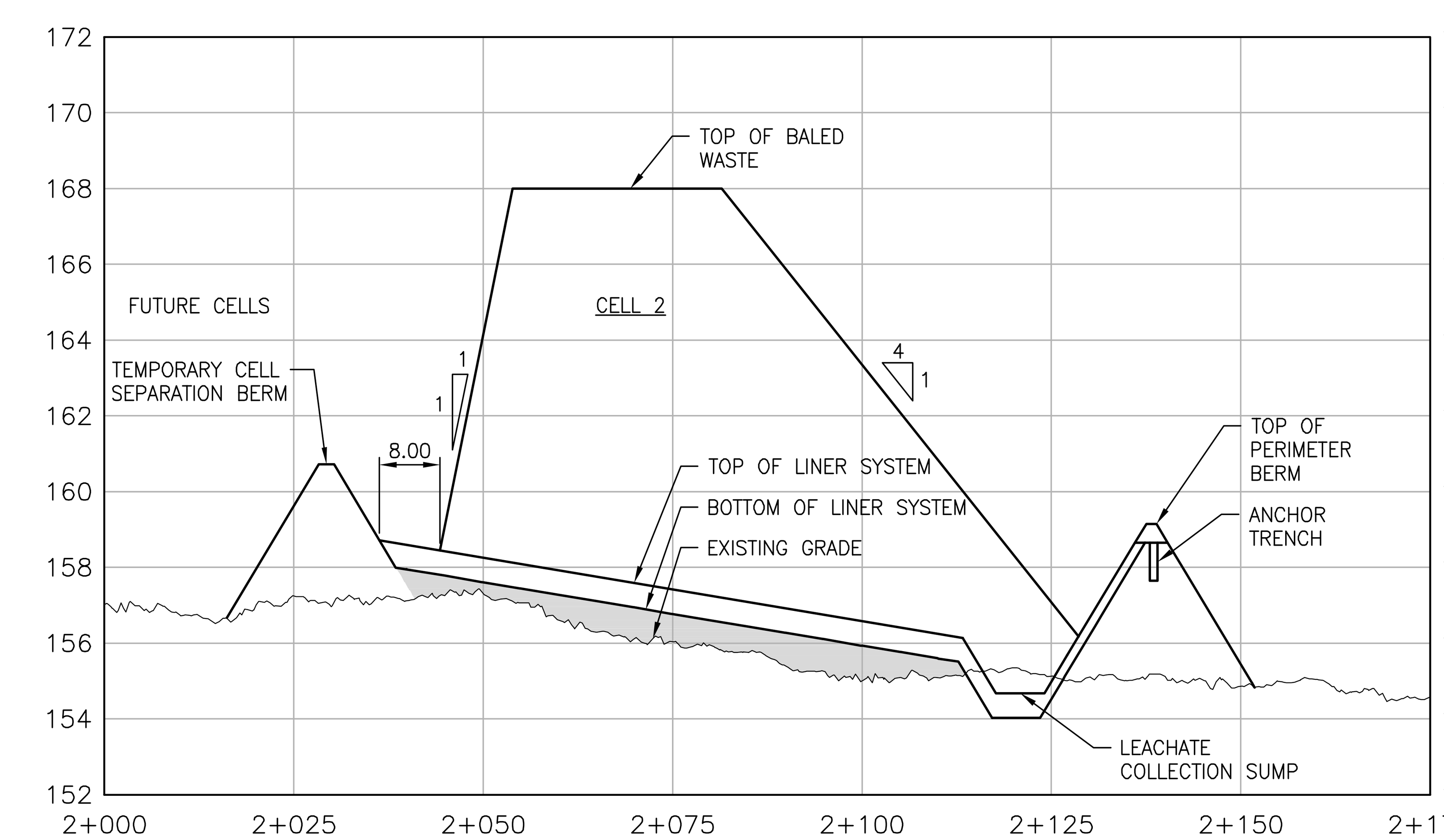

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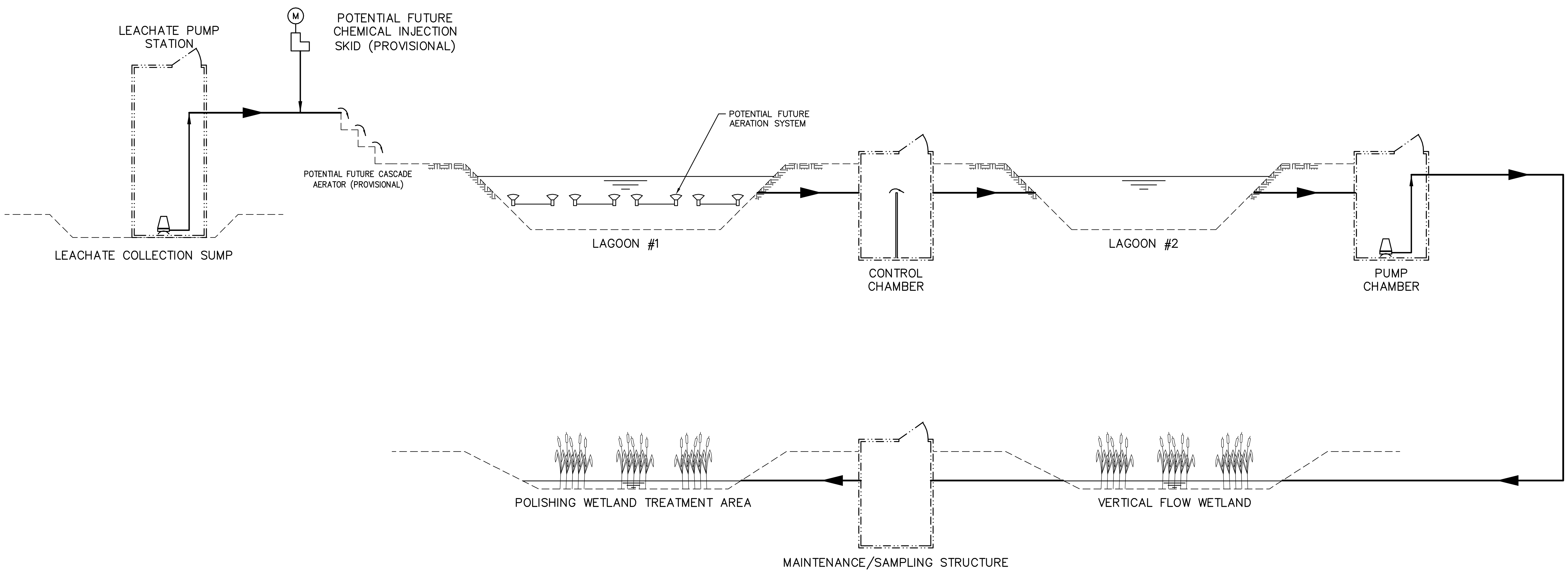
CITY OF IQALUIT
SOLID WASTE LANDFILL

CELL 1 AND 2 - PLAN AND SECTIONS

PROJECT NO. 19-9543

SHEET NO. LF-C03



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CITY OF IQALUIT
SOLID WASTE LANDFILL

LEACHATE PROCESS FLOW DIAGRAM

PROJECT NO. 19-9543

SHEET NO. LF-C04

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LEACHATE LAGOONS AND WETLAND
PLAN AND PROFILE

PROJECT NO. 19-9543

SHEET NO. LF-C05

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CITY OF IQALUIT
SOLID WASTE LANDFILL

PROPOSED BOTTOM OF LINER SYSTEM

PROJECT NO. 19-9543

SHEET NO. LF-C06

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CITY OF IQALUIT
SOLID WASTE LANDFILL

PROPOSED TOP OF FINAL WASTE

PROJECT NO. 19-9543

SHEET NO. LF-C07

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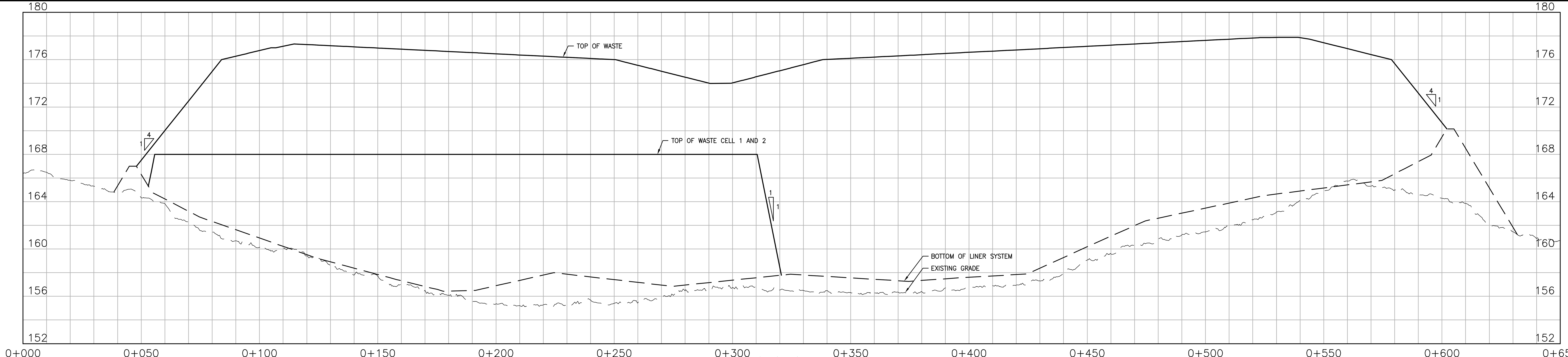

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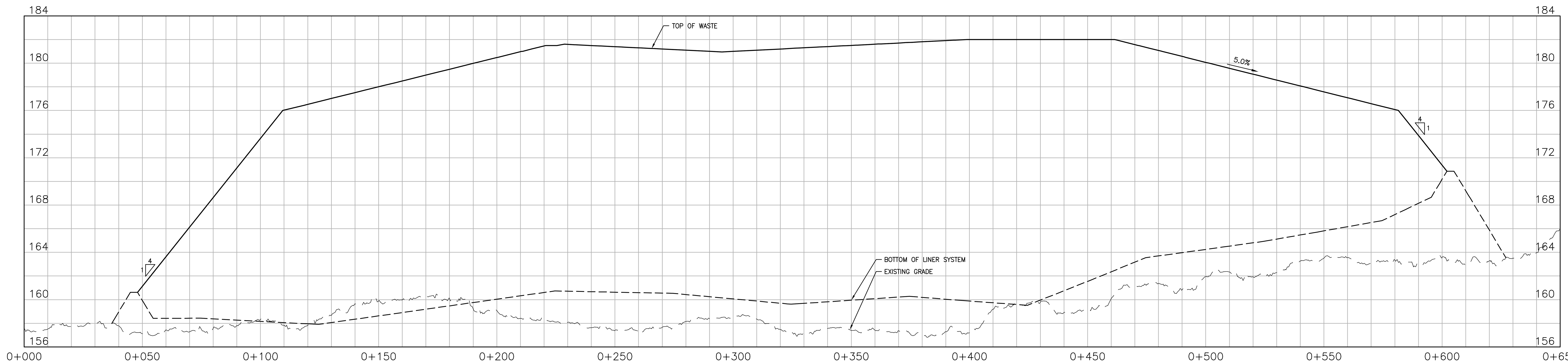

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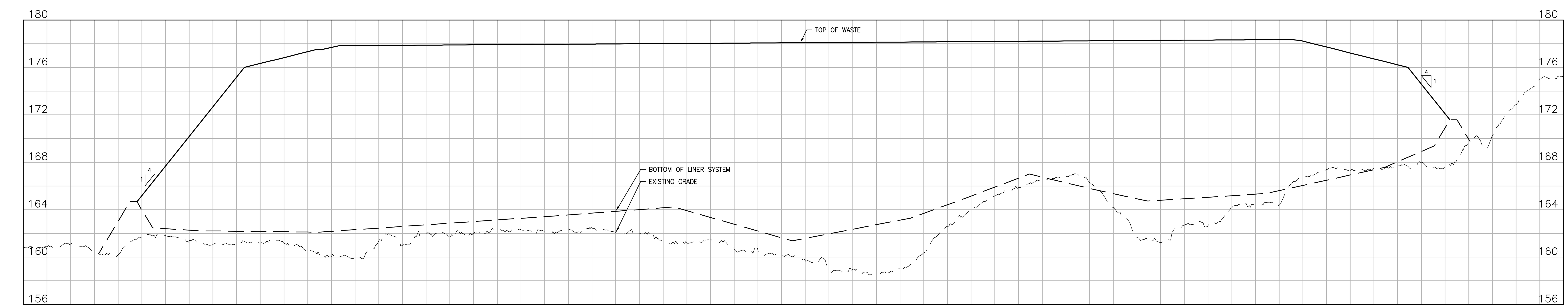

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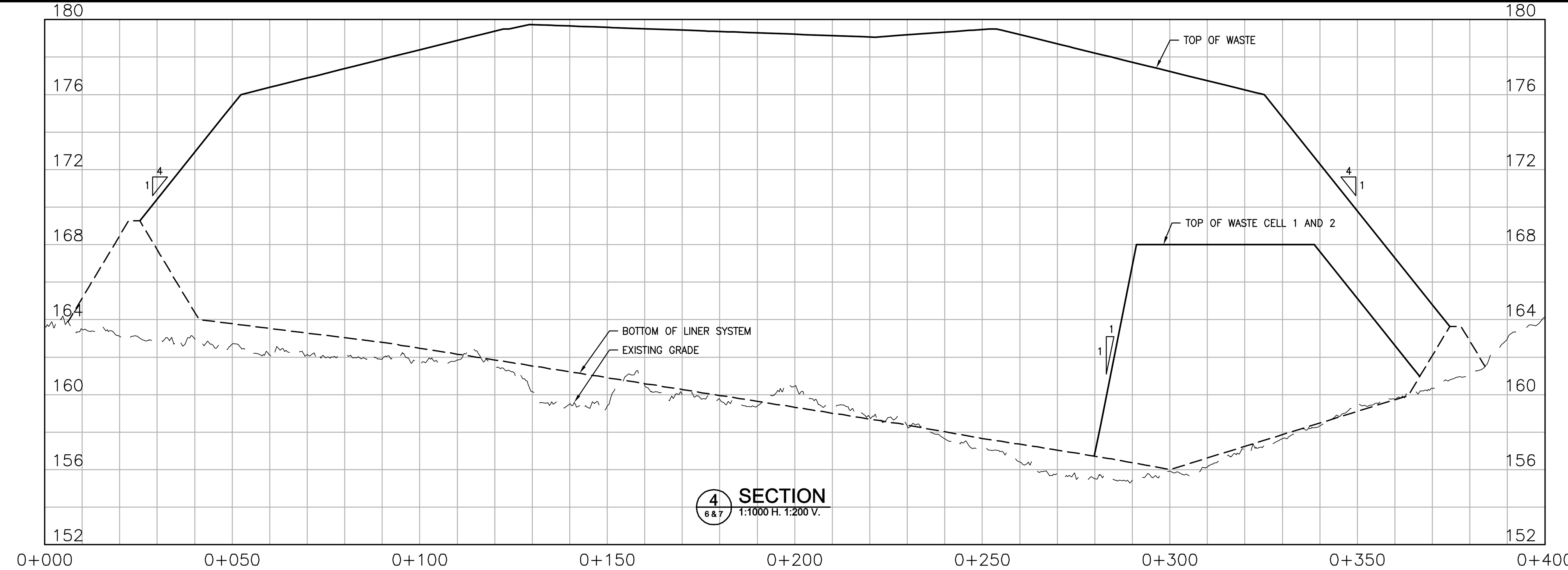
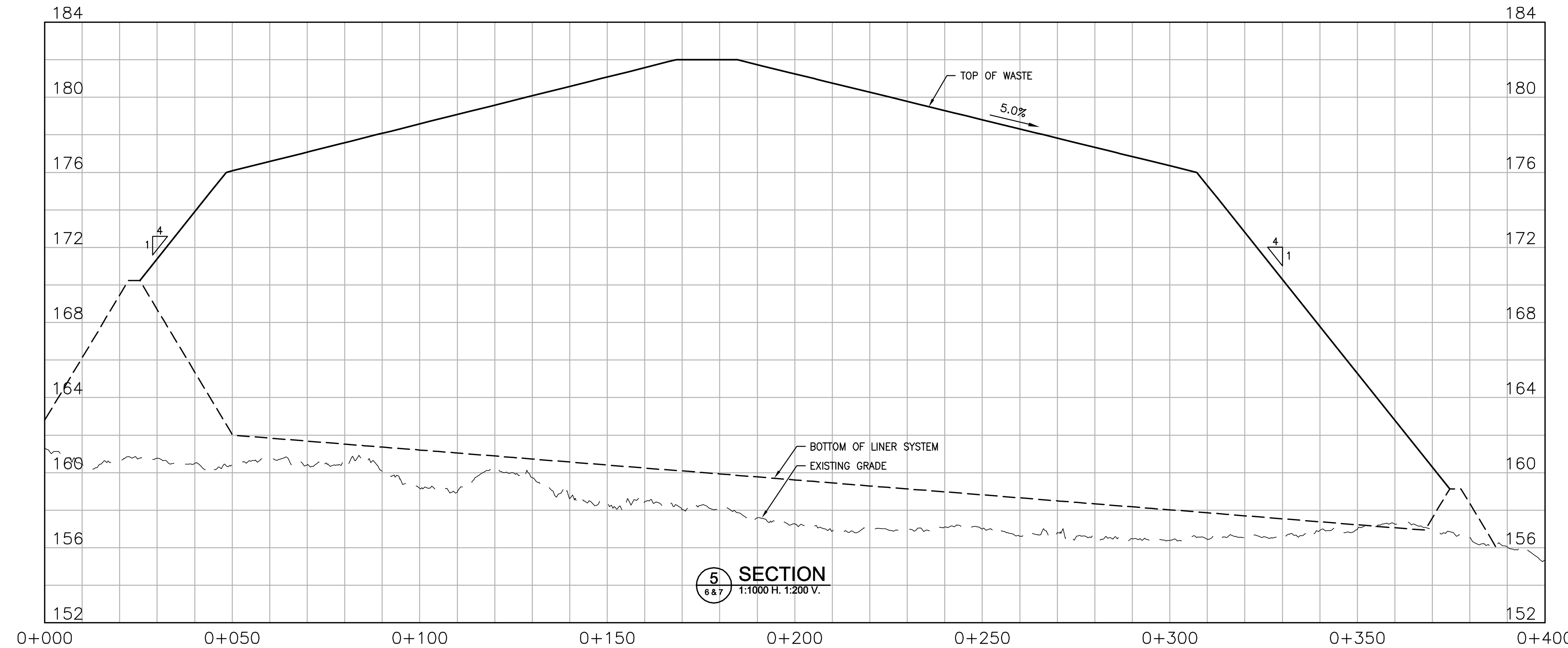
CITY OF IQALUIT
SOLID WASTE LANDFILL

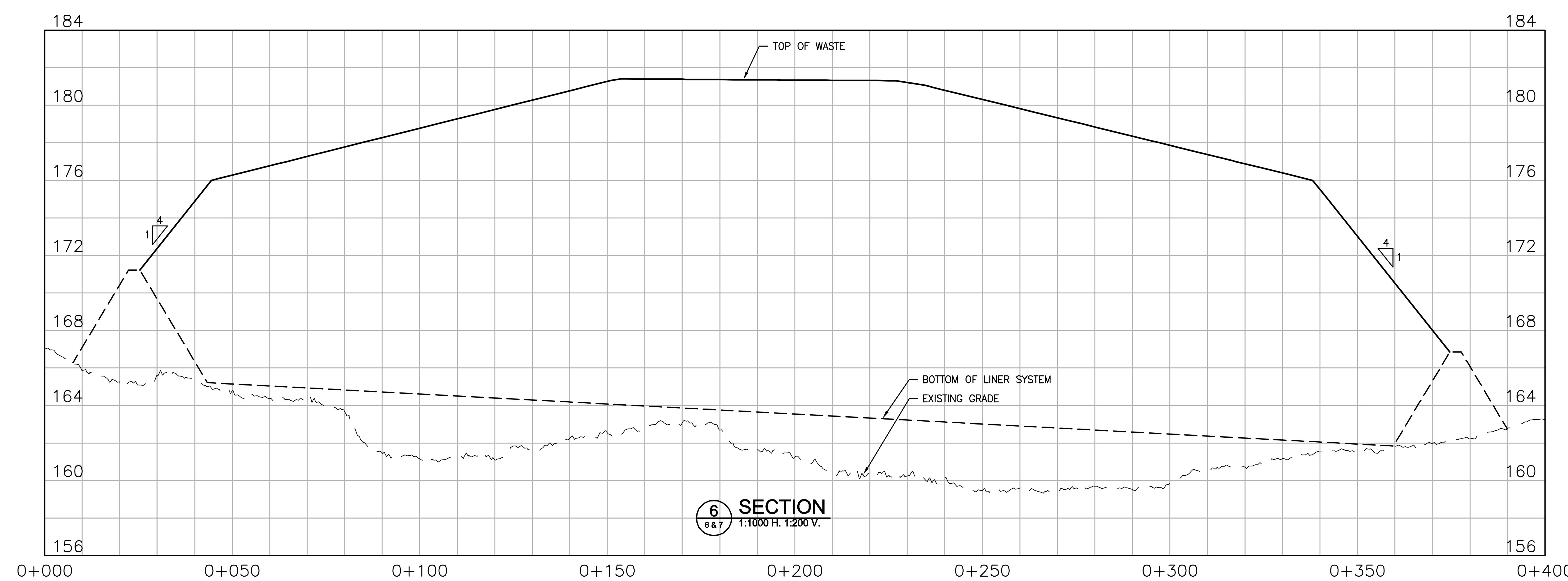
LANDFILL SECTIONS 1 TO 3

PROJECT NO. 19-9543

SHEET NO. LF-C08







FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\PROJECTS 2019\SODRC\DMS12727\0-199543-02-SITE-CON-SECTIONS.DWG PLOTTED BY: CURNEW, DOUGLAS
PLOT DATE: 2019-06-05 @ 12:45:39 PM PLOT SCALE: 1:25.4 PLOT STYLE: DILLON-STANDARD.CTB

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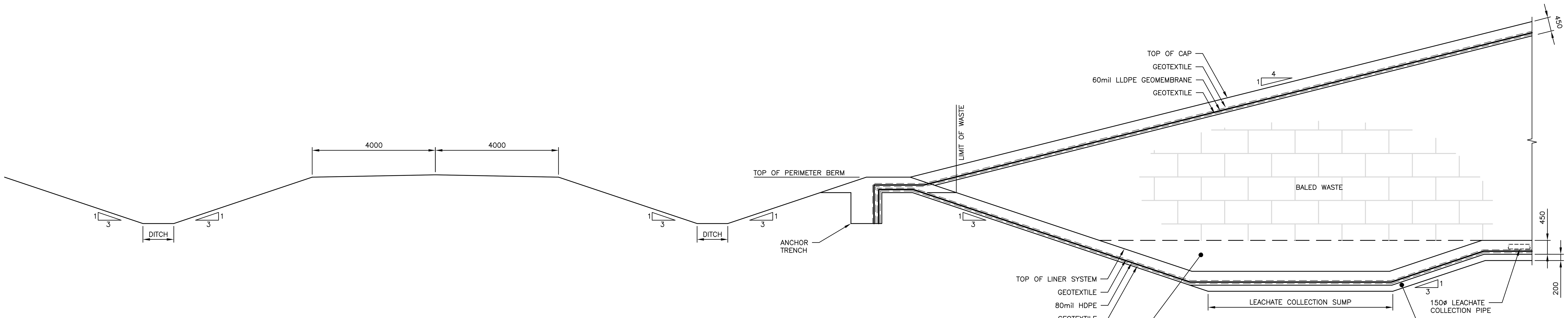
DRAWN: D.B.C.	CHECKED BY: K.B.
DATE: MAY 2019	
SCALE: AS NOTED	

CITY OF IQALUIT
SOLID WASTE LANDFILL

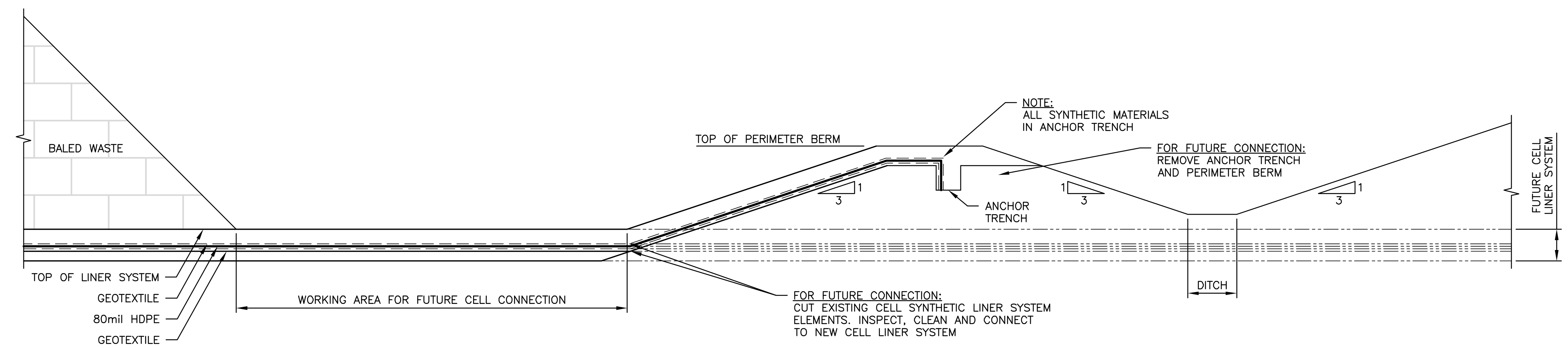
LANDFILL SECTIONS 4 TO 6

PROJECT NO. 19-9543

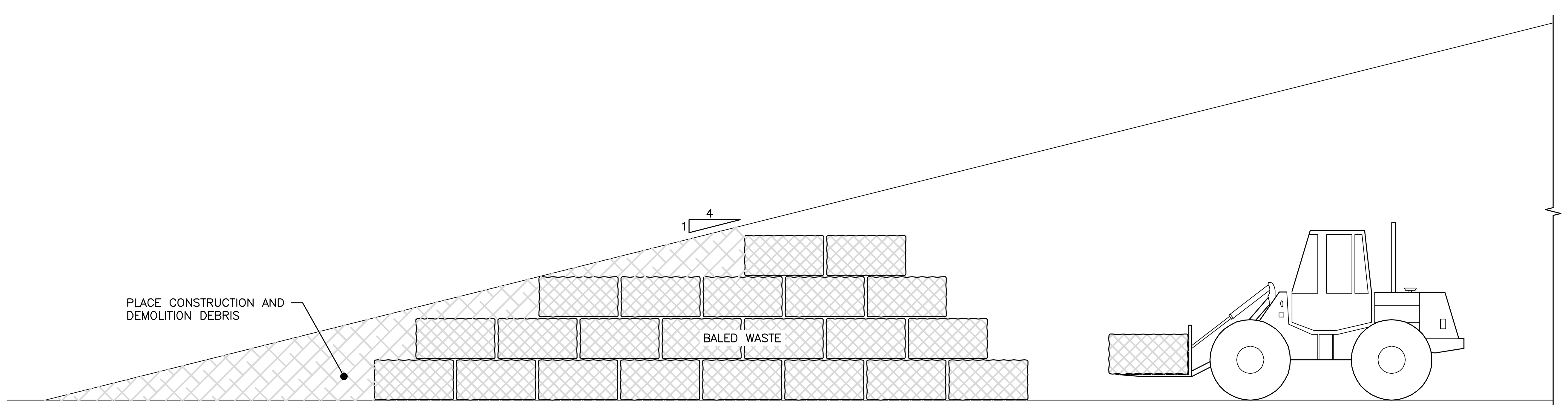
SHEET NO. LF-C09



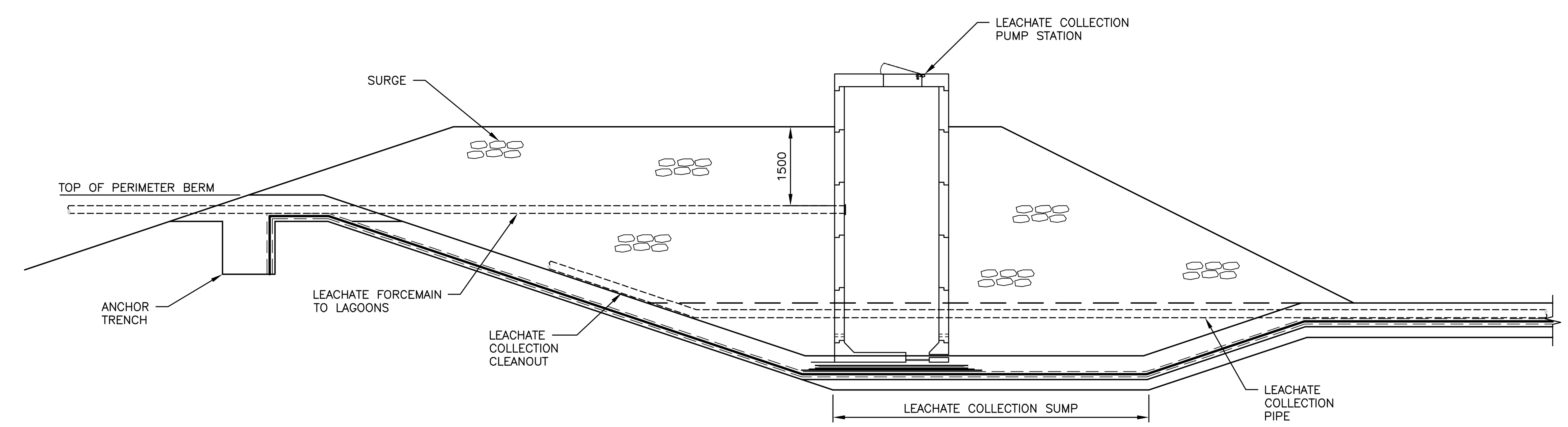
TYPICAL LANDFILL SECTION
1:75



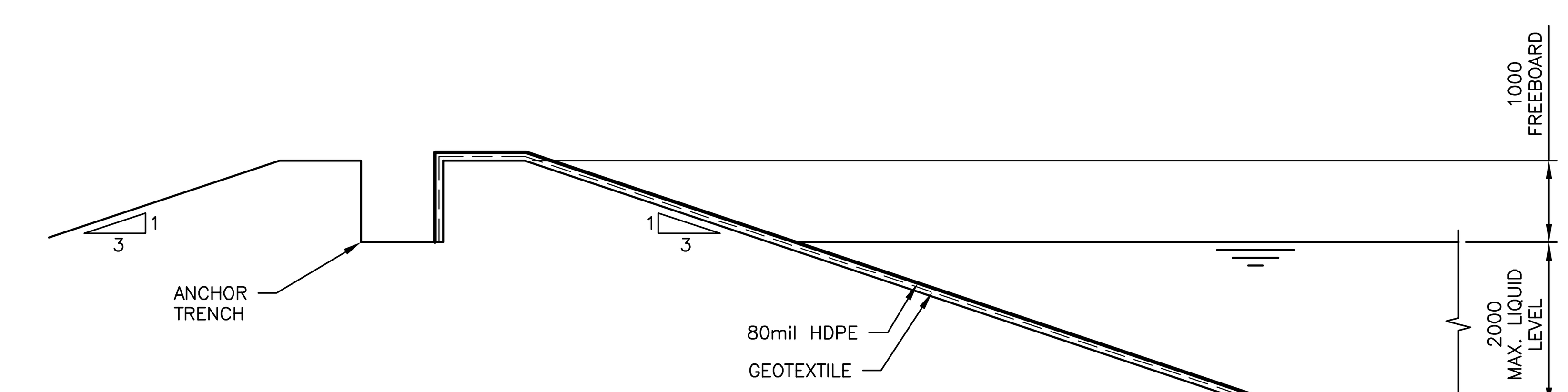
TEMPORARY CELL SEPARATION BERM
1:75



TYPICAL LIFT DETAIL
1:75



LEACHATE COLLECTION PUMP STATION SECTION
1:75



TYPICAL LEACHATE HOLDING POND DETAIL

FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\PROJECTS 2019\SODBC\DMS12727\10-199543-02-SITE-CON-SECTIONS.DWG PLOTTED BY: CURNEW, DOUGLAS
PLOT DATE: 2019-06-05 @ 12:42:24 PM PLOT SCALE: 1:25.4 PLOT STYLE: DILLON-STANDARD.CTB

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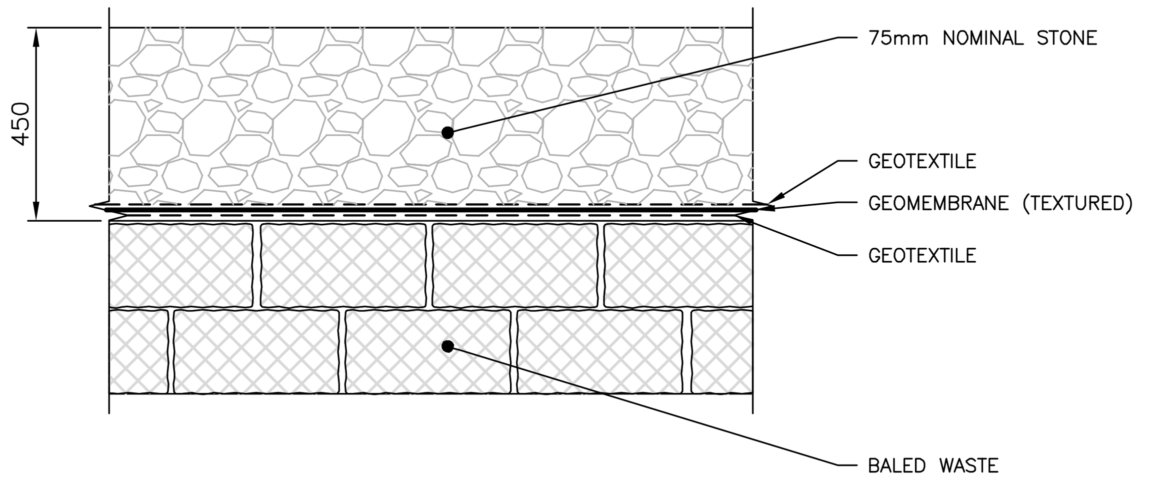
DRAWN: D.B.C.	CHECKED BY: K.B.
DATE: MAY 2019	
SCALE: AS NOTED	

CITY OF IQALUIT
SOLID WASTE LANDFILL

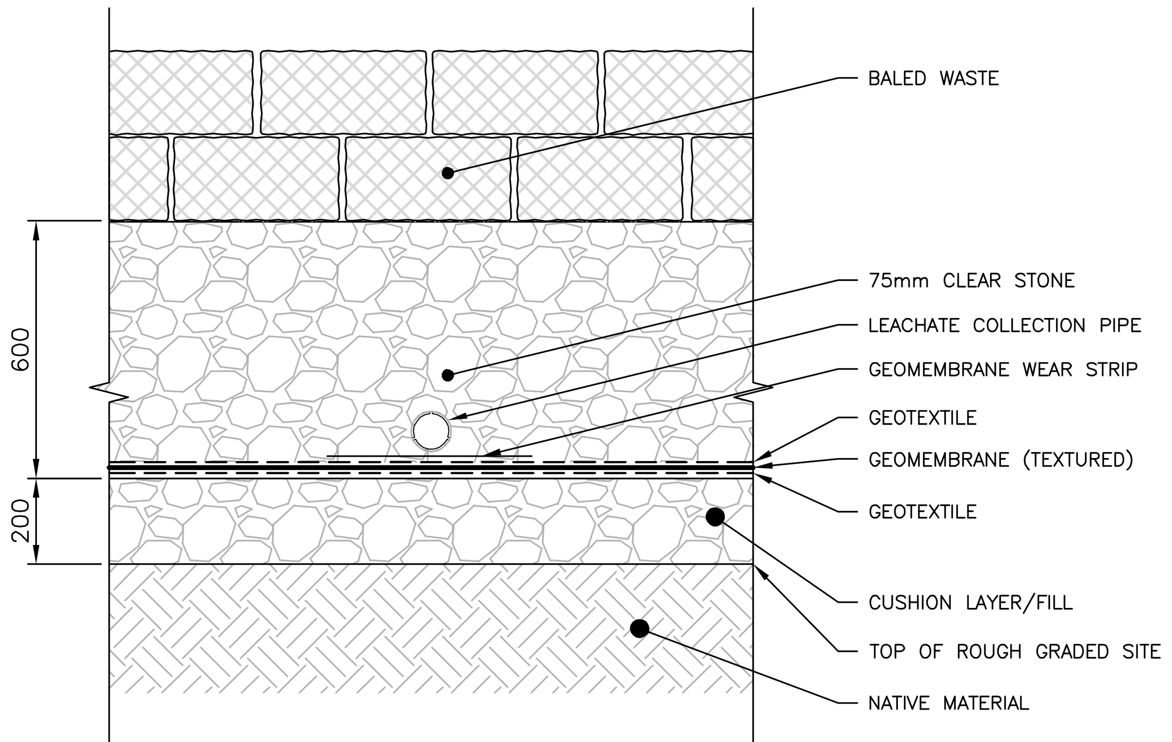
SECTIONS AND DETAILS

PROJECT NO. 19-9543

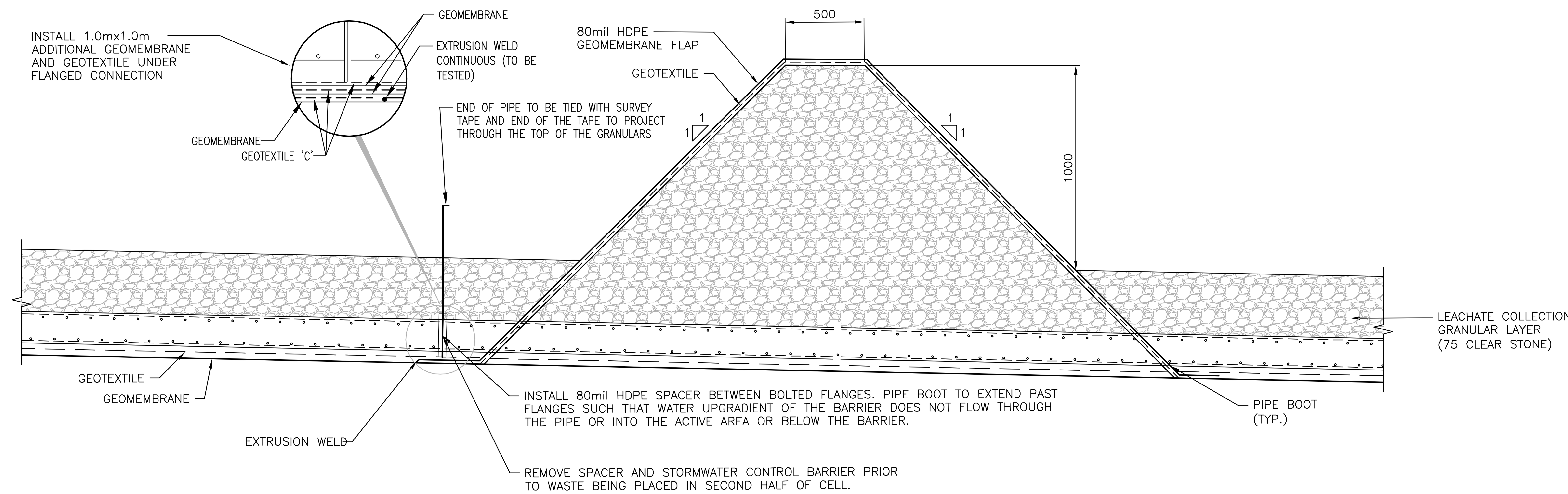
SHEET NO. LF-C10



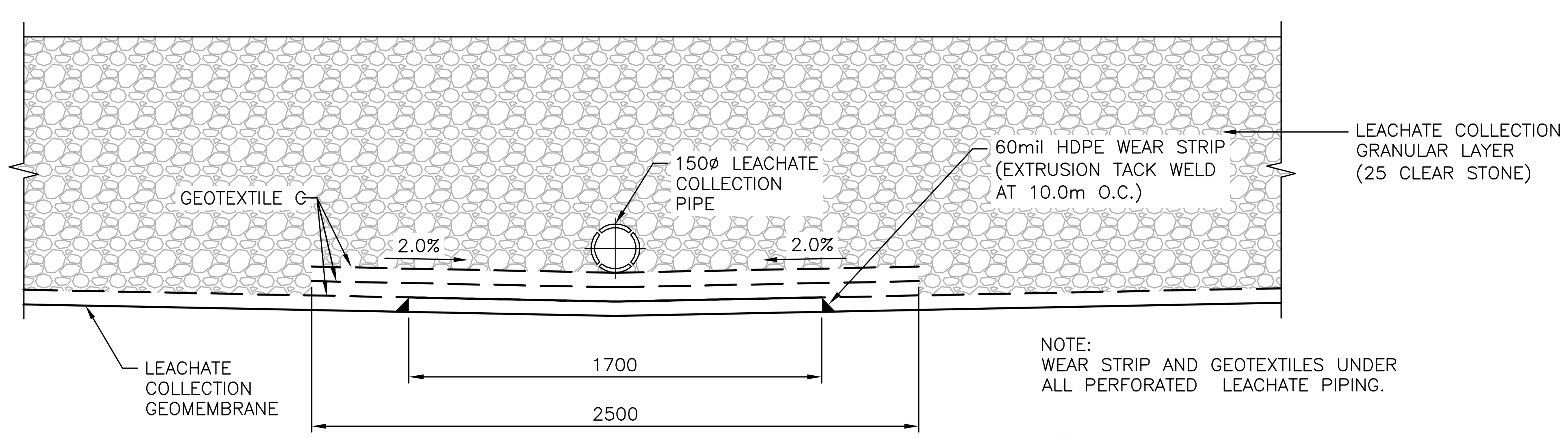
CAP SYSTEM SCHEMATIC
N.T.S.



LINER SYSTEM SCHEMATIC
N.T.S.



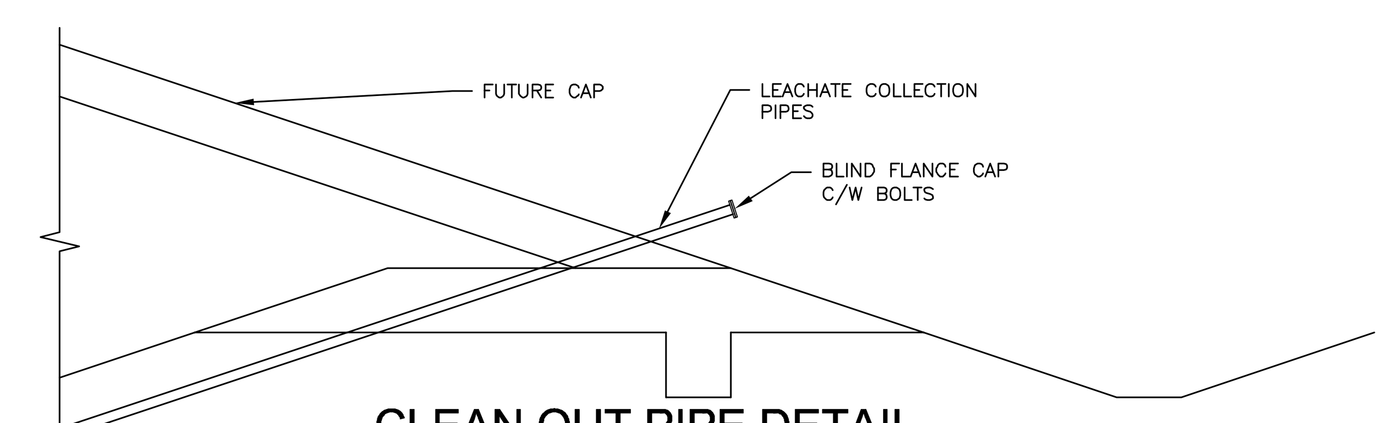
STORMWATER CONTROL BARRIER
N.T.S.



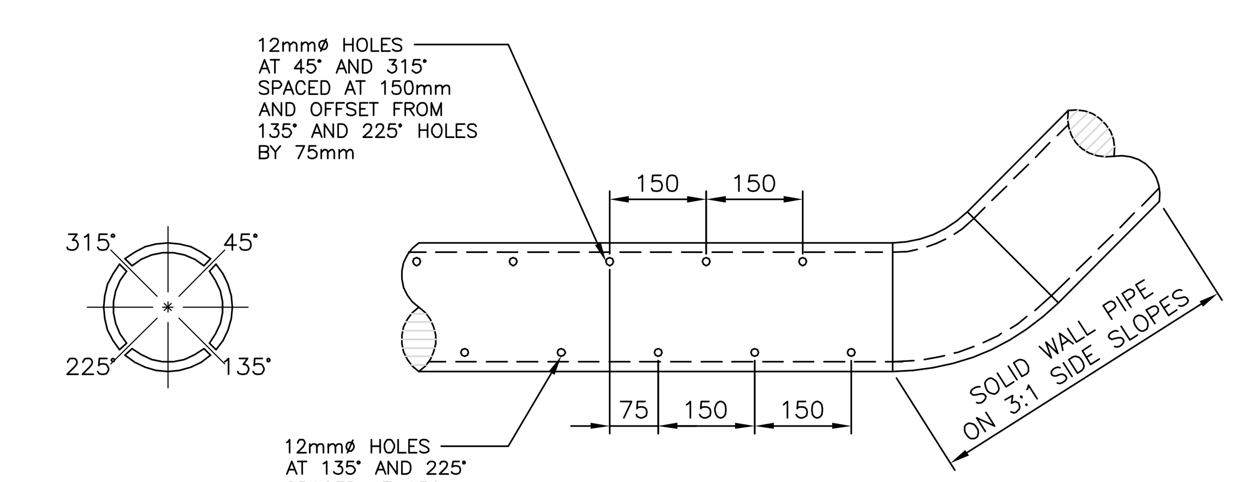
NOTE:
WEAR STRIP AND GEOTEXTILES UNDER ALL PERFORATED LEACHATE PIPING.

NOTE:
SYNTHETIC MATERIALS SHOWN EXAGGERATED FOR CLARITY

LEACHATE COLLECTION PIPE DETAIL
1:20



CLEAN OUT PIPE DETAIL
1:100



150 DIA. LEACHATE COLLECTION PIPE - PERFORATION DETAIL
1:10

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DRAWN: D.B.C. CHECKED BY: K.B.
DATE: MAY 2019
SCALE: AS NOTED

CITY OF IQALUIT
SOLID WASTE LANDFILL

LINER DETAILS

PROJECT NO. 19-9543

SHEET NO. LF-C11

FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\PROJECTS 2019\5008(C)\DMS12728\199543-02-SITE-CON-WTS-EXISTING.DWG PLOTTED BY: CURNEW, DOUGLAS
PLOT DATE: 2019-06-05 @ 12:38:53 PM PLOT SCALE: 1:25.4 PLOT STYLE: DILLON-STANDARD.CTB

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DESIGN C.R.S.	REVIEWED BY S.D.K.
DRAWN D.B.C.	CHECKED BY K.B.
DATE MAY 2019	
SCALE 1:500	

CITY OF IQALUIT
WASTE TRANSFER STATION

EXISTING CONDITIONS SITE PLAN

PROJECT NO. 19-9543

SHEET NO. WTS-C01

FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\PROJECTS 2019\SODBC\DMS12728\199543-02-SITE-CON-WTS-PROPOSED.DWG PLOTTED BY: CURNEW, DOUGLAS
PLOT DATE: 2019-06-05 @ 12:36:31 PM PLOT SCALE: 1:25.4 PLOT STYLE: DILLON-STANDARD.CTB

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1	30% REVIEW	2019/06/04	K.B.

DESIGN: C.R.S. REVIEWED BY: S.D.K.
DRAWN: D.B.C. CHECKED BY: K.B.
DATE: MAY 2019
SCALE: 1:500

CITY OF IQALUIT
WASTE TRANSFER STATION

PROPOSED CONDITIONS SITE PLAN

PROJECT NO. 19-9543

SHEET NO. WTS-C02

FILENAME: C:\PROJECTWISE\ WORKING DIRECTORY\PROJECTS 2019\DODDS\DMS12728\199543-02-SITE-CON-WTS-PROPOSED.DWG PLOTTED BY: CURNEW, DOUGLAS
PLOT DATE: 2019-06-05 @ 12:35:33 PM PLOT SCALE: 1:25.4 PLOT STYLE: DILLON-STANDARD.CTB

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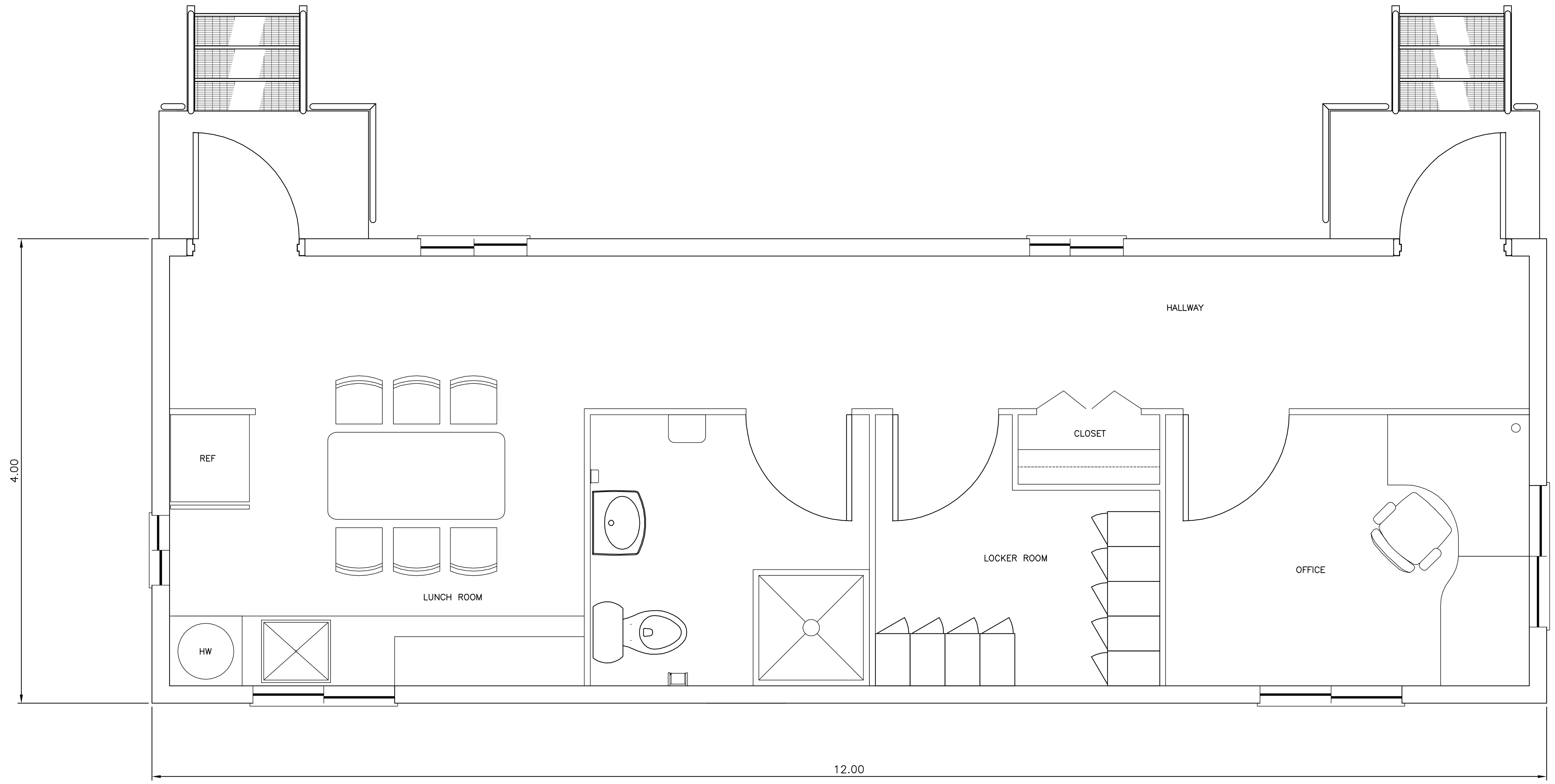
DESIGN	REVIEWED BY
C.R.S.	S.D.K.
DRAWN	CHECKED BY
D.B.C.	K.B.
DATE	
MAY 2019	
SCALE	
1:500 H. 1:100 V.	

CITY OF IQALUIT
WASTE TRANSFER STATION

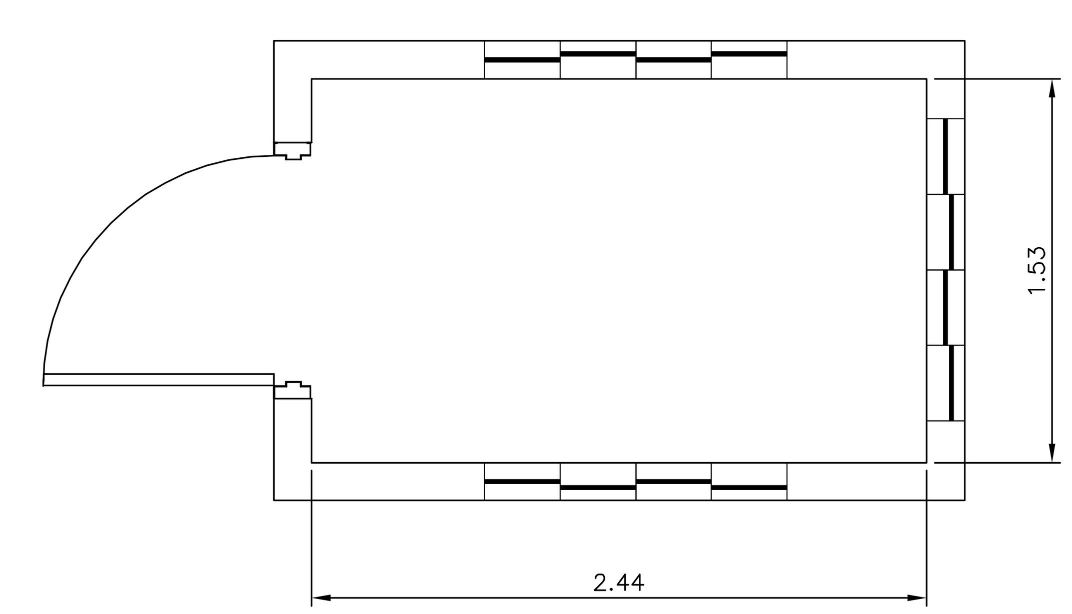
PLAN AND PROFILE

PROJECT NO. 19-9543

SHEET NO. WTS-C03



SITE OFFICE PLAN
1:25



SCALE HOUSE PLAN
1:25

0.5 0 0.5
SCALE 1:25 METRES

FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\PROJECTS 2019\SODRC\DMS12728\199543-02-SITE-CON-WTS-SCALEHOUSE.DWG PLOTTED BY: CURNEW, DOUGLAS
PLOT DATE: 2019-06-05 @ 12:33:52 PM PLOT SCALE: 1:25.4 PLOT STYLE: DILLON-STANDARD.CTB

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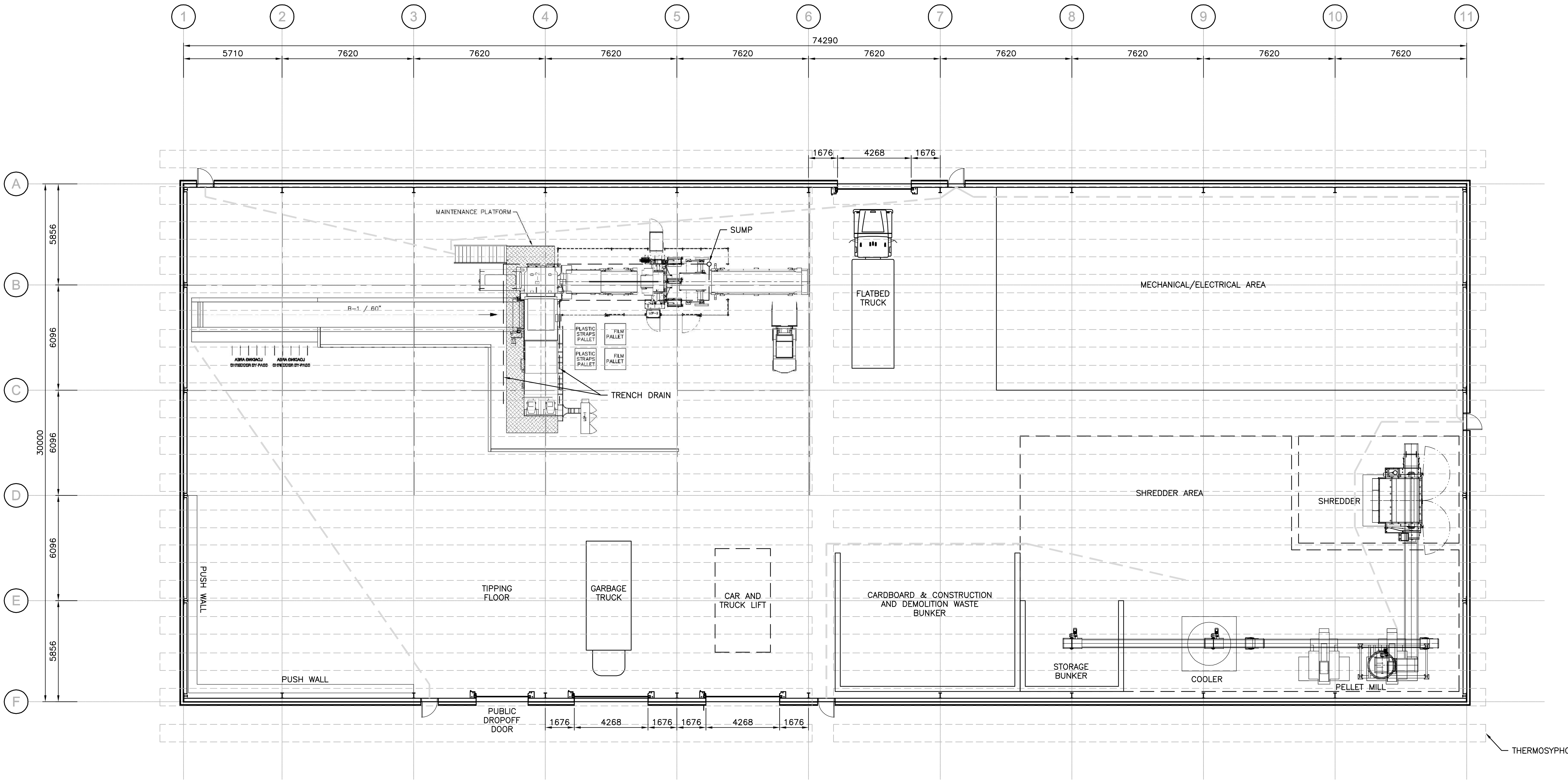
DESIGN | REVIEWED BY
DRAWN | CHECKED BY
DATE: MAY 2019
SCALE: AS NOTED

CITY OF IQALUIT
WASTE TRANSFER STATION

SITE OFFICE AND SCALE HOUSE

PROJECT NO. 19-9543

SHEET NO. **WTS-C04**



FLOOR PLAN
1:125

SCALE 1:125 METRES

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DESIGN: JAA
REVIEWED BY:
DRAWN: PDR
CHECKED BY:
DATE: MAY 2019
SCALE: NOTED

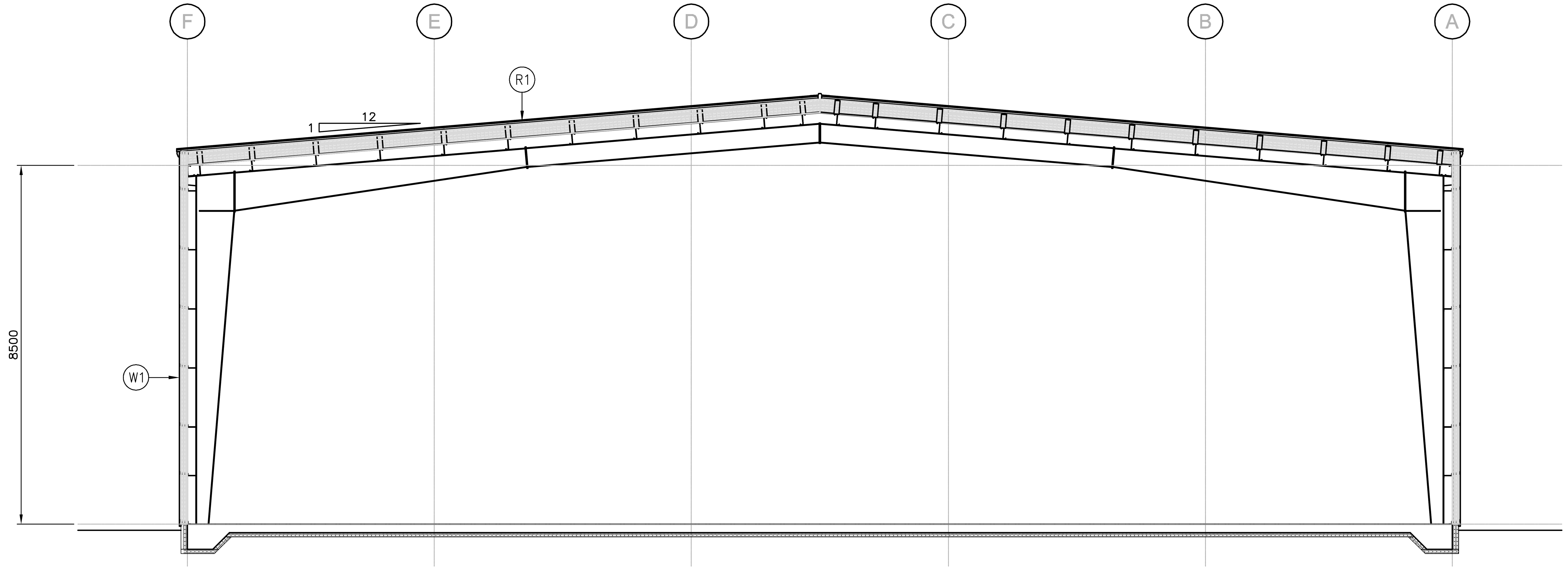
CITY OF IQALUIT
WASTE TRANSFER STATION

FLOOR PLAN

PROJECT NO. 19-9543

SHEET NO. WTS-A01

FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\PROJECTS 2019\DOCS\...\199543_01_ARCH.DWG PLOTTED BY: CURNEW, DOUGLAS
PLOT DATE: 2019-06-05 12:31:34 PM PLOT SCALE: 1:25.4 PLOT STYLE: DILLON-STANDARD.CTB



1 SECTION
A1 1:75

WALL AND PARTITION SCHEDULE	
TYPE	DESCRIPTION
W1	38 PREFINISHED METAL SIDING 152 SEMI RIGID INSULATION (R19) WITH NOTCHED Z SUB GIRTS 16 METAL LINER PANEL / VAPOUR BARIER 203 Z GIRTS
P1	TO BE DETERMINED

2 SECTION
A1 1:75

ROOF SCHEDULE	
TYPE	DESCRIPTION
R1	38 STANDING SEAM ROOF PANELS 51 HAT CHANNELS THERMAL HAT CLIPS TO PROVIDE DEPTH FOR R40 INSULATION R40 SEMI RIGID INSULATION 16 LINER PANE / VAPOUR BARRIER 254 ROOF PURLINS

1.5 0 1.5
SCALE 1:75 METRES

FILENAME: C:\PROJECTWISE\WORKING DIRECTORY\PROJECTS 2019\SDODC\DMS12728\199543_01 ARCH.DWG PLOTTED BY: CURNEW, DOUGLAS
PLOT DATE: 2019-06-05 @ 12:30:49 PM PLOT SCALE: 1:25.4 PLOT STYLE: DILLON-STANDARD.CTB

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1	30% REVIEW	2019/06/04	K.B.

DESIGN: JAA
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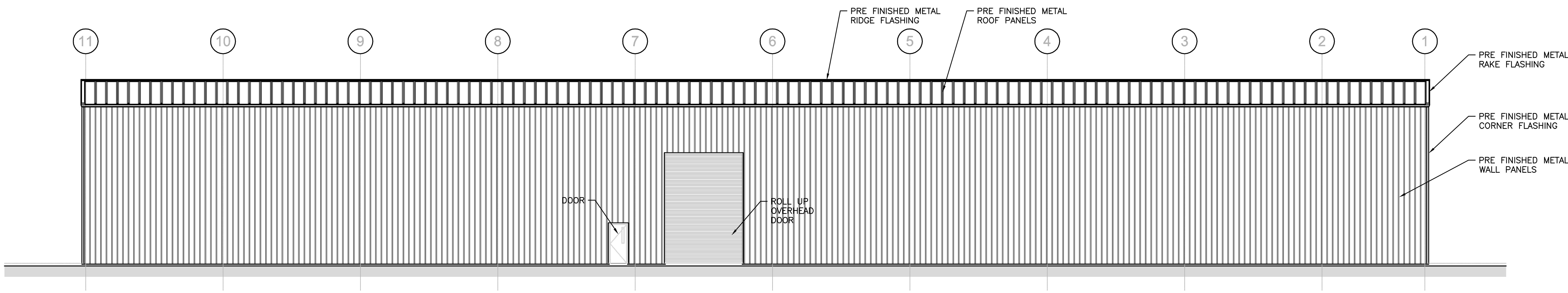
DRAWN: PDR
CHECKED BY:
DATE: MAY 2019
SCALE: NOTED

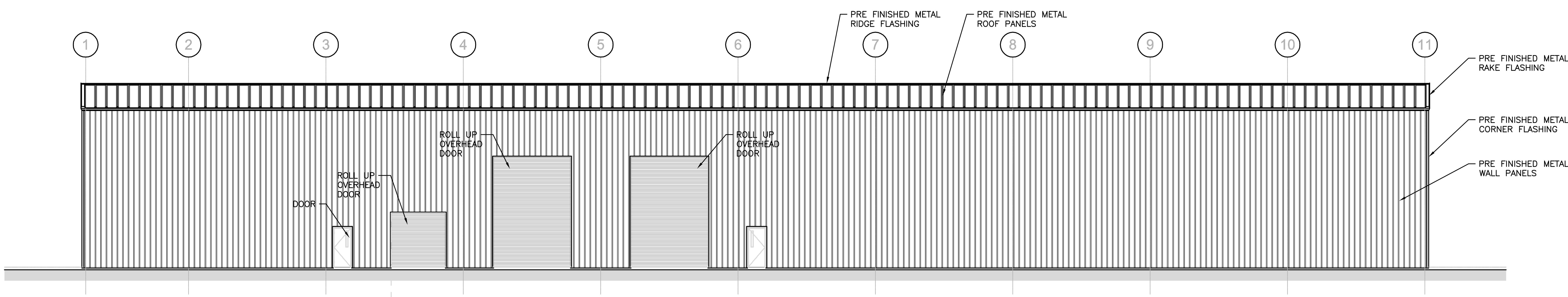
CITY OF IQALUIT
WASTE TRANSFER STATION

CROSS SECTIONS

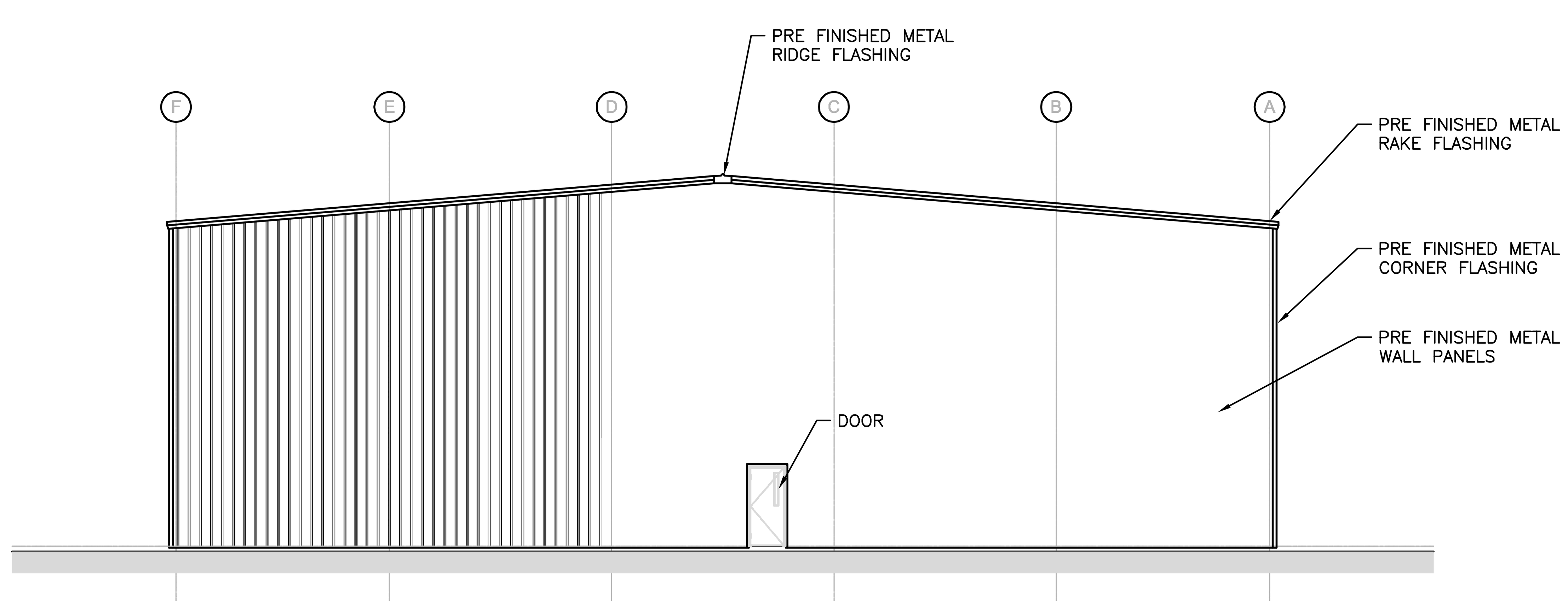
PROJECT NO. 19-9543
SHEET NO. WTS-A02



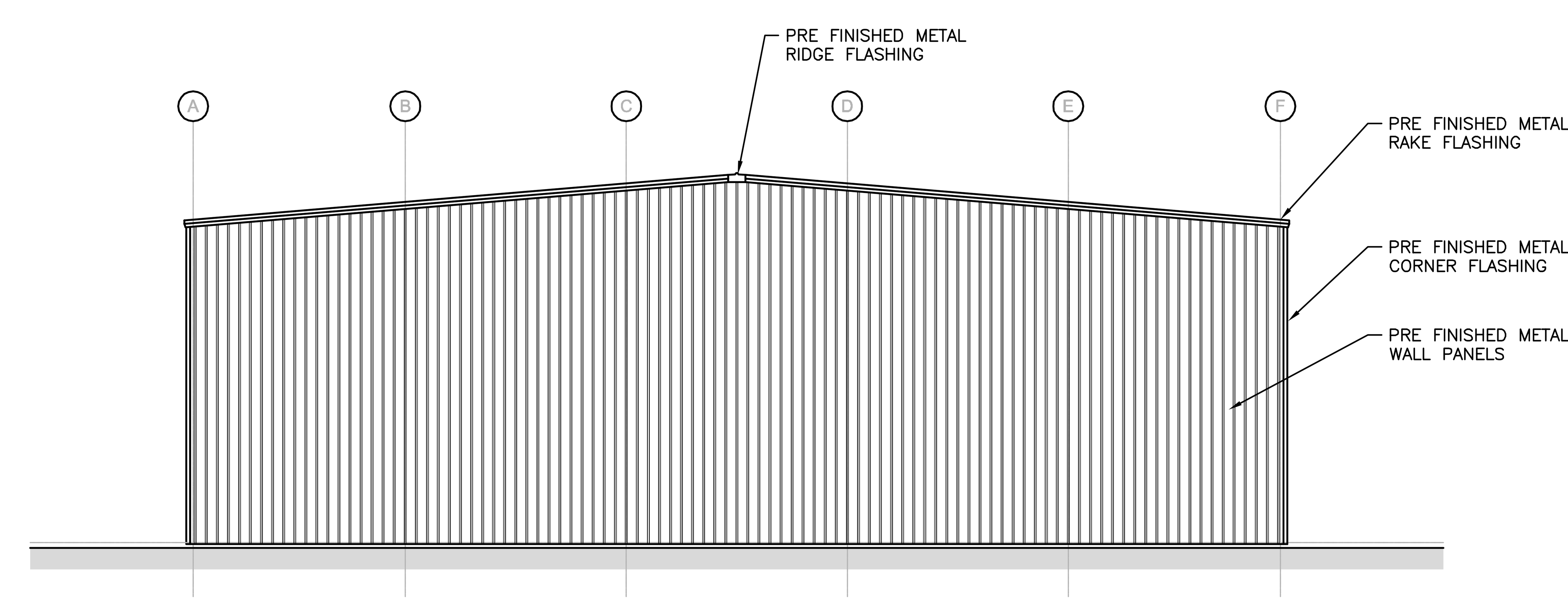
NORTH ELEVATION
1:125



SOUTH ELEVATION
1:125



EAST ELEVATION
1:125



WEST ELEVATION
1:125

2.5 0 2.5
SCALE 1:125 METRES

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DESIGN: JAA
REVIEWED BY:
DRAWN: PDR
CHECKED BY:
DATE: MAY 2019
SCALE: NOTED

CITY OF IQALUIT
WASTE TRANSFER STATION

BUILDING ELEVATIONS

PROJECT NO. 19-9543

SHEET NO. WTS-A03

GENERAL NOTES:

1. CHECK AND VERIFY ALL DIMENSIONS AND ELEVATIONS ON SITE PRIOR TO COMMENCING WITH CONSTRUCTION WORKS.
2. DO NOT SCALE FROM THE DRAWINGS.
3. THESE DRAWINGS TO BE READ IN CONJUNCTION WITH THE CONTRACT SPECIFICATIONS, CIVIL DRAWINGS, ARCHITECTURAL DRAWINGS, MECHANICAL DRAWINGS, AND ELECTRICAL DRAWINGS.
4. ALL WORK SHALL CONFORM TO THE LATEST NATIONAL BUILDING CODE 2015. ALL REFERENCES TO CODES, STANDARDS, SPECIFICATIONS, GUIDELINES, ETC. SHALL MEAN THE LATEST EDITION APPLICABLE.
5. DO NOT CONSTRUCT FROM THIS DRAWING UNLESS MARKED "ISSUED FOR CONSTRUCTION".
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR SITE PREPARATION AS PER DRAWINGS
7. TEMPORARY SUPPORT AND BRACING FOR CONSTRUCTION LOADING AND CONDITIONS IS THE RESPONSIBILITY OF THE CONTRACTOR.
8. THE CONTRACTOR SHALL BE RESPONSIBLE FOR APPLYING AND SECURING ALL NECESSARY PERMITS.
9. THE CONTRACTOR SHALL BE PRESENT AT SITE REVIEW MEETINGS.

DESIGN LOADS

CLIMATIC DATA:	CITY OF IQALUIT
IMPORTANCE FACTOR:	NORMAL
WIND LOAD	
REFERENCE HOURLY WIND PRESSURE (1/10)	0.45 kPa
REFERENCE HOURLY WIND PRESSURE (1/50)	0.58 kPa
SNOW LOAD	
S_S	2.9 kPa
S_r	0.2 kPa
SEISMIC DATA	
S_a	0.087
S_a	0.065
S_a	0.043
S_a	0.023
S_a	0.0058
S_a	0.0025
PGA	0.051
PGV	0.052
DEAD LOAD	
BUILDING	
SHREDDER	
LIVE LOAD	
STORAGE AREA	4.8 kPa

GEOTECHNICAL NOTES

1. GEOTECHNICAL INVESTIGATION WAS CONDUCTED BY EXP. SERVICES INC. AND THE GEOTECHNICAL REPORT HAS BEEN PREPARED FOR THE PROJECT DATED OCTOBER 19, 2018 ENTITLED "CITY OF IQALUIT GEOTECHNICAL INVESTIGATION" PROJ # OTT-00248813-A0.
2. GEOTHERMAL ANALYSIS WAS CONDUCTED BY WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS, DATED MAY 14, 2019, ENTITLED "GEOTHERMAL MODELLING AND GEOTECHNICAL RECOMMENDATIONS TRANSFER STATION AND LANDFILL IN IQALUIT, NUNAVUT PROJECT # CG14359.
3. SHORING IS THE RESPONSIBILITY OF THE CONTRACTOR AND SHALL BE DESIGNED BY OTHERS.

BACKFILL AND COMPACTION

1. A GEOTECHNICAL ENGINEER OR QUALIFIED PERSONNEL SHALL BE RETAINED TO INSPECT & CONFIRM THE COMPACTION AND THE FEE BE PAID FOR BY THE OWNER OR COMPACTION TESTS TO BE ARRANGED AND PAID FOR BY THE OWNER.
2. ALL BACKFILL MATERIALS AND BACKFILL PLACEMENT SHALL BE REVIEWED BY QUALIFIED GEOTECHNICAL PERSONNEL.

SITE REVIEW AND SHOP DRAWING REVIEW

1. NOTIFY THE ENGINEER 24 HOURS PRIOR TO POURING CONCRETE FOR SITE REVIEW.
2. PREPARE AND SUBMIT ALL REQUIRED SHOP DRAWINGS FOR REVIEW 7 DAYS PRIOR TO FABRICATION.
3. THE REVIEW IS ONLY FOR THE WORK SHOWN ON THE STRUCTURAL DRAWINGS AND IS TO ASCERTAIN THAT THE WORK IS IN GENERAL CONFORMANCE WITH THE DRAWINGS.
4. THE REVIEW DOES NOT RELIEVE THE CONTRACTOR RESPONSIBILITY TO PERFORM THE WORK IN CONFORMANCE WITH THE CONTRACT DOCUMENTS.
5. THE REVIEW DOES NOT RELIEVE THE CONTRACTOR RESPONSIBILITY FOR THE OMISSIONS OF THE CONTRACTOR, SUBCONTRACTORS OR TRADES PERFORMING THE WORK.

REINFORCING STEEL

1. ALL REINFORCING SHALL BE BLACK STEEL CONFORMING TO CSA G30.18, GRADE 400W.

or REINFORCING STEEL SHALL CONFORM TO CSA G30.18-09 GRADE 400. USE GRADE 400W WHERE WELDING IS REQUIRED OR NOTED.

2. ALL REBAR SHALL BE STORED ON WOOD BLOCKING AT THE SITE.
3. REINFORCEMENT SHALL BE FREE OF CLAY, DIRT AND FORM OIL OR OTHER DELETERIOUS MATERIAL WHICH WOULD REDUCE THE BOND TO CONCRETE.
4. CONCRETE COVER SHALL CONFORM TO THE FOLLOWING LIST:

SLAB BOTTOM & SIDES	75 mm
TOP OF SLAB	100 mm

5. LAP SLICE LENGTH FOR 20M SHALL BE 1200 mm.
6. CLEAR SPACING SHALL BE GREATER THAN 2 TIMES BAR DIAMETER.
7. CONTRACTOR SHALL PREPARE AND SUBMIT DETAILED REINFORCING STEEL DRAWINGS FOR REVIEW PRIOR TO COMMENCING FABRICATION.
8. DO NOT FIELD BEND REINFORCEMENT EXCEPT WHERE INDICATED AND WHERE AUTHORIZED BY THE ENGINEER.
9. REPLACE BARS WHICH DEVELOP CRACKS OR SPLITS.
10. PLACE REINFORCING STEEL IN ACCORDANCE WITH CAN/CSA-A23.1.
11. NOTIFY THE ENGINEER 24 HOURS PRIOR TO POURING CONCRETE FOR SITE REVIEW. THE REVIEW IS ONLY FOR THE WORK SHOWN ON THE STRUCTURAL DRAWINGS AND IS TO ASCERTAIN THAT THE WORK IS IN GENERAL CONFORMANCE WITH THE DRAWINGS.

CONCRETE FORMWORK

1. FORM WORK TO CONFORM TO CSA A23.1/A23.2. or THE LATEST BUILDING CODE.
2. FORM STRIPPING AGENT - COLORLESS MINERAL OIL, NON-TOXIC, BIODEGRADABLE, FREE OF KEROSENE.
3. PROVIDE BRACING TO ENSURE STABILITY OF FORMWORK.
4. DO NOT PLACE SHORES AND MUD SILLS ON FROZEN GROUND.
5. FORM WORK SHALL BE CLEANED OF DEBRIS BEFORE PLACING CONCRETE.
6. REMOVE ALL LOOSE CONCRETE FROM TOPS OF PILES.
7. ENSURE TOPS OF PILES ARE SOUND CONCRETE.
8. FORMWORK TO FOLLOW THE MAXIMUM TOLERANCES:

HORIZONTAL AND VERTICAL LINES	3/8" in 65' 0"
WALLS	¼"
CROSS SECTIONAL DIMENSION BEAMS	±1/8"
CAMBER, BEAMS	0.2% OF SPAN
CAMBER, SLABS	0.1% OF SPAN FOR ALL SPAN > 10' 0"

9. LEAVE FORM WORK IN PLACE FOR THE FOLLOWING MINIMUM OF 7 DAYS FOR GRADE BEAMS AND 5 DAYS FOR SLABS OR UNTIL THE CONCRETE HAS REACHED 70% OF ITS DESIGN STRENGTH.
10. DO NOT WEDGE PRY BARS OR HAMMERS AGAINST CONCRETE SURFACES.

CAST-IN-PLACE CONCRETE

1. CONCRETE MATERIAL, QUALITY, MIXING, PLACING, FORMWORK AND OTHER CONSTRUCTION PRACTICES TO CONFORM TO CSA A23.1/A23.2.
2. CONCRETE FALSE WORK/FORMWORKS SHALL CONFORM TO CSA A269.1.
3. ALL CONCRETE SHALL BE NORMAL WEIGHT CONCRETE.
4. ADMIXTURES CONTAINING CALCIUM CHLORIDE ARE NOT ALLOWED.
5. ALL EXPOSED CORNERS SHALL HAVE A 1" CHAMFER OR FILLET UNLESS NOTED OTHERWISE.
6. CONCRETE STRENGTH AND MIX SPECIFICATIONS ARE AS FOLLOWED, UNLESS NOTED OTHERWISE:

EXP. CLASS	SUPPLY AND USE	MAX. W/C	STRENGTH	CEMENT TYPE	SLUMP	MAX. AGG. SIZE	AIR ENTRAIN-MENT	MAX. FLY ASH CONTENT
C-1	STRUCTURAL SLAB	0.40	35 MPa @ 28 DAYS	GU	120mm ± 25mm	19mm	5% -8%	25%

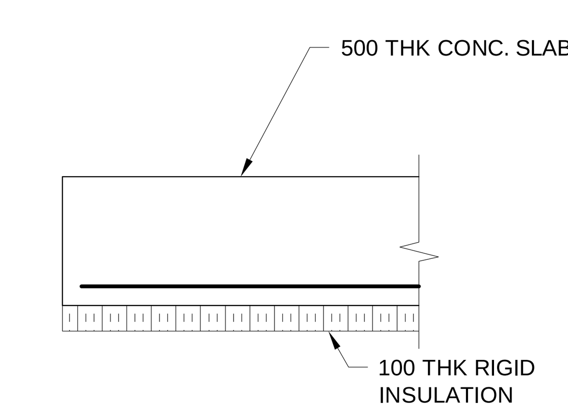
7. FINISH CONCRETE IN ACCORDANCE WITH CAN/CSA-A23.1
8. REJECT ALL CONCRETE IF BATCHING TIME AND PLACING TIME EXCEEDS TWO HOURS.
9. CONTRACTOR SHALL PREPARE AND SUBMIT CONCRETE MIX DESIGN SHOP DRAWINGS FOR REVIEW 7 DAYS PRIOR TO COMMENCING RELATED WORK.
10. PROVIDE CERTIFICATION FOR PLANT, EQUIPMENT, AND MATERIAL TO BE USED IN CONCRETE COMPLY WITH REQUIREMENTS OF CAN/CSA-123.1

HOT WEATHER REQUIREMENTS

11. WHEN THE AMBIENT TEMPERATURE IS AT OR ABOVE 25°C OR WHEN THERE IS A PROBABILITY OF THE AMBIENT TEMPERATURE RISING TO OR ABOVE 25°C DURING CONCRETE PLACEMENT, THE TEMPERATURE OF CONCRETE WHEN PLACED IS NOT TO BE MORE THAN 25°C. TO ACCOMPLISH THIS, THE MIXING WATER, IF NECESSARY THE AGGREGATES, IS TO BE COOLED.
12. WHEN POURS ARE MASSIVE OR WHERE SURFACES ARE TO BE TROWEL FINISHED, OR WOOD FLOATED, USE A RETARDER THAT WILL SLOW THE INITIAL SET OF THE CONCRETE.
13. WHEN THE AMBIENT TEMPERATURE IS AT OR ABOVE 25°C, EXPOSED SURFACES OF THE CONCRETE ARE TO BE SHADED FROM DIRECT SUN RAY AND SHELTERED FROM DIRECT WIND.
14. MOIST CURE CONCRETE WHEN THE AMBIENT TEMPERATURE IS AT OR ABOVE 25°C INSTEAD OF USING CURING COMPOUNDS.

COLD WEATHER REQUIREMENTS

15. WHEN THE AMBIENT TEMPERATURE IS AT OR BELOW 5°C OR WHEN THERE IS A PROBABILITY OF THE AMBIENT TEMPERATURE DROPPING TO OR BELOW 5°C DURING CONCRETE PLACEMENT, THE TEMPERATURE OF CONCRETE DURING PLACING SHALL BE BETWEEN 15°C AND 25°C.
16. PLACED CONCRETE SHALL BE PROTECTED AND MAINTAINED AT A TEMPERATURE OF AT LEAST 10°C FOR NOT LESS THAN 3 DAYS OR NOT LESS THAN 20°C FOR 2 DAYS AND ALL CONCRETE TO BE MAINTAINED ABOVE FREEZING FOR A MINIMUM OF 7 DAYS.
17. CONCRETE SHALL BE PROTECTED FROM ALTERNATE FREEZING AND THAWING FOR A MINIMUM OF 14 DAYS.
18. PROTECTED AND HEATED CONCRETE TO BE BROUGHT GRADUALLY TO AMBIENT AIR TEMPERATURE AT A DROP NOT MORE THAN 15°C PER 24 HOUR PERIOD.
19. HEATING ENCLOSURE SHALL BE CLEAR OF CONCRETE AND FORMING SURFACES FOR AIR CIRCULATION.
20. FROZEN CONCRETE WILL BE REJECTED.



SLAB SECTION
1:125

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DILLON CONSULTING

No.	ISSUED FOR	DATE	BY
1	30% REVIEW	2019/06/04	K.B.

DESIGN | REVIEWED BY | DRAWN | CHECKED BY

DATE: MAY 2019

SCALE

CITY OF IQALUIT
WASTE TRANSFER STATION

NOTES AND SECTION

PROJECT NO. 19-9543

SHEET NO. WTS-S01

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DATE: AUGUST 18, 2014

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN rEVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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CITY OF IQALUIT

PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

LOCATION PLAN

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	LOC-1
checked by	S.L.B.		
date	30/05/14		
scale	NTS		

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PROJECT
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE
SITE PLAN

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	SP-1
checked by	S.L.B.		
date	30/05/14		
scale	1:2000		

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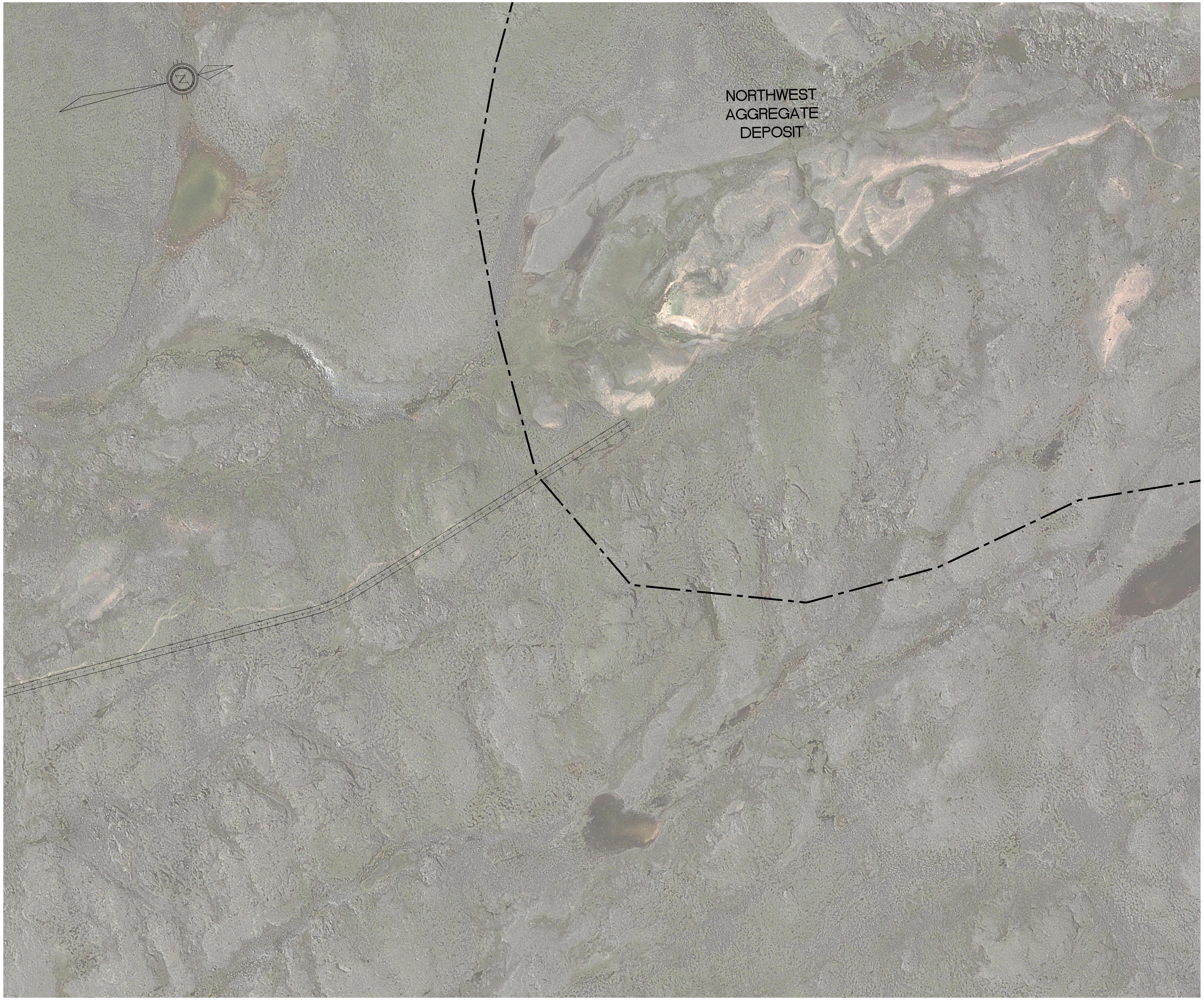
PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

SITE PLAN

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	SP-2
checked by	S.L.B.		
date	30/05/14		
scale	1:2000		



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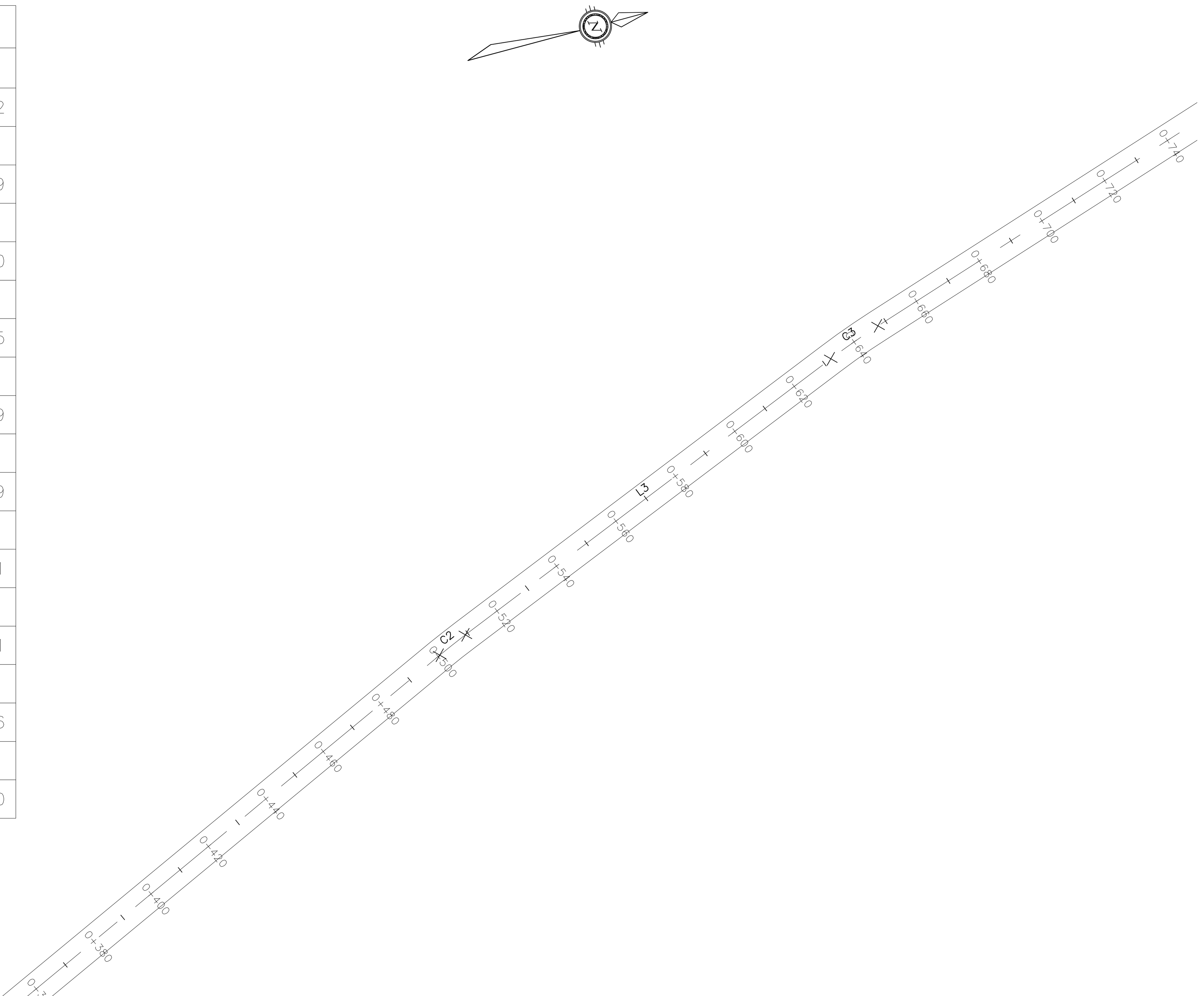
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

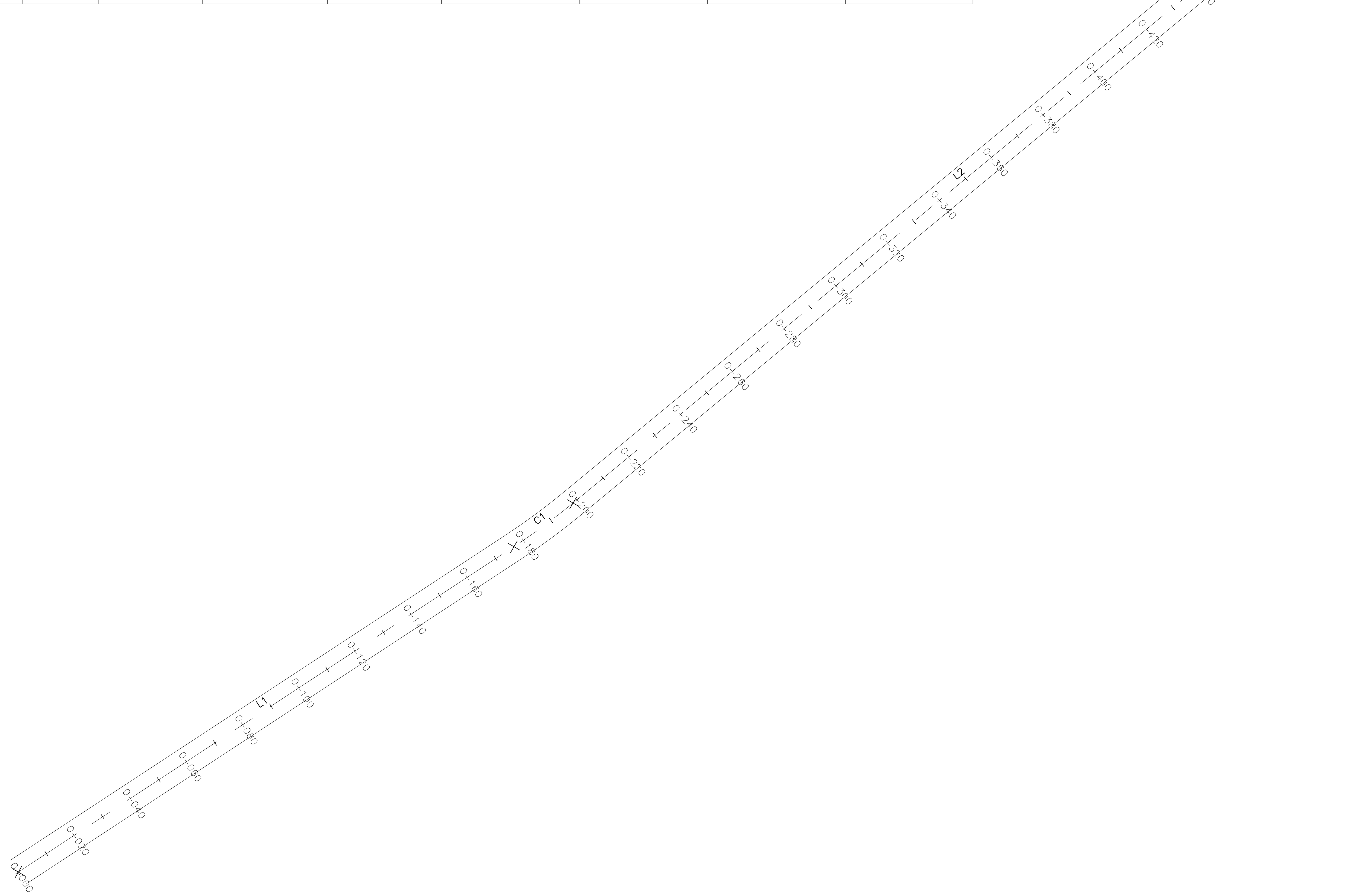
TITLE

SITE PLAN

design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	SP–3
checked by	S.L.B.		
date	30/05/14		
scale	1:2000		

Alignment – (2)									
Number	Length	Radius	Direction	Start Station	End Station	Start Northing	Start Easting	End Northing	End Easting
L1	176.480		N18° 19'W	0+00.00	1+76.48	7073535.4169	521705.3709	7073702.9573	521649.9162
C1	21.889	200.00	N21° 27'W	0+176.48	0+198.37	7073702.957	521649.916	7073723.320	521641.916
L2	302.067		N24° 35'W	1+98.37	5+00.44	7073723.3197	521641.9159	7073998.0034	521516.2439
C2	8.785	200.00	N23° 20'W	0+500.44	0+509.22	7073998.003	521516.244	7074006.069	521512.766
L3	122.924		N22° 04'W	5+09.22	6+32.14	7074006.0694	521512.7658	7074119.9876	521466.5820
C3	15.449	200.00	N19° 51'W	0+632.14	0+647.59	7074119.988	521466.582	7074134.515	521461.336
L4	236.522		N17° 39'W	6+47.59	8+84.12	7074134.5150	521461.3360	7074359.9127	521389.6525
C4	57.413	200.00	N25° 52'W	0+884.12	0+941.53	7074359.913	521389.653	7074411.396	521364.691
L5	294.979		N34° 05'W	9+41.53	12+36.51	7074411.3963	521364.6912	7074655.6865	521199.3579
C5	114.360	200.00	N17° 43'W	1+236.51	1+350.87	7074655.687	521199.358	7074763.150	521165.044
L6	441.604		N1° 20'W	13+50.87	17+92.47	7074763.1499	521165.0437	7075204.6358	521154.8099
C6	81.763	100.00	N24° 45'W	1+792.47	1+874.24	7075204.636	521154.810	7075276.836	521121.523
L7	354.459		N48° 10'W	18+74.24	22+28.69	7075276.8364	521121.5230	7075513.2117	520857.3871
C7	94.480	200.00	N34° 38'W	2+228.69	2+323.17	7075513.212	520857.387	7075590.223	520804.179
L8	388.490		N21° 06'W	23+23.17	27+11.66	7075590.2225	520804.1789	7075952.6466	520664.2731
C8	74.540	200.00	N10° 26'W	2+711.66	2+786.20	7075952.647	520664.273	7076025.531	520650.856
L9	770.804		N0° 15'E	27+86.20	35+57.01	7076025.5308	520650.8556	7076796.3278	520654.1656
C9	60.585	200.00	N8° 26'W	3+557.01	3+617.59	7076796.328	520654.166	7076856.029	520645.315
L10	352.661		N17° 07'W	36+17.59	39+70.25	7076856.0293	520645.3154	7077193.0810	520541.5580





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DATE: AUGUST 18, 2014

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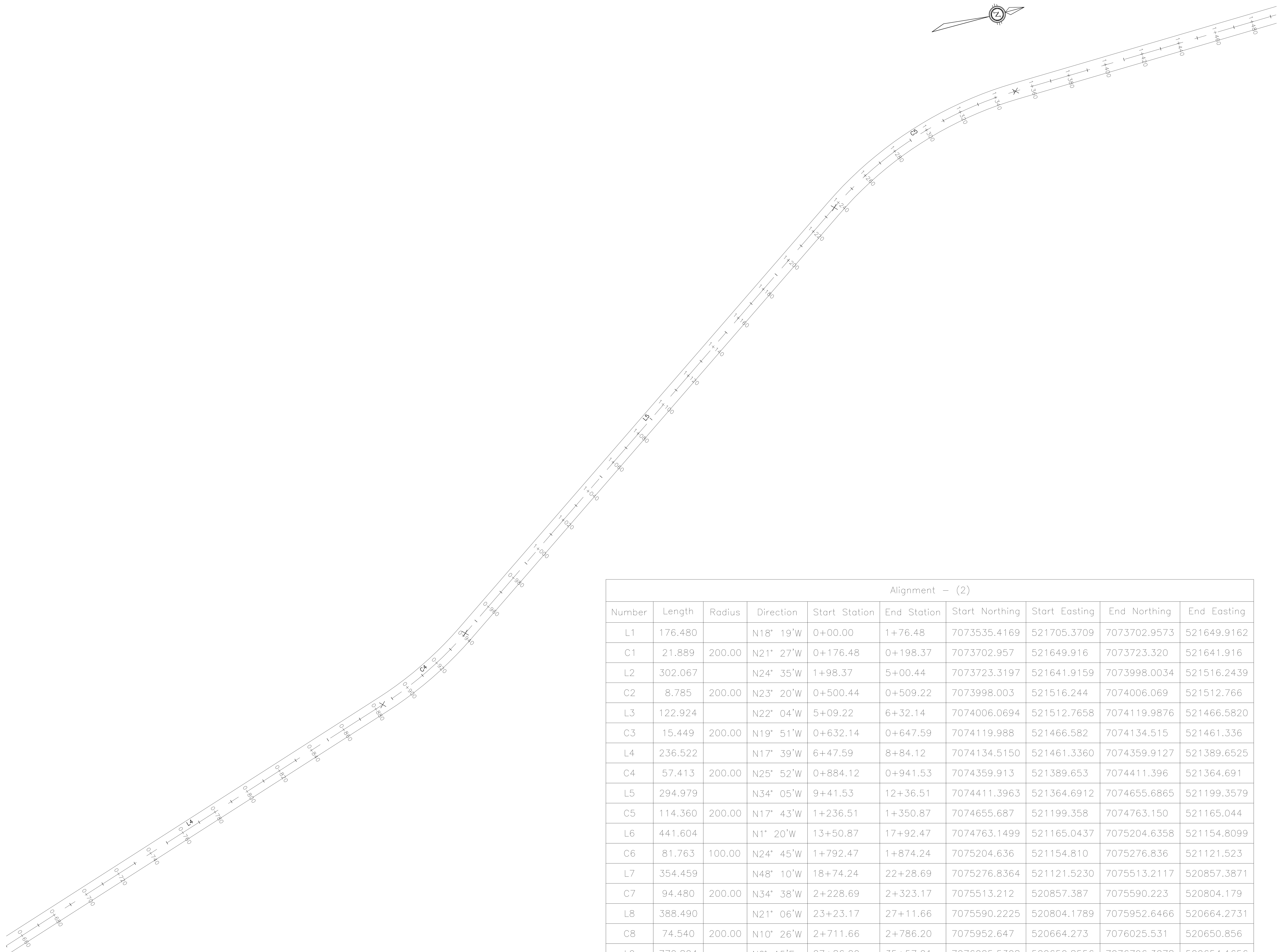
PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

LAYOUT PLAN

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	LP-1
checked by	S.L.B.		
date	30/05/14		
scale	1:1000		



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Number	Length	Radius	Direction	Start Station	End Station	Start Northing	Start Easting	End Northing	End Easting
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L8	388.490		N21° 06'W	23+23.17	27+11.66	7075590.2225	520804.1789	7075952.6466	520664.2731
C8	74.540	200.00	N10° 26'W	2+711.66	2+786.20	7075952.647	520664.273	7076025.531	520650.856
L9	770.804		N0° 15'E	27+86.20	35+57.01	7076025.5308	520650.8556	7076796.3278	520654.1656
C9	60.585	200.00	N8° 26'W	3+557.01	3+617.59	7076796.328	520654.166	7076856.029	520645.315
L10	352.661		N17° 07'W	36+17.59	39+70.25	7076856.0293	520645.3154	7077193.0810	520541.5580

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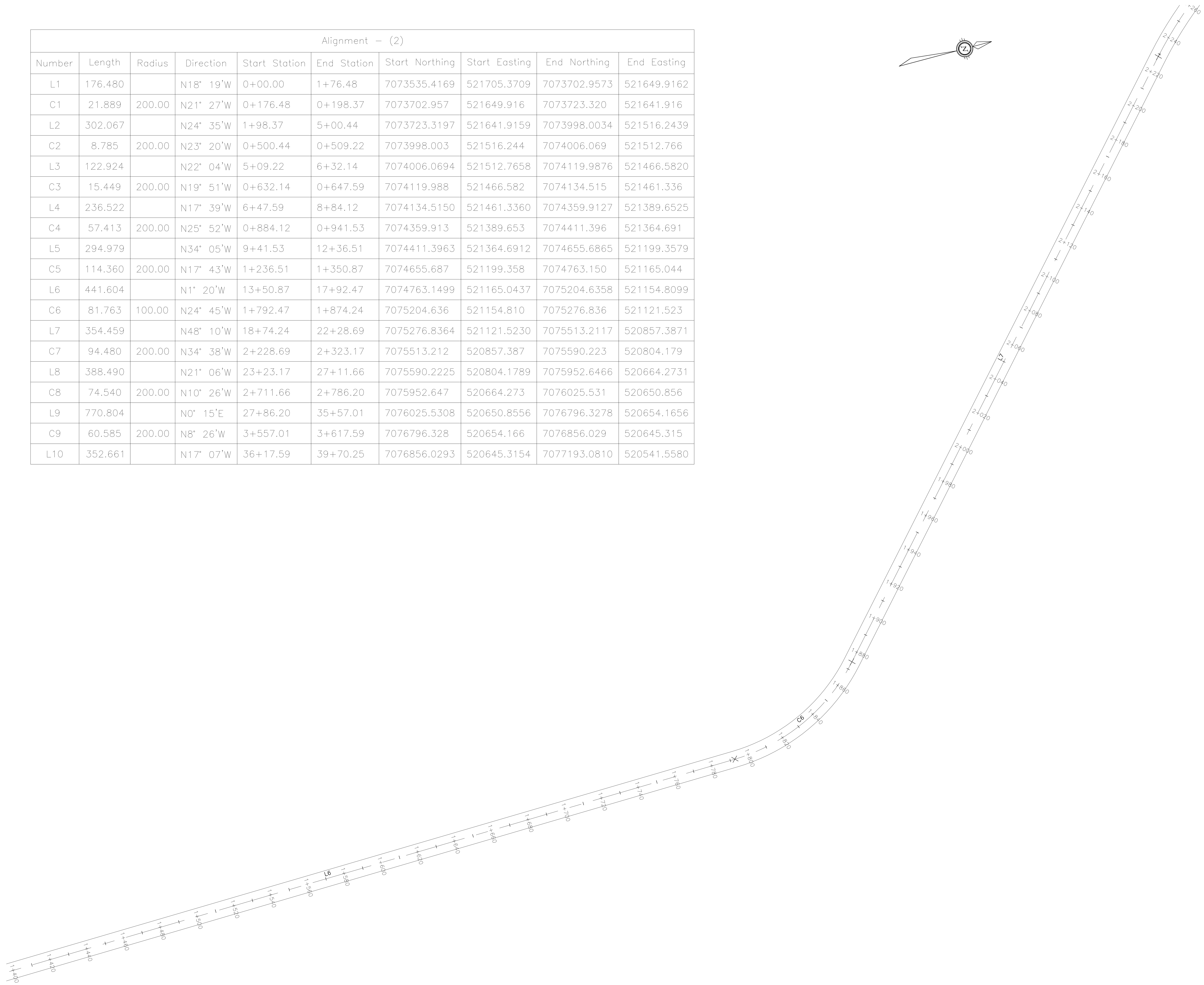
PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

LAYOUT PLAN

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	LP-2
checked by	S.L.B.		
date	30/05/14		
scale	1:1000		



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L2	302.067		N24° 35'W	1+98.37	5+00.44	7073723.3197	521641.9159	7073998.0034	521516.2439
C2	8.785	200.00	N23° 20'W	0+500.44	0+509.22	7073998.003	521516.244	7074006.069	521512.766
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L4	236.522		N17° 39'W	6+47.59	8+84.12	7074134.5150	521461.3360	7074359.9127	521389.6525
C4	57.413	200.00	N25° 52'W	0+884.12	0+941.53	7074359.913	521389.653	7074411.396	521364.691
L5	294.979		N34° 05'W	9+41.53	12+36.51	7074411.3963	521364.6912	7074655.6865	521199.3579
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L6	441.604		N1° 20'W	13+50.87	17+92.47	7074763.1499	521165.0437	7075204.6358	521154.8099
C6	81.763	100.00	N24° 45'W	1+792.47	1+874.24	7075204.636	521154.810	7075276.836	521121.523
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L8	388.490		N21° 06'W	23+23.17	27+11.66	7075590.2225	520804.1789	7075952.6466	520664.2731
C8	74.540	200.00	N10° 26'W	2+711.66	2+786.20	7075952.647	520664.273	7076025.531	520650.856
L9	770.804		N0° 15'E	27+86.20	35+57.01	7076025.5308	520650.8556	7076796.3278	520654.1656
C9	60.585	200.00	N8° 26'W	3+557.01	3+617.59	7076796.328	520654.166	7076856.029	520645.315
L10	352.661		N17° 07'W	36+17.59	39+70.25	7076856.0293	520645.3154	7077193.0810	520541.5580

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PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

LAYOUT PLAN

design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	LP–3
checked by	S.L.B.		
date	30/05/14		
scale	1:1000		

Alignment – (2)

Number	Length	Radius	Direction	Start Station	End Station	Start Northing	Start Easting	End Northing	End Easting
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C1	21.889	200.00	N21° 27'W	0+176.48	0+198.37	7073702.957	521649.916	7073723.320	521641.916
L2	302.067		N24° 35'W	1+98.37	5+00.44	7073723.3197	521641.9159	7073998.0034	521516.2439
C2	8.785	200.00	N23° 20'W	0+500.44	0+509.22	7073998.003	521516.244	7074006.069	521512.766
L3	122.924		N22° 04'W	5+09.22	6+32.14	7074006.0694	521512.7658	7074119.9876	521466.5820
C3	15.449	200.00	N19° 51'W	0+632.14	0+647.59	7074119.988	521466.582	7074134.515	521461.336
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C4	57.413	200.00	N25° 52'W	0+884.12	0+941.53	7074359.913	521389.653	7074411.396	521364.691
L5	294.979		N34° 05'W	9+41.53	12+36.51	7074411.3963	521364.6912	7074655.6865	521199.3579
C5	114.360	200.00	N17° 43'W	1+236.51	1+350.87	7074655.687	521199.358	7074763.150	521165.044
L6	441.604		N1° 20'W	13+50.87	17+92.47	7074763.1499	521165.0437	7075204.6358	521154.8099
C6	81.763	100.00	N24° 45'W	1+792.47	1+874.24	7075204.636	521154.810	7075276.836	521121.523
L7	354.459		N48° 10'W	18+74.24	22+28.69	7075276.8364	521121.5230	7075513.2117	520857.3871
C7	94.480	200.00	N34° 38'W	2+228.69	2+323.17	7075513.212	520857.387	7075590.223	520804.179
L8	388.490		N21° 06'W	23+23.17	27+11.66	7075590.2225	520804.1789	7075952.6466	520664.2731
C8	74.540	200.00	N10° 26'W	2+711.66	2+786.20	7075952.647	520664.273	7076025.531	520650.856
L9	770.804		N0° 15'E	27+86.20	35+57.01	7076025.5308	520650.8556	7076796.3278	520654.1656
C9	60.585	200.00	N8° 26'W	3+557.01	3+617.59	7076796.328	520654.166	7076856.029	520645.315
L10	352.661		N17° 07'W	36+17.59	39+70.25	7076856.0293	520645.3154	7077193.0810	520541.5580

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DATE: AUGUST 18, 2014

BENCH MARK

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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CITY OF IQALUIT

PROJECT

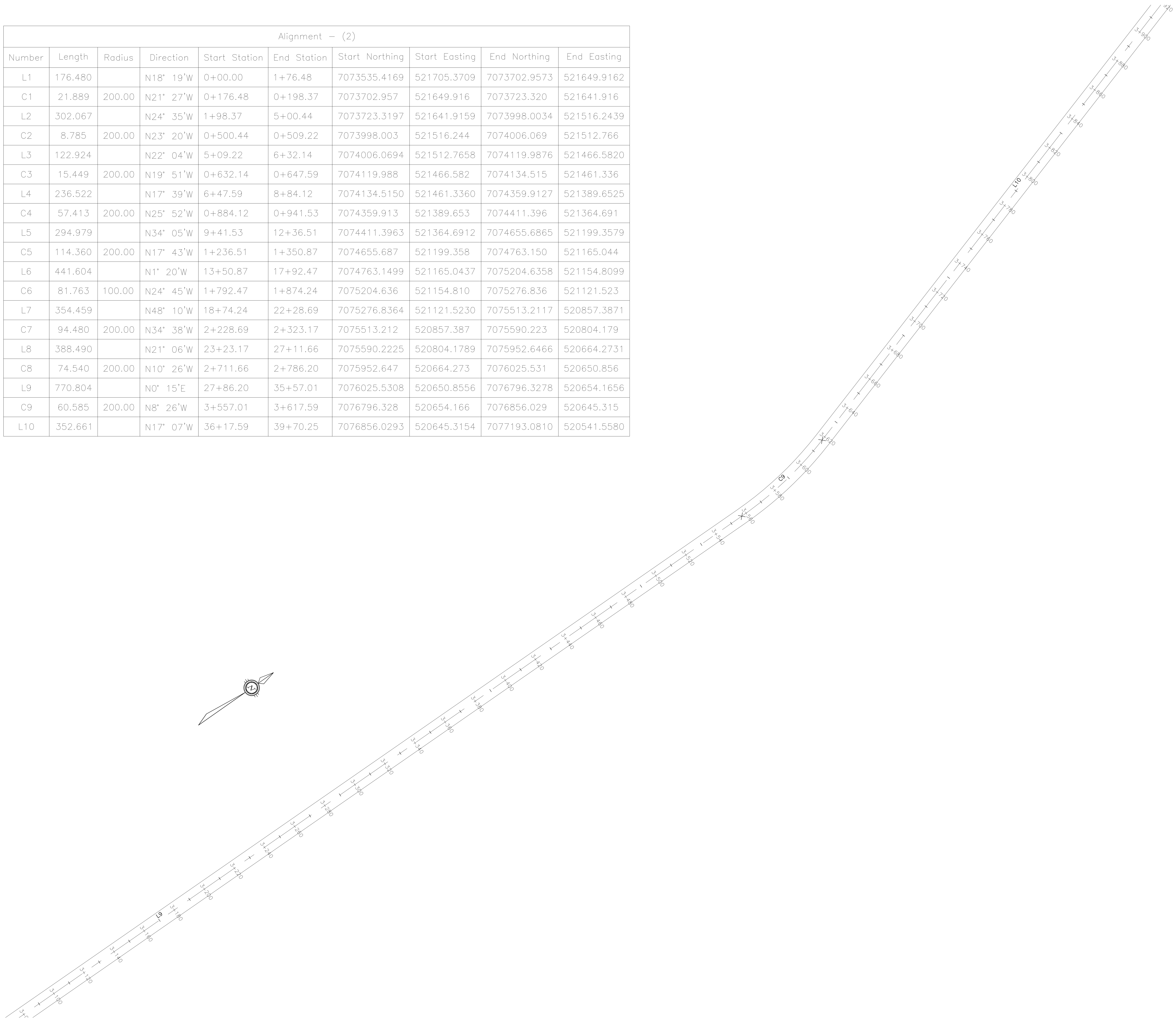
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

LAYOUT PLAN

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	LP-4
checked by	S.L.B.		
date	30/05/14		
scale	1:1000		

Alignment – (2)									
Number	Length	Radius	Direction	Start Station	End Station	Start Northing	Start Easting	End Northing	End Easting
L1	176.480		N18° 19'W	0+00.00	1+76.48	7073535.4169	521705.3709	7073702.9573	521649.9162
C1	21.889	200.00	N21° 27'W	0+176.48	0+198.37	7073702.957	521649.916	7073723.320	521641.916
L2	302.067		N24° 35'W	1+98.37	5+00.44	7073723.3197	521641.9159	7073998.0034	521516.2439
C2	8.785	200.00	N23° 20'W	0+500.44	0+509.22	7073998.003	521516.244	7074006.069	521512.766
L3	122.924		N22° 04'W	5+09.22	6+32.14	7074006.0694	521512.7658	7074119.9876	521466.5820
C3	15.449	200.00	N19° 51'W	0+632.14	0+647.59	7074119.988	521466.582	7074134.515	521461.336
L4	236.522		N17° 39'W	6+47.59	8+84.12	7074134.5150	521461.3360	7074359.9127	521389.6525
C4	57.413	200.00	N25° 52'W	0+884.12	0+941.53	7074359.913	521389.653	7074411.396	521364.691
L5	294.979		N34° 05'W	9+41.53	12+36.51	7074411.3963	521364.6912	7074655.6865	521199.3579
C5	114.360	200.00	N17° 43'W	1+236.51	1+350.87	7074655.687	521199.358	7074763.150	521165.044
L6	441.604		N1° 20'W	13+50.87	17+92.47	7074763.1499	521165.0437	7075204.6358	521154.8099
C6	81.763	100.00	N24° 45'W	1+792.47	1+874.24	7075204.636	521154.810	7075276.836	521121.523
L7	354.459		N48° 10'W	18+74.24	22+28.69	7075276.8364	521121.5230	7075513.2117	520857.3871
C7	94.480	200.00	N34° 38'W	2+228.69	2+323.17	7075513.212	520857.387	7075590.223	520804.179
L8	388.490		N21° 06'W	23+23.17	27+11.66	7075590.2225	520804.1789	7075952.6466	520664.2731
C8	74.540	200.00	N10° 26'W	2+711.66	2+786.20	7075952.647	520664.273	7076025.531	520650.856
L9	770.804		N0° 15'E	27+86.20	35+57.01	7076025.5308	520650.8556	7076796.3278	520654.1656
C9	60.585	200.00	N8° 26'W	3+557.01	3+617.59	7076796.328	520654.166	7076856.029	520645.315
L10	352.661		N17° 07'W	36+17.59	39+70.25	7076856.0293	520645.3154	7077193.0810	520541.5580



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DATE: AUGUST 18, 2014

BENCH MARK

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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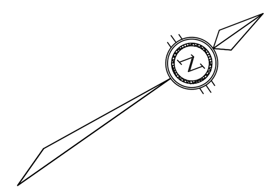
PROJECT

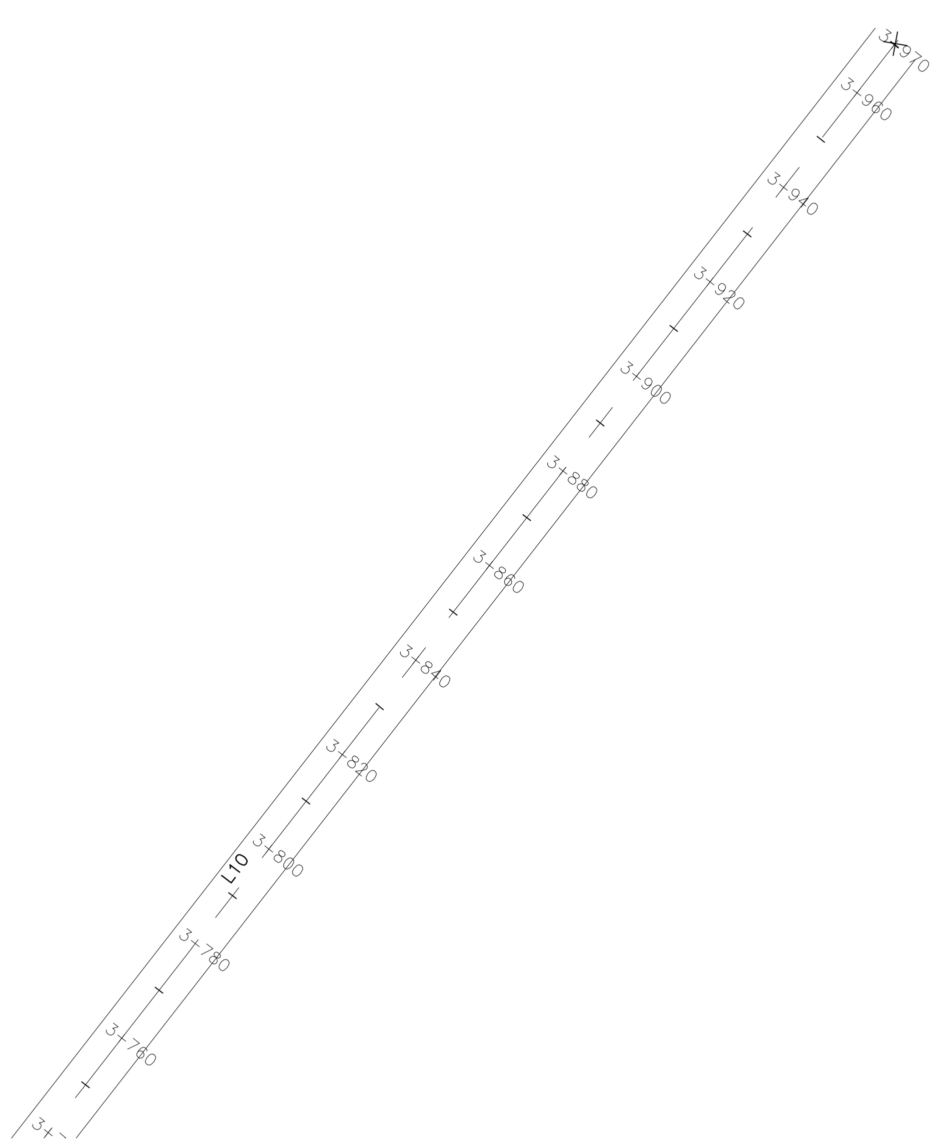
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

LAYOUT PLAN

design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	LP–5
checked by	S.L.B.		
date	30/05/14		
scale	1:1000		





Alignment - (2)									
Number	Length	Radius	Direction	Start Station	End Station	Start Northing	Start Easting	End Northing	End Easting
L1	176.480		N18° 19'W	0+00.00	1+76.48	7073535.4169	521705.3709	7073702.9573	521649.9162
C1	21.889	200.00	N21° 27'W	0+176.48	0+198.37	7073702.957	521649.916	7073723.320	521641.916
L2	302.067		N24° 35'W	1+98.37	5+00.44	7073723.3197	521641.9159	7073998.0034	521516.2439
C2	8.785	200.00	N23° 20'W	0+500.44	0+509.22	7073998.003	521516.244	7074006.069	521512.766
L3	122.924		N22° 04'W	5+09.22	6+32.14	7074006.0694	521512.7658	7074119.9876	521466.5820
C3	15.449	200.00	N19° 51'W	0+632.14	0+647.59	7074119.988	521466.582	7074134.515	521461.336
L4	236.522		N17° 39'W	6+47.59	8+84.12	7074134.5150	521461.3360	7074359.9127	521389.6525
C4	57.413	200.00	N25° 52'W	0+884.12	0+941.53	7074359.913	521389.653	7074411.396	521364.691
L5	294.979		N34° 05'W	9+41.53	12+36.51	7074411.3963	521364.6912	7074655.6865	521199.3579
C5	114.360	200.00	N17° 43'W	1+236.51	1+350.87	7074655.687	521199.358	7074763.150	521165.044
L6	441.604		N1° 20'W	13+50.87	17+92.47	7074763.1499	521165.0437	7075204.6358	521154.8099
C6	81.763	100.00	N24° 45'W	1+792.47	1+874.24	7075204.636	521154.810	7075276.836	521121.523
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C7	94.480	200.00	N34° 38'W	2+228.69	2+323.17	7075513.212	520857.387	7075590.223	520804.179
L8	388.490		N21° 06'W	23+23.17	27+11.66	7075590.2225	520804.1789	7075952.6466	520664.2731
C8	74.540	200.00	N10° 26'W	2+711.66	2+786.20	7075952.647	520664.273	7076025.531	520650.856
L9	770.804		N0° 15'E	27+86.20	35+57.01	7076025.5308	520650.8556	7076796.3278	520654.1656
C9	60.585	200.00	N8° 26'W	3+557.01	3+617.59	7076796.328	520654.166	7076856.029	520645.315
L10	352.661		N17° 07'W	36+17.59	39+70.25	7076856.0293	520645.3154	7077193.0810	520541.5580

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DATE: AUGUST 18, 2014

BENCH MARK

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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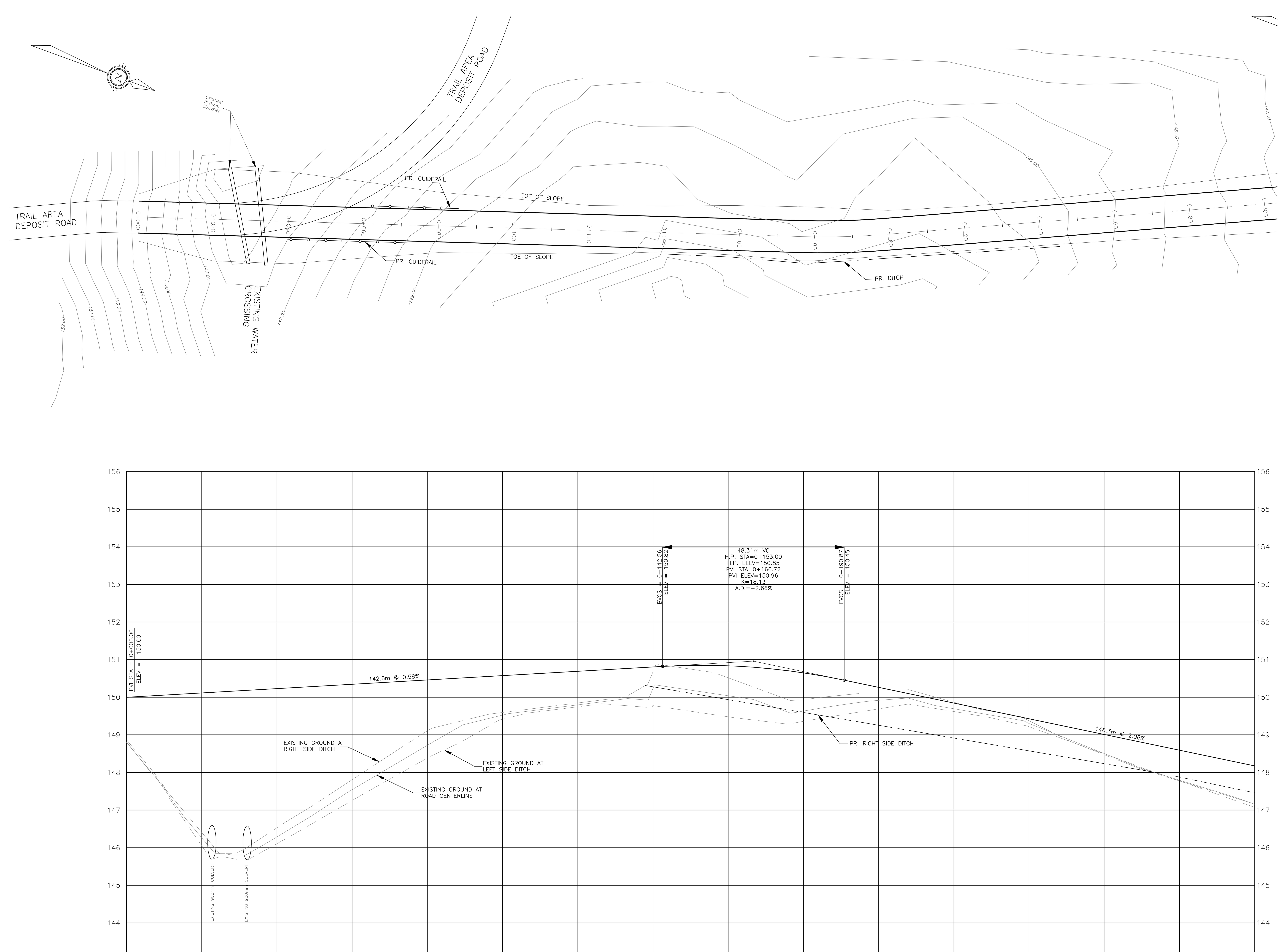
CITY OF IQALUIT

PROJECT
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE
LAYOUT PLAN

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	LP-6
checked by	S.L.B.		
date	30/05/14		
scale	1:1000		



	0+000	0+020	0+040	0+060	0+080	0+100	0+120	0+140	0+160	0+180	0+200	0+220	0+240	0+260	0+280	0+300
PROPOSED ROAD ℄ ELEVATION	150.00	150.12	150.23	150.35	150.46	150.58	150.69	150.81	150.84	150.65	150.26	149.85	149.43	149.01	148.59	148.17
EXISTING ℄ R.O.W ELEVATION	148.80	146.26	146.29	147.54	148.72	149.53	149.80	150.23	150.04	149.63	149.92	149.69	149.30	148.50	147.60	147.15

CHAINAGE

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

ISSUED FOR TENDER PURPOSES ONLY

DATE: AUGUST 18, 2014

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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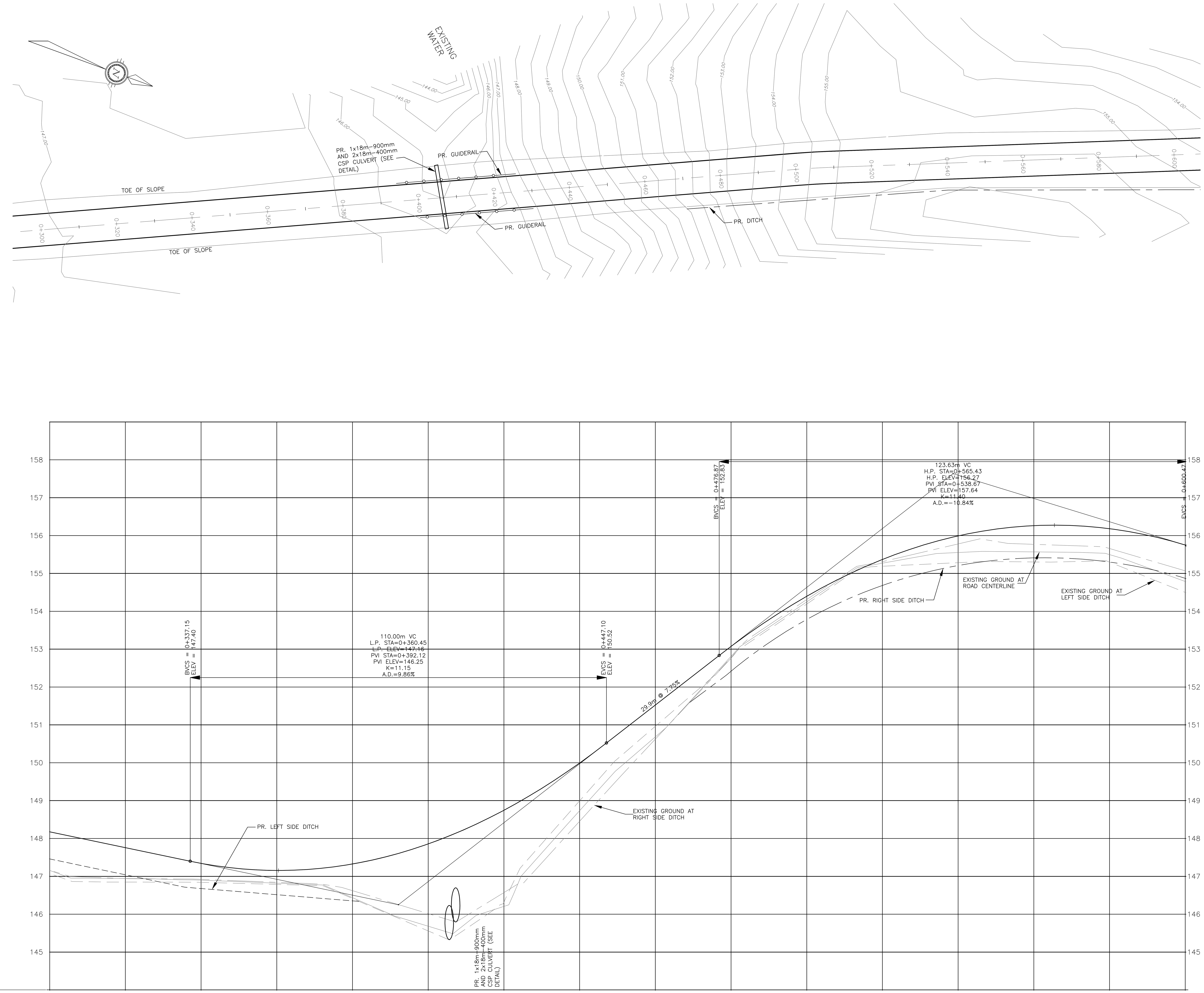
PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

PLAN & PROFILE

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	PP-1
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		



PROPOSED ROAD ℄ ELEVATION	148.17	147.76	147.34	147.16	147.33	147.86	148.75	149.99	151.52	153.07	154.40	155.37	155.99	156.26	156.18	155.75
EXISTING ℄ R.O.W ELEVATION	147.15	146.94	146.90	146.82	146.44	145.68	146.21	148.73	150.68	152.81	154.25	155.27	155.55	155.57	155.50	154.79
CHAINAGE	0+300	0+320	0+340	0+360	0+380	0+400	0+420	0+440	0+460	0+480	0+500	0+520	0+540	0+560	0+580	0+600

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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DATE: AUGUST 18, 2014

BENCH MARK

No.	DESCRIPTION	DATE	BY	APP'D
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02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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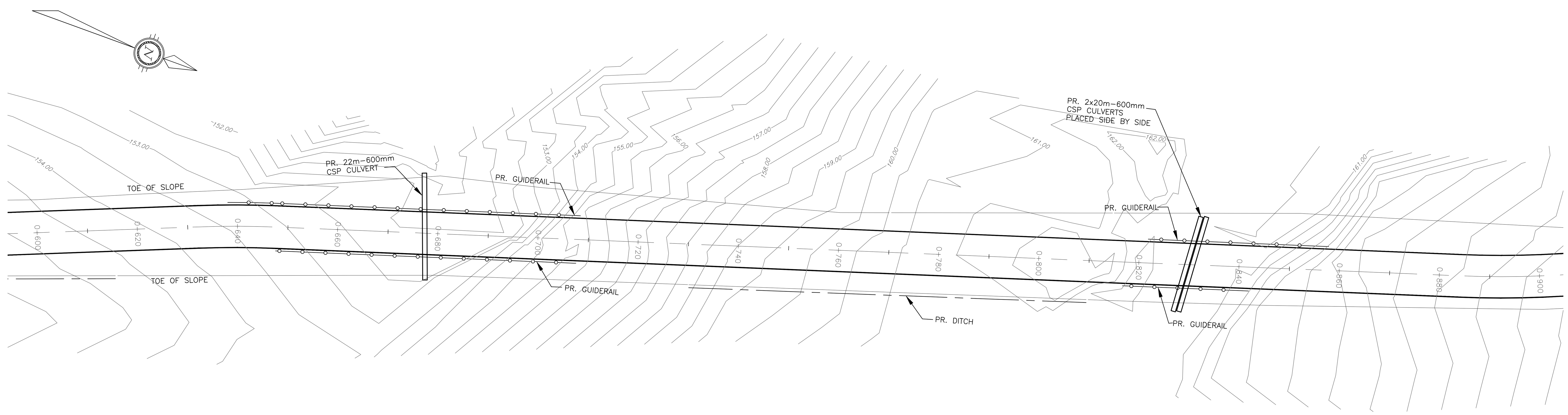
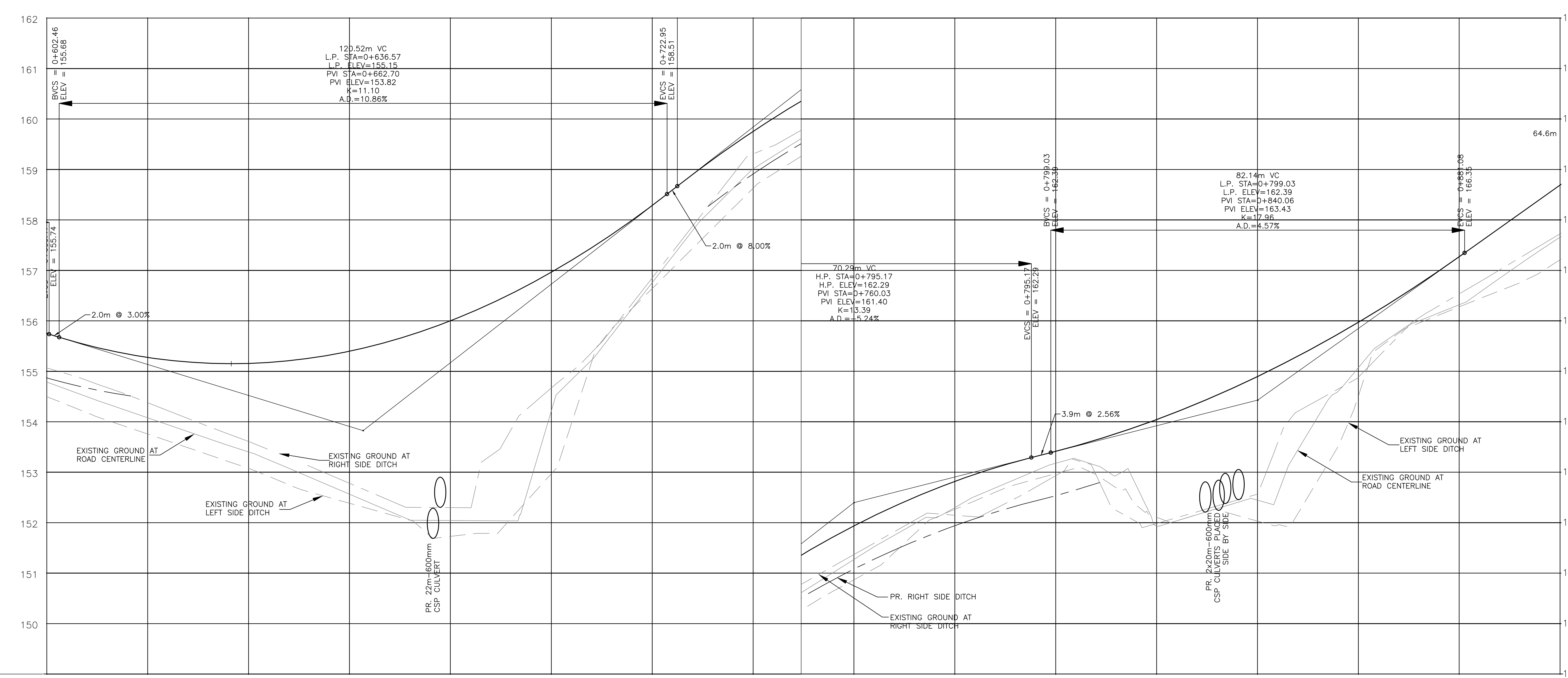
PROJECT
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE
PLAN & PROFILE

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	PP–2
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		





PROPOSED ROAD ℄ ELEVATION	155.75	155.27	155.16	155.40	156.00	156.96	158.29	159.75	160.94	161.82	162.41	163.04	163.90	164.97	166.27	167.69
EXISTING ℄ R.O.W ELEVATION	154.79	154.08	153.40	152.56	152.04	154.21	156.76	159.01	160.27	161.30	162.18	160.94	161.45	164.07	165.32	166.65
CHAINAGE	0+600	0+620	0+640	0+660	0+680	0+700	0+720	0+740	0+760	0+780	0+800	0+820	0+840	0+860	0+880	0+900

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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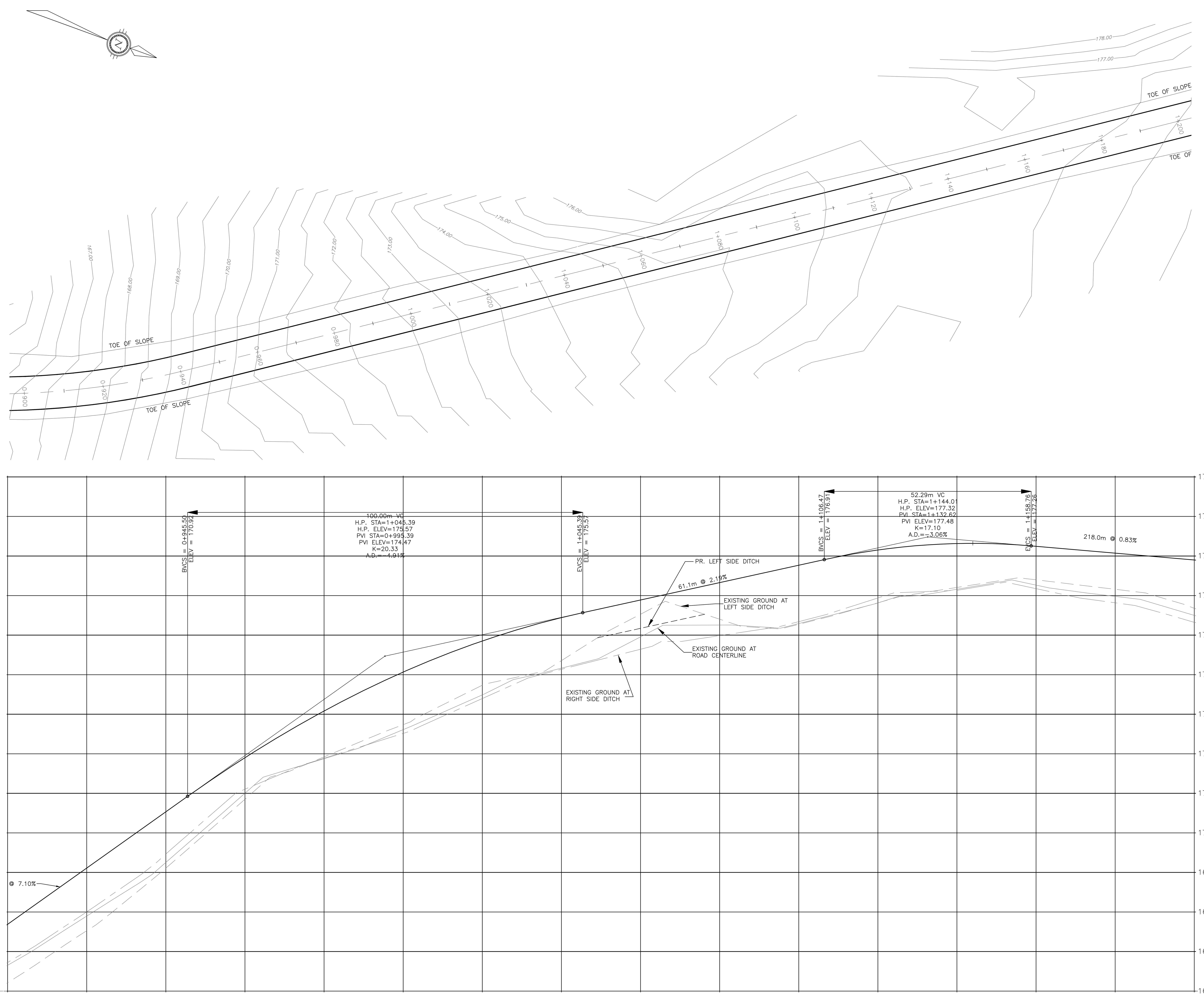
PROJECT
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE
PLAN & PROFILE

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	PP-3
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		



CHAINAGE	PROPOSED ROAD ℄ ELEVATION	EXISTING ℄ R.O.W ELEVATION
0+900	167.69	166.65
0+920	169.11	167.90
0+940	170.53	169.25
0+960	171.90	171.00
0+980	173.08	171.88
1+000	174.07	172.61
1+020	174.85	173.49
1+040	175.44	174.17
1+060	175.89	174.96
1+080	176.33	175.25
1+100	176.77	175.29
1+120	177.15	175.81
1+140	177.32	176.16
1+160	177.25	176.26
1+180	177.07	175.98
1+200	176.90	175.50

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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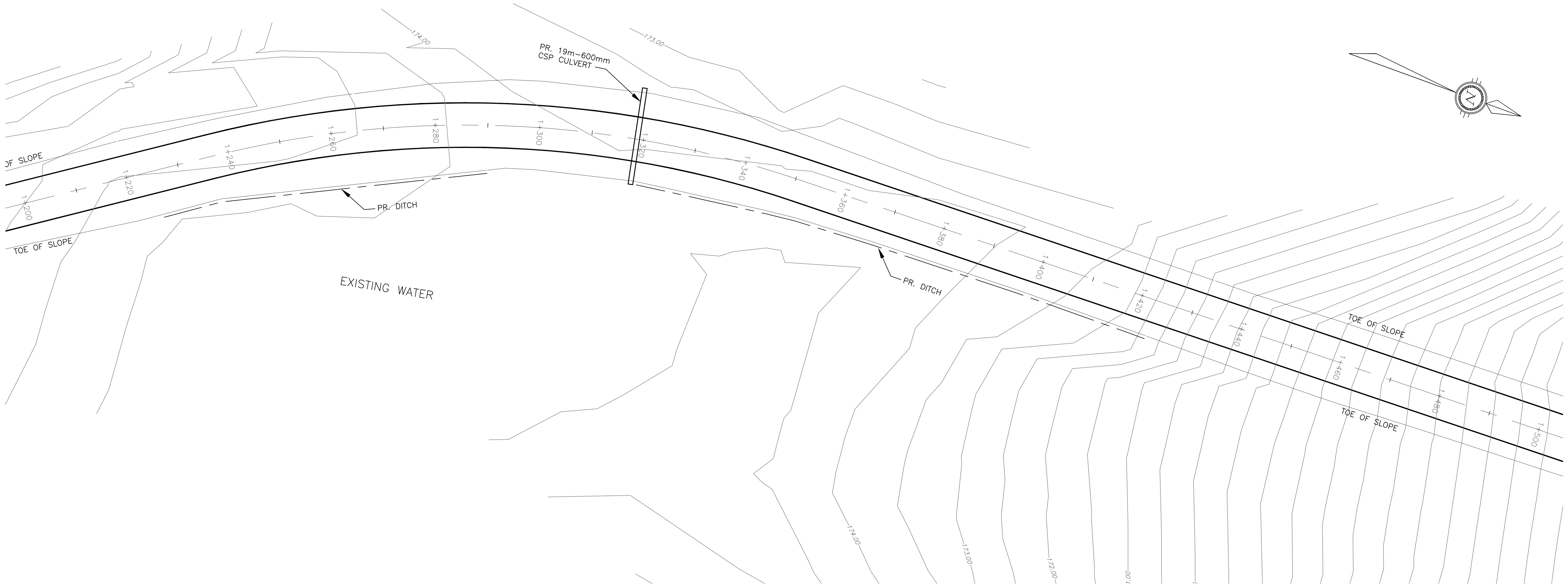
PROJECT

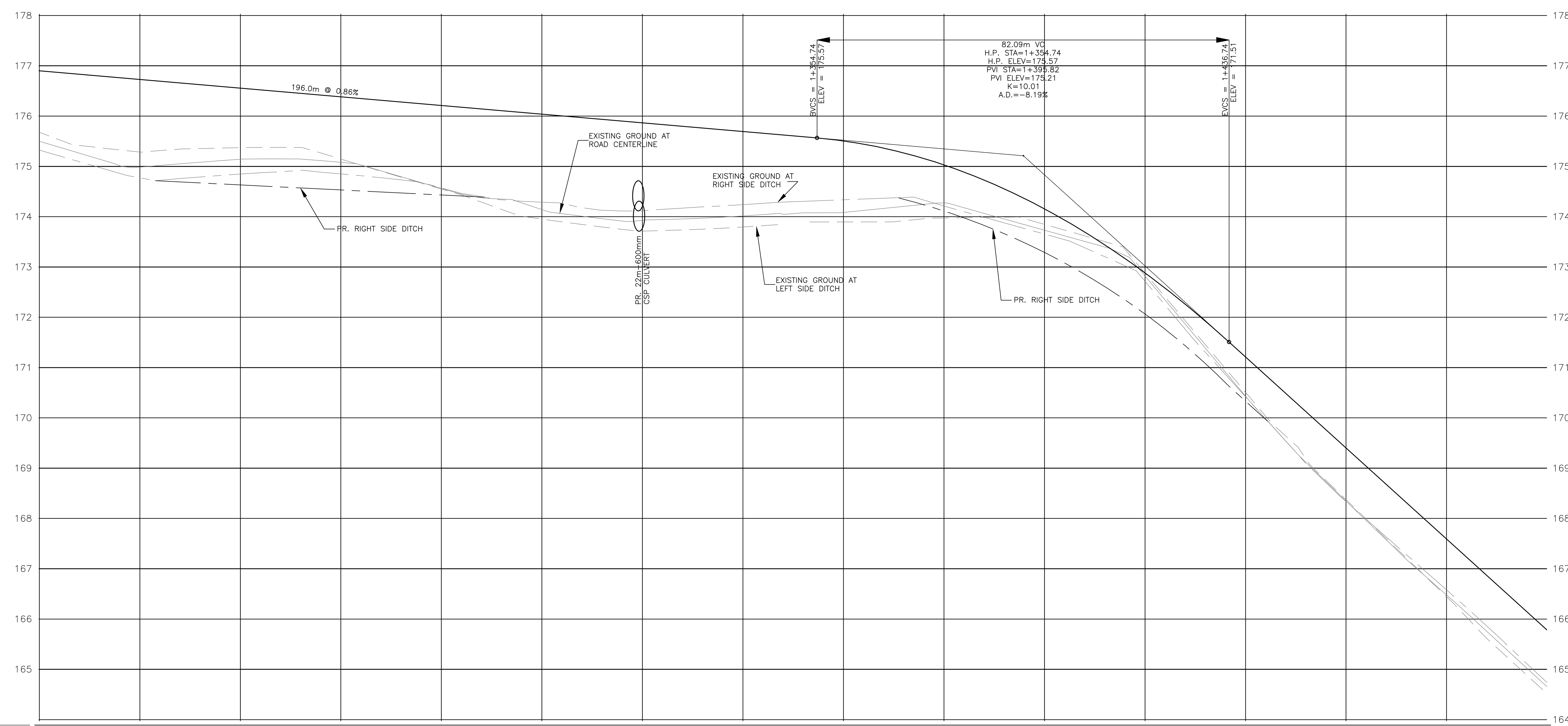
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

PLAN & PROFILE

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	PP-4
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		





CHAINAGE	PROPOSED ROAD ℄ ELEVATION	EXISTING ℄ R.O.W ELEVATION
1+200	176.90	175.50
1+220	176.73	174.98
1+240	176.56	175.14
1+260	176.38	175.08
1+280	176.21	174.56
1+300	176.04	174.14
1+320	175.87	173.93
1+340	175.69	174.02
1+360	175.51	174.08
1+380	175.03	174.27
1+400	174.16	173.73
1+420	172.88	172.82
1+440	171.21	170.43
1+460	169.40	168.35
1+480	167.59	166.48
1+500	165.78	164.65

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
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- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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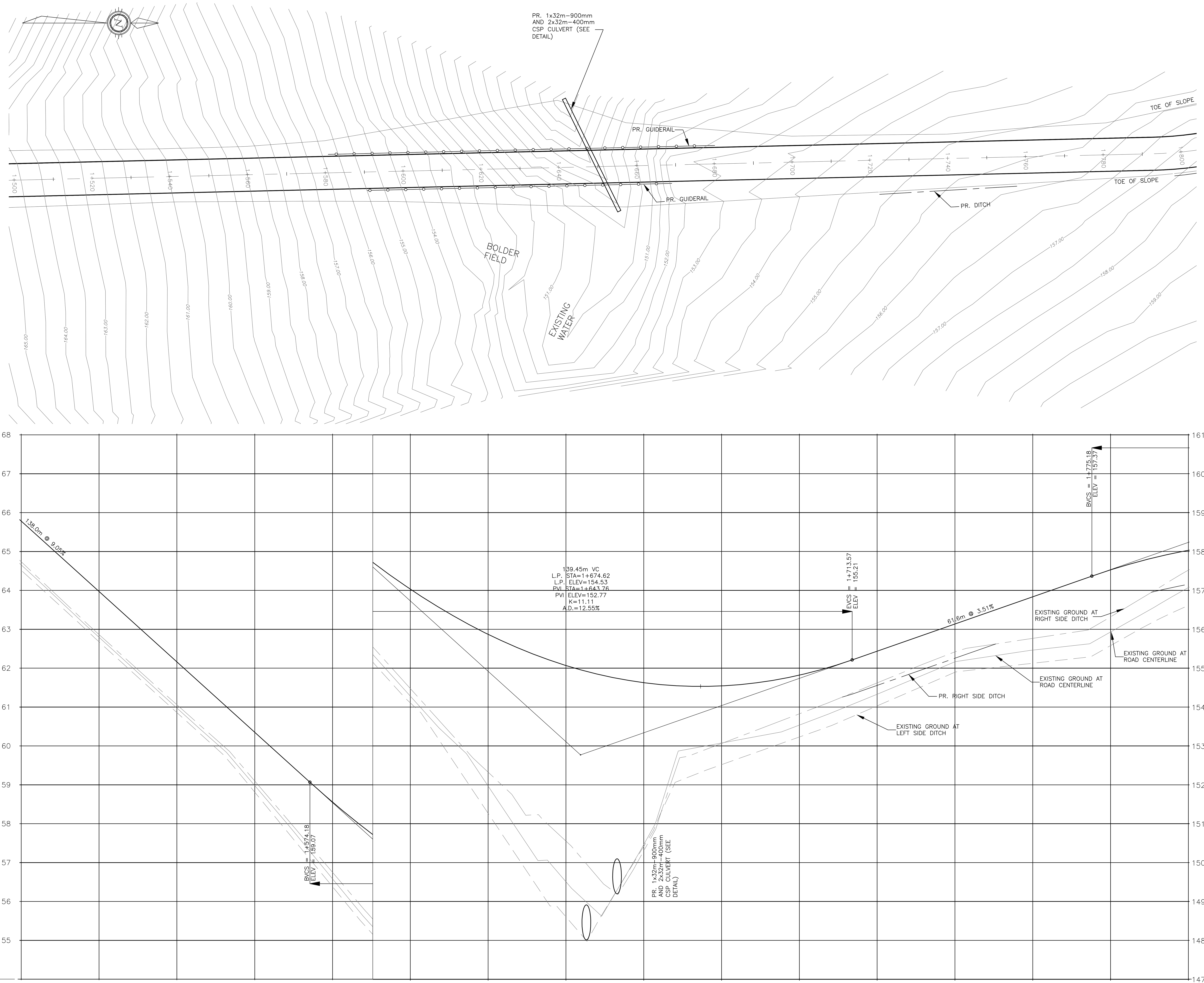
PROJECT
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE
PLAN & PROFILE

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	PP-5
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		



CHAINAGE	PROPOSED ROAD ℄ ELEVATION	EXISTING ℄ R.O.W ELEVATION
1+500	165.78	164.65
1+520	163.97	162.79
1+540	162.16	160.97
1+560	160.35	158.98
1+580	158.56	156.58
1+600	157.03	154.28
1+620	155.87	151.97
1+640	155.07	149.51
1+660	154.63	150.46
1+680	154.54	153.08
1+700	154.82	153.54
1+720	155.44	154.33
1+740	156.14	155.16
1+760	156.84	155.46
1+780	157.53	155.93
1+800	158.03	157.07

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

ISSUED FOR TENDER PURPOSES ONLY

DATE: AUGUST 18, 2014

BENCH MARK

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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CITY OF IQALUIT

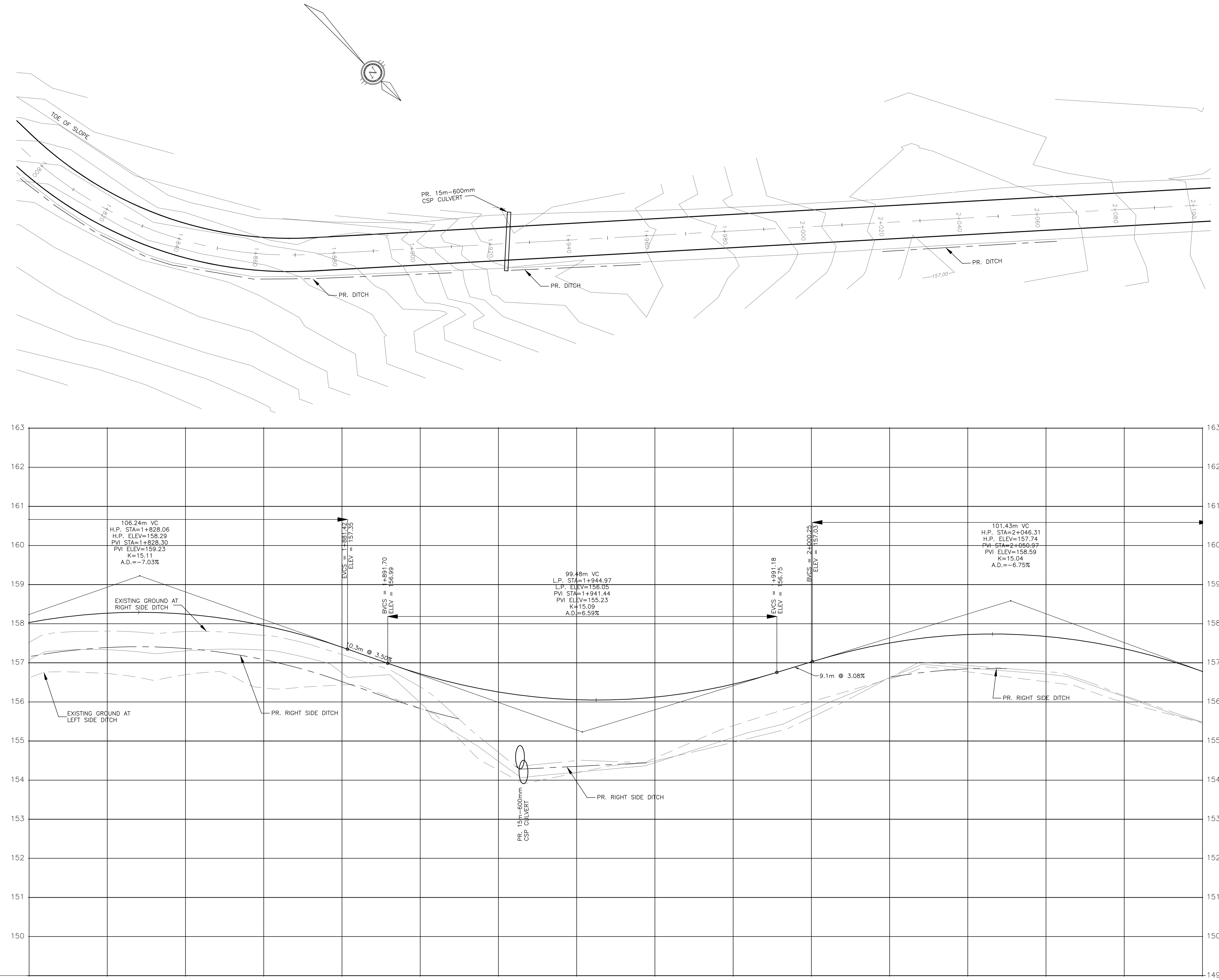
PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

PLAN & PROFILE

design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	PP–6
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		



PROPOSED ROAD ℄ ELEVATION	158.03	158.27	158.24	157.95	157.40	156.72	156.25	156.05	156.12	156.45	157.02	157.51	157.72	157.68	157.36	156.78
EXISTING ℄ R.O.W ELEVATION	157.07	157.33	157.30	157.32	156.74	155.98	154.48	154.20	154.44	155.09	155.78	156.62	156.87	156.71	156.13	155.48
CHAINAGE	1+800	1+820	1+840	1+860	1+880	1+900	1+920	1+940	1+960	1+980	2+000	2+020	2+040	2+060	2+080	2+100

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
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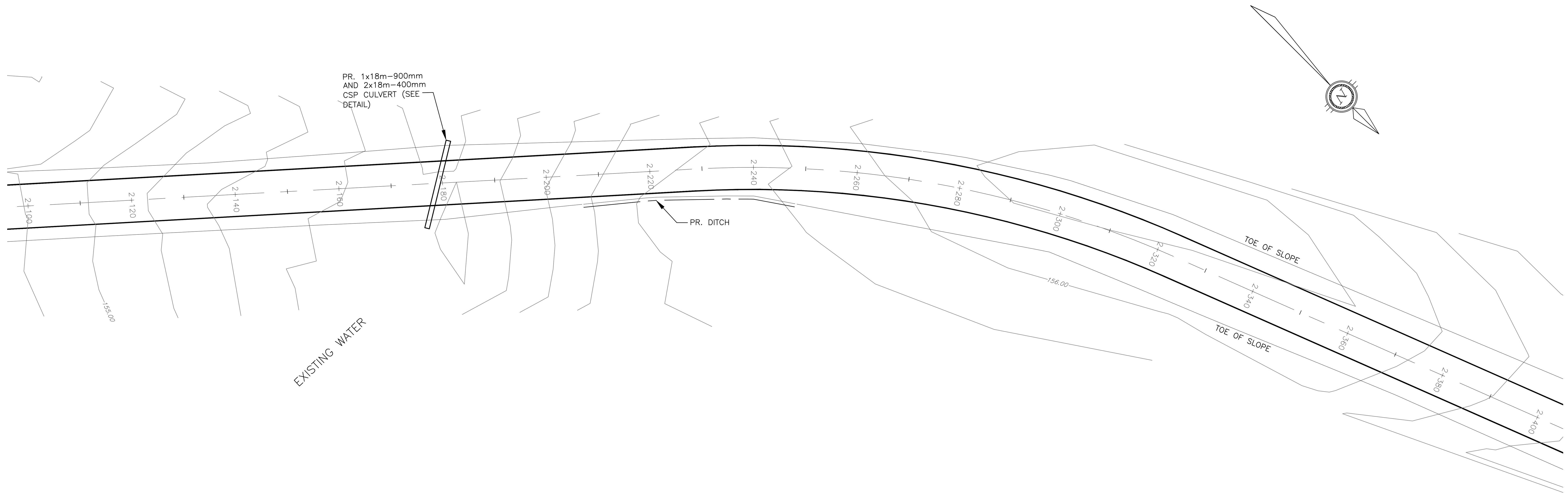
PROJECT

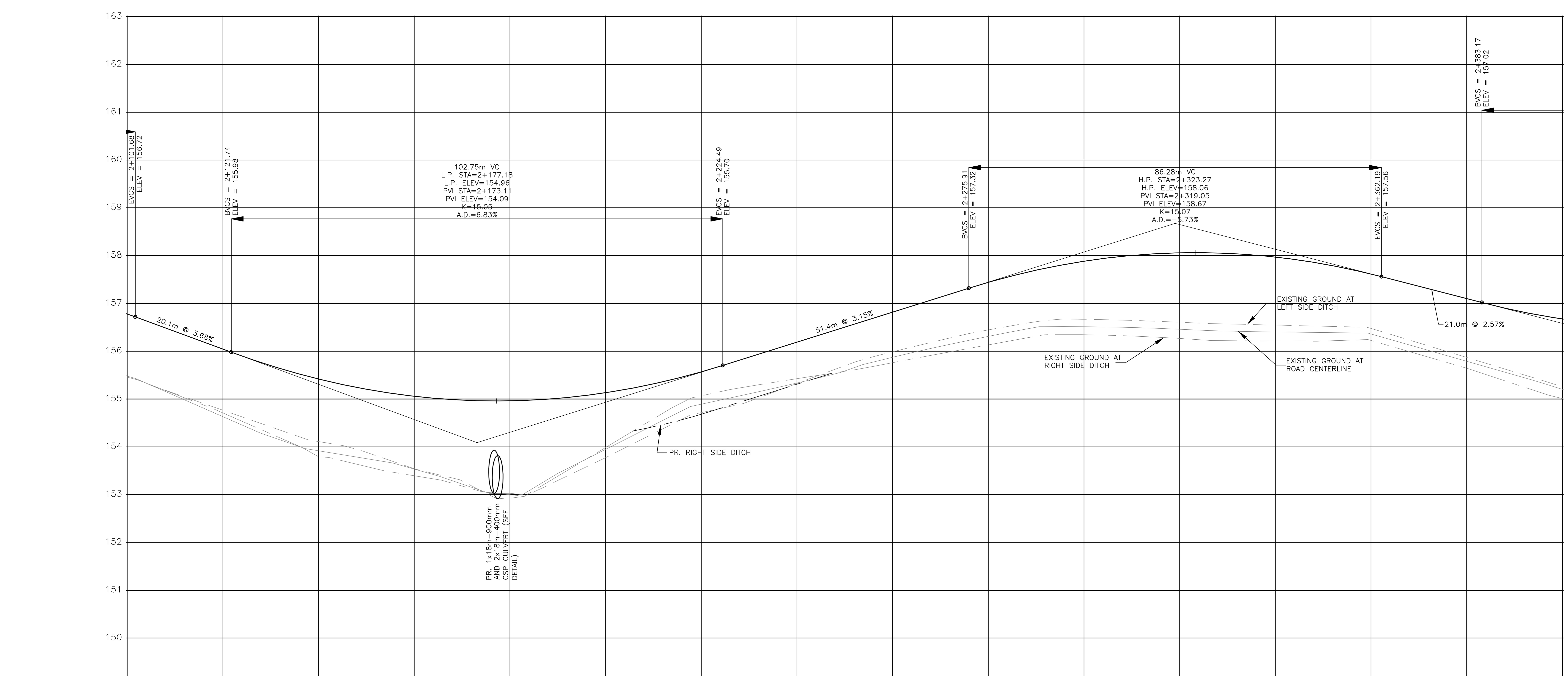
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

PLAN & PROFILE

design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	PP–7
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		





PROPOSED ROAD ℄ ELEVATION	156.78	156.04	155.42	155.06	154.96	155.13	155.57	156.19	156.82	157.44	157.88	158.06	157.97	157.62	157.10	156.67
EXISTING ℄ R.O.W ELEVATION	155.48	154.63	153.92	153.53	153.03	153.95	154.89	155.34	155.87	156.31	156.51	156.46	156.40	156.36	155.79	155.20
CHAINAGE	2+100	2+120	2+140	2+160	2+180	2+200	2+220	2+240	2+260	2+280	2+300	2+320	2+340	2+360	2+380	2+400

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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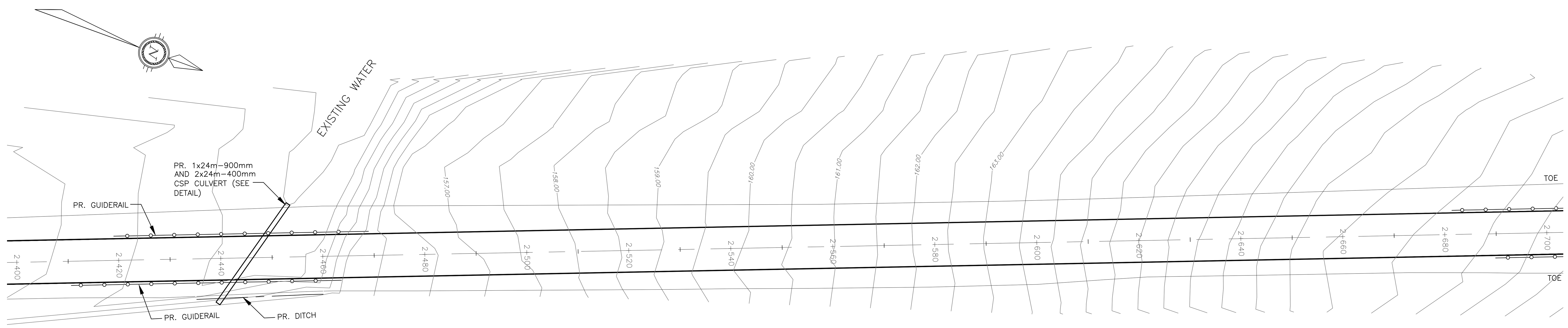
PROJECT

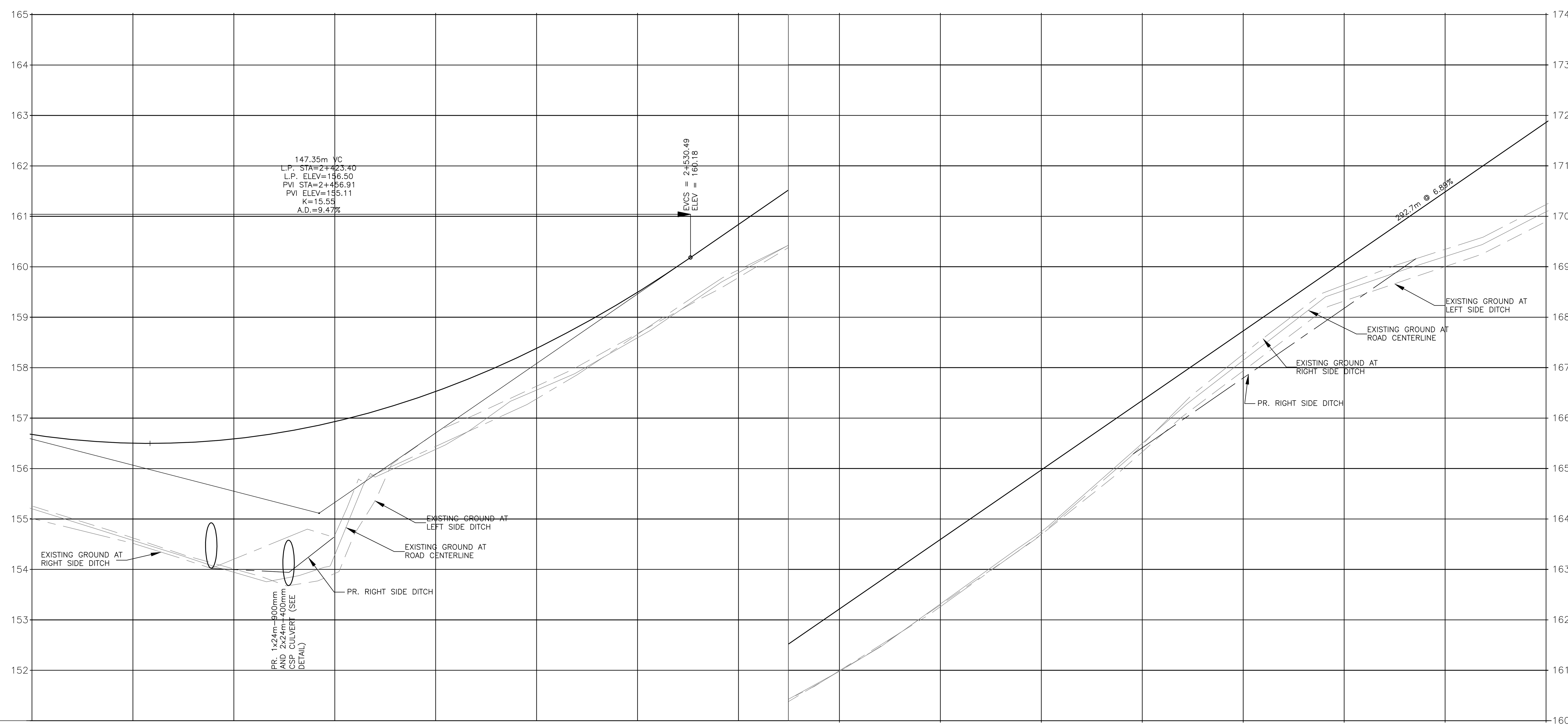
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

PLAN & PROFILE

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	PP-8
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		





CHAINAGE	PROPOSED ROAD ℄ ELEVATION	EXISTING ℄ R.O.W ELEVATION
2+400	156.67	155.20
2+420	156.50	154.58
2+440	156.59	153.94
2+460	156.93	154.29
2+480	157.53	156.38
2+500	158.38	157.56
2+520	159.50	158.59
2+540	160.84	159.88
2+560	162.22	160.98
2+580	163.59	162.32
2+600	164.97	163.75
2+620	166.35	165.50
2+640	167.73	167.14
2+660	169.11	168.53
2+680	170.48	169.20
2+700	171.86	170.09

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

ISSUED FOR TENDER PURPOSES ONLY

DATE: AUGUST 18, 2014

BENCH MARK

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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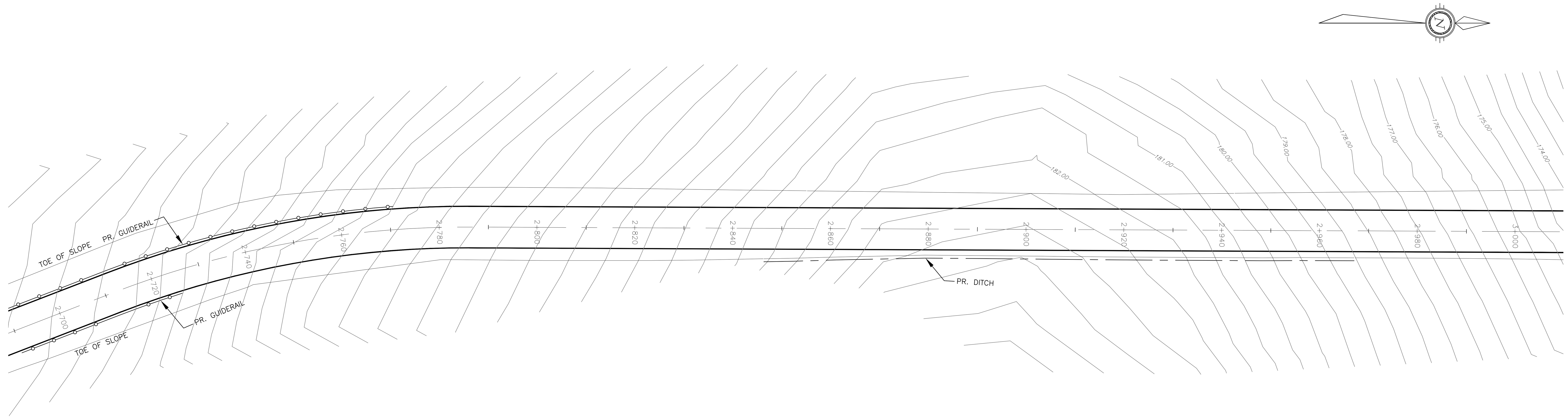
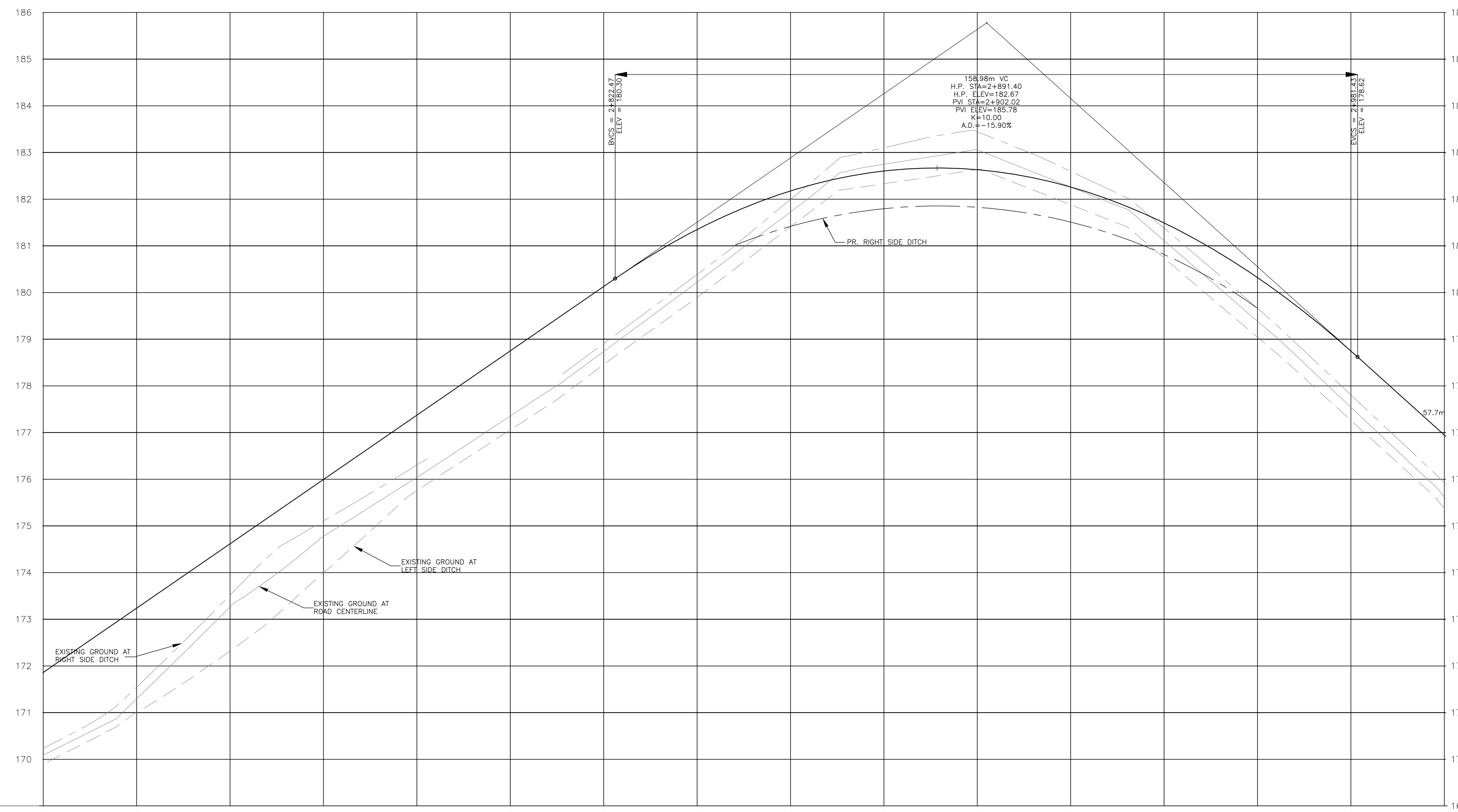
PROJECT
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE
PLAN & PROFILE

design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	PP–9
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		





PROPOSED ROAD ℄ ELEVATION	171.86	173.24	174.62	175.99	177.37	178.75	180.13	181.35	182.18	182.60	182.63	182.26	181.49	180.32	178.75	176.95
EXISTING ℄ R.O.W ELEVATION	170.09	171.29	173.27	174.78	176.04	177.35	178.74	180.22	181.73	182.75	183.06	182.26	181.11	179.38	177.54	175.62
CHAINAGE	2+700	2+720	2+740	2+760	2+780	2+800	2+820	2+840	2+860	2+880	2+900	2+920	2+940	2+960	2+980	3+000

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

ISSUED FOR TENDER PURPOSES ONLY

DATE: AUGUST 18, 2014

BENCH MARK

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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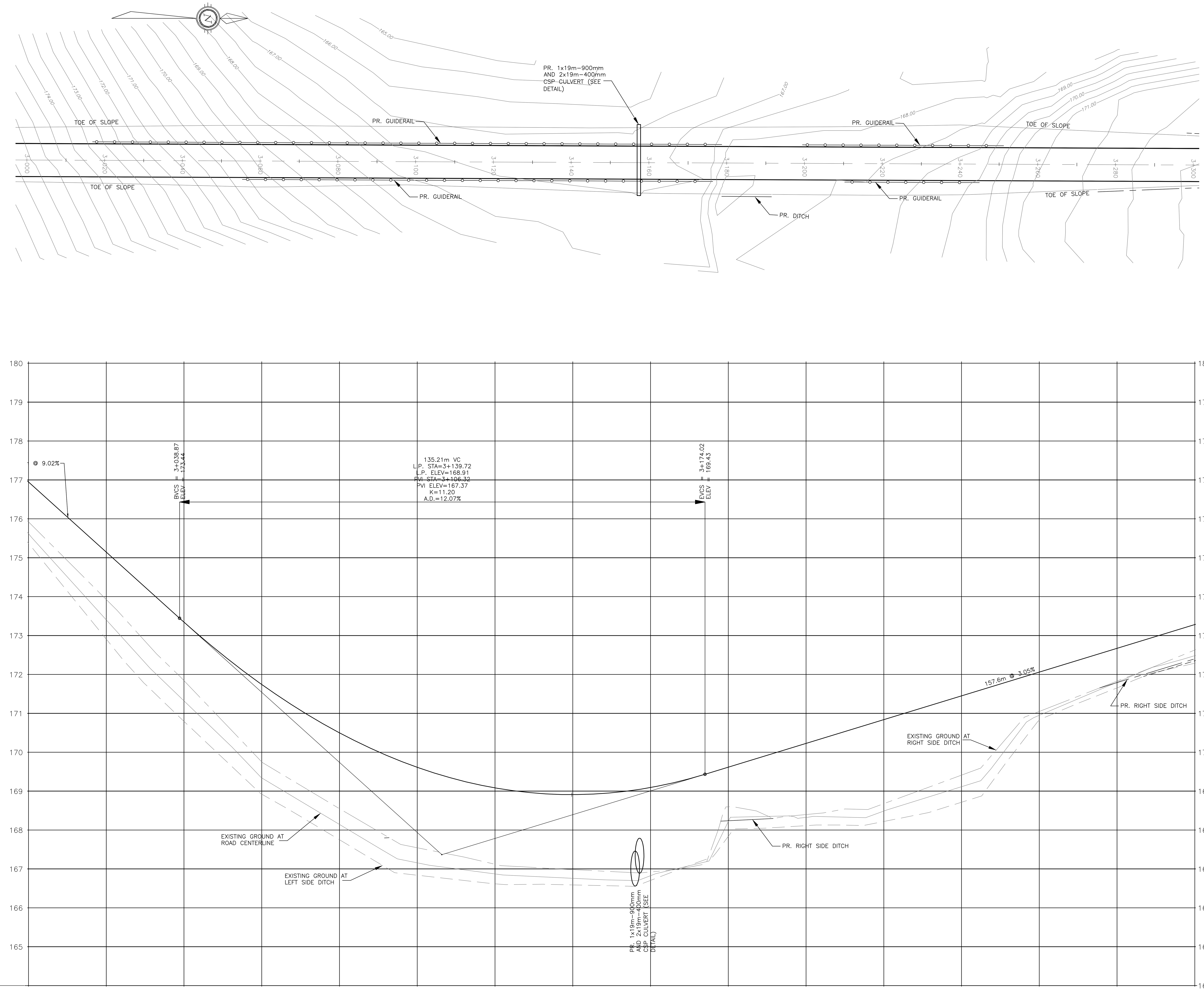
PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

PLAN & PROFILE

design by	A.B.Z	project no.	OTT−00219428−A0
drawn by	A.B.Z	drawing no.	PP−10
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		



PROPOSED ROAD ℄ ELEVATION	176.95	175.15	173.34	171.74	170.50	169.61	169.08	168.91	169.09	169.62	170.23	170.84	171.45	172.06	172.67	173.28
EXISTING ℄ R.O.W ELEVATION	175.62	173.40	171.32	169.34	168.14	167.16	166.87	166.76	166.83	168.22	168.32	168.49	169.11	170.95	171.80	172.48
CHAINAGE	3+000	3+020	3+040	3+060	3+080	3+100	3+120	3+140	3+160	3+180	3+200	3+220	3+240	3+260	3+280	3+300

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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DATE: AUGUST 18, 2014

BENCH MARK

No.	DESCRIPTION	DATE	BY	APP'D
03	TENDER SUBMISSION	18/08/14	ABZ	SLB
02	80% DESIGN REVIEW	18/06/14	ABZ	SLB
01	PRELIMINARY DRAWING	30/05/14	ABZ	SLB

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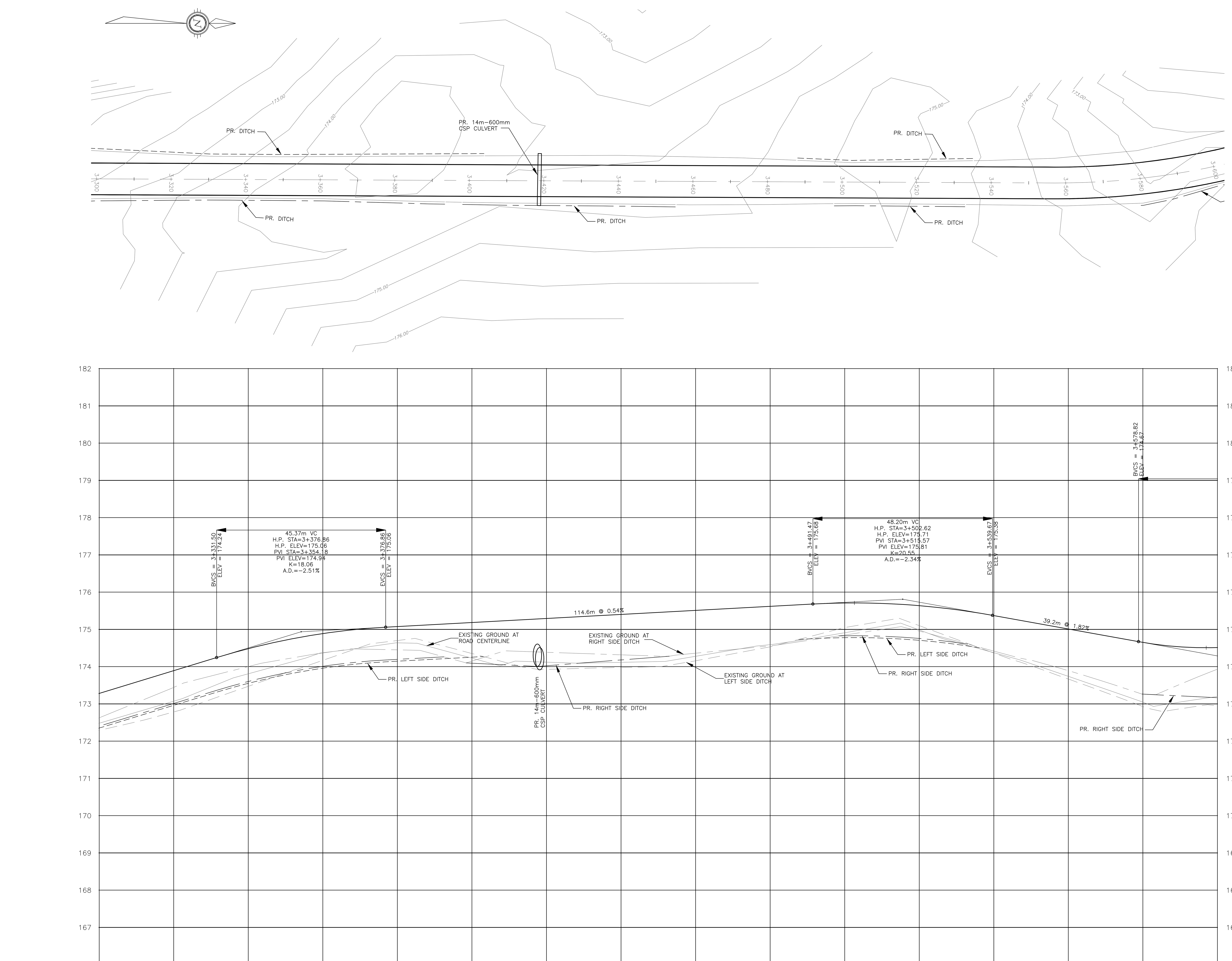
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

PLAN & PROFILE

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	PP–11
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		



PROPOSED ROAD ℄ ELEVATION	173.28	173.89	174.48	174.89	175.08	175.18	175.29	175.40	175.51	175.62	175.71	175.64	175.37	175.01	174.65	174.51
EXISTING ℄ R.O.W ELEVATION	172.48	173.07	173.81	174.37	174.64	174.23	174.12	174.12	174.28	174.59	174.91	174.98	174.37	173.74	173.05	173.20
CHAINAGE	3+300	3+320	3+340	3+360	3+380	3+400	3+420	3+440	3+460	3+480	3+500	3+520	3+540	3+560	3+580	3+600

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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03	TENDER SUBMISSION	18/08/14	ABZ	SLB
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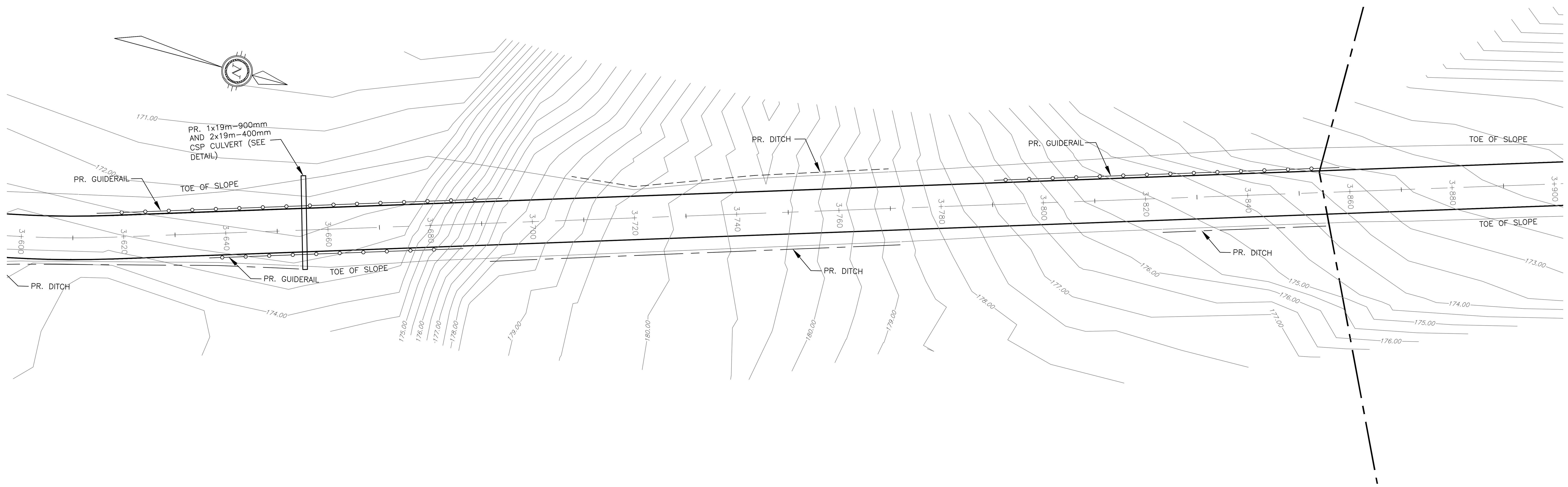
PROJECT

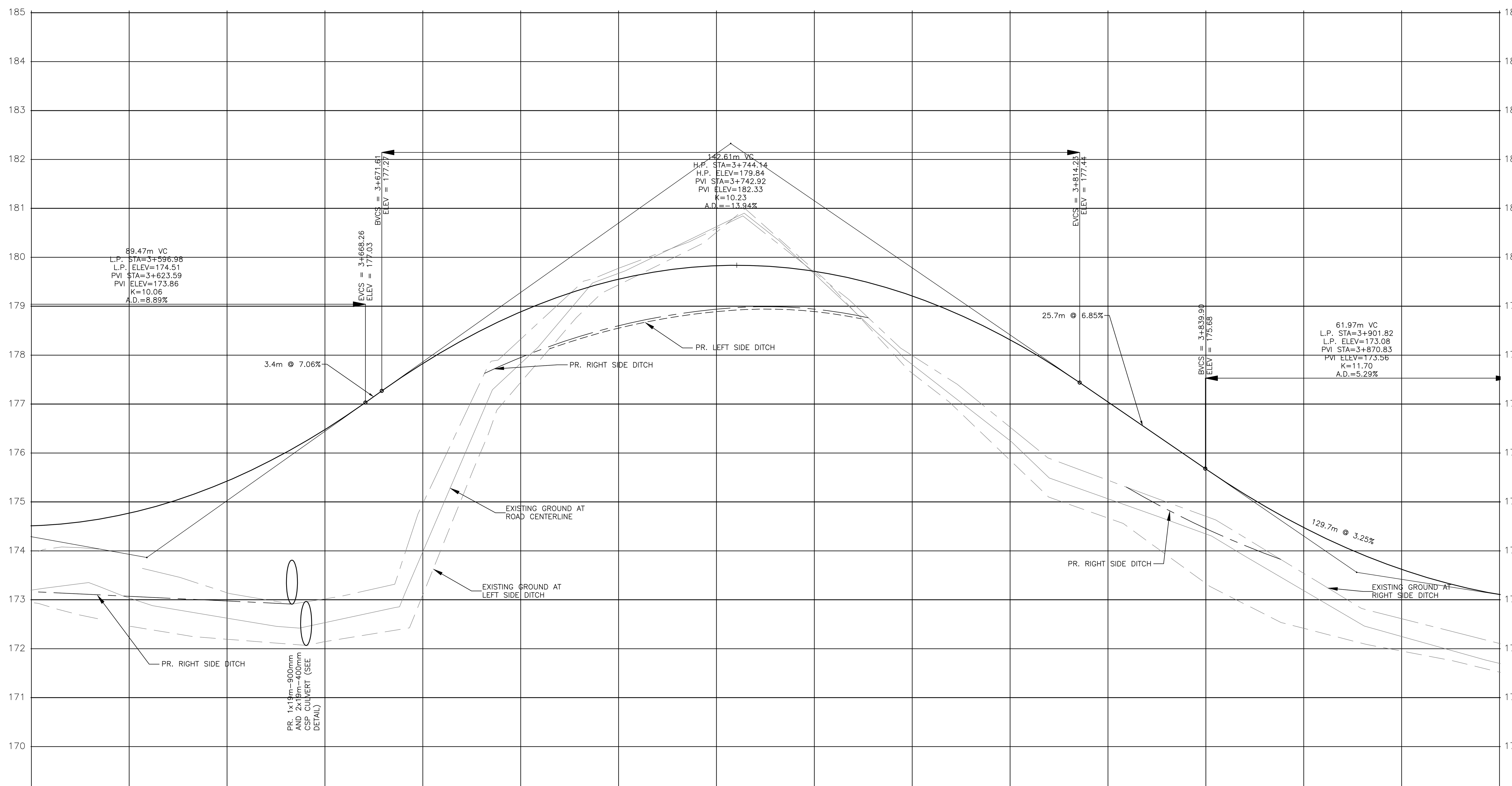
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

PLAN & PROFILE

design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	PP–12
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		





PROPOSED ROAD ℄ ELEVATION	174.51	174.77	175.43	176.48	177.83	178.89	179.55	179.83	179.71	179.21	178.31	177.04	175.67	174.48	173.62	173.11
EXISTING ℄ R.O.W ELEVATION	173.20	173.04	172.62	172.53	173.98	177.83	179.67	180.63	179.66	177.81	176.25	175.06	174.35	173.19	172.25	171.70
CHAINAGE	3+600	3+620	3+640	3+660	3+680	3+700	3+720	3+740	3+760	3+780	3+800	3+820	3+840	3+860	3+880	3+900

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
- NEW CULVERT LOCATION

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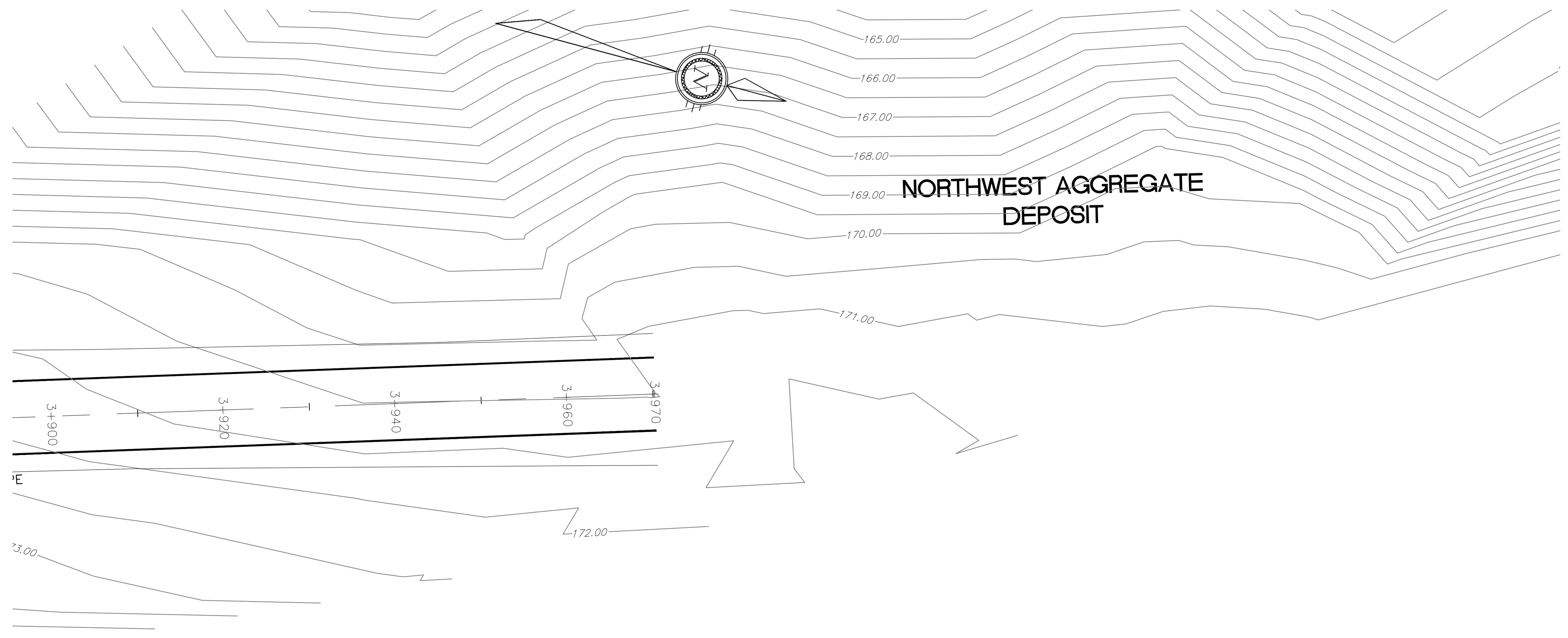
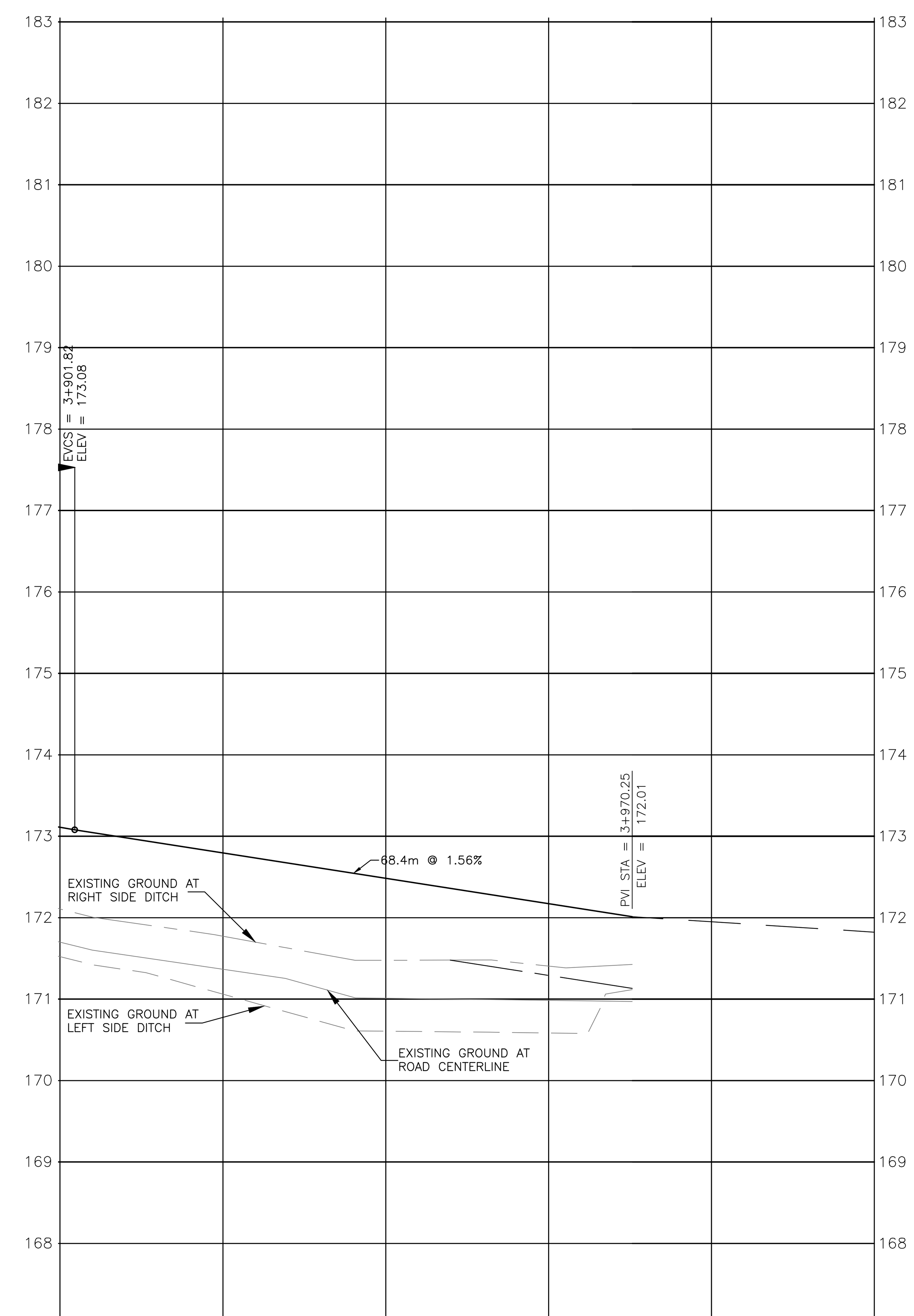
design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	PP–13
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		





PROPOSED ROAD ℄ ELEVATION	173.11	172.79	172.48	172.17		
EXISTING ℄ R.O.W ELEVATION	171.70	171.37	171.01	170.98		
CHAINAGE	3+900	3+920	3+940	3+960	3+980	4+000

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LEGEND

- EXISTING GROUND AT C/L NEW ROAD
- EXISTING GROUND AT C/L RIGHT SIDE DITCH
- EXISTING GROUND AT C/L LEFT SIDE DITCH
- C/L OF NEW ROAD
- C/L OF NEW DITCH RIGHT
- C/L OF NEW DITCH LEFT
- NEW GUIDE RAIL LOCATION
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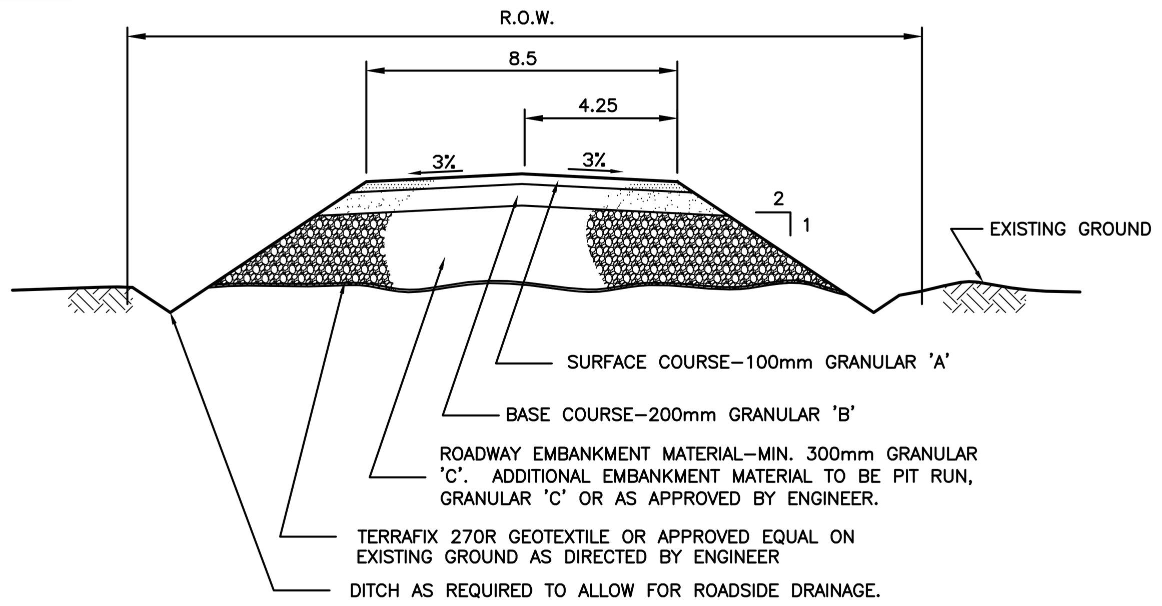
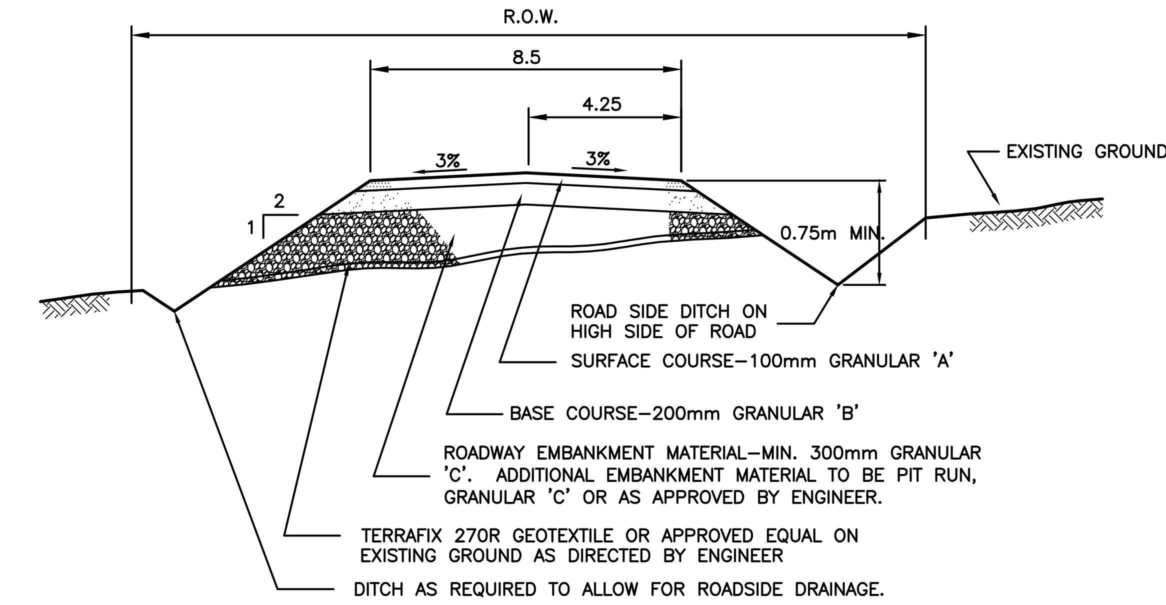
design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	PP-14
checked by	S.L.B.		
date	30/05/14		
scale	1:500 HORZ. 1:50 VERT.		



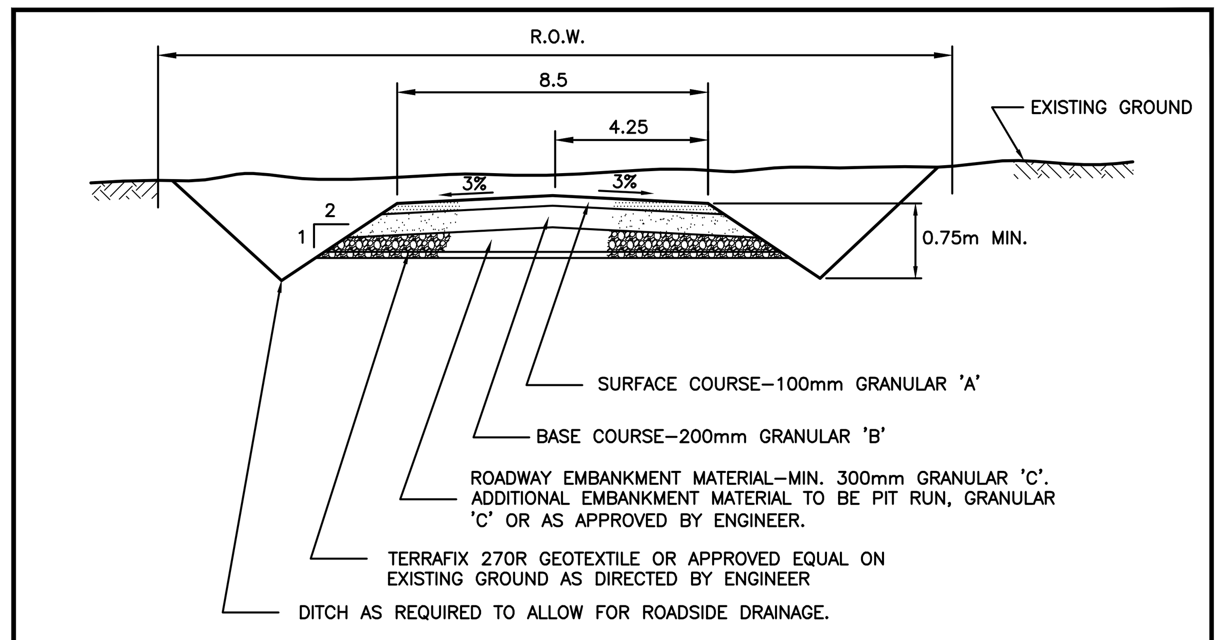
1 ROAD EMBANKMENT–LEVEL GROUND

N.T.S.



2 ROAD EMBANKMENT–SLOPED GROUND

N.T.S.



3 ROAD EMBANKMENT–IN A ROAD CUT

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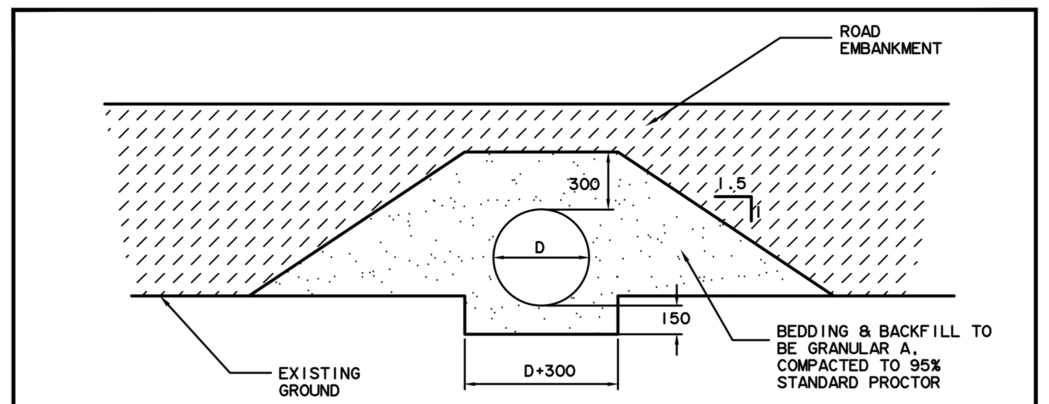
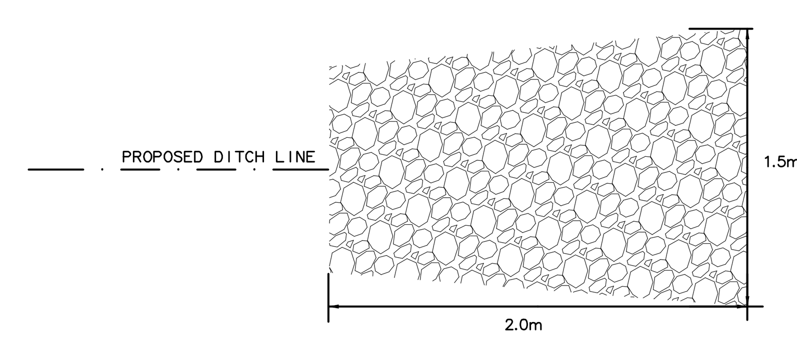


NOTES:

1. MINIMUM COVER TO BE 450mm IN ROADS AND 300mM IN DRIVEWAYS.
2. INVERT OF CULVERT TO BE 0.1D BELOW EXISTING GROUND.
3. SEE DRAWING T-6 FOR CULVERT APRON DETAIL.

4 PIPE CULVERT–IN AN EMBANKMENT

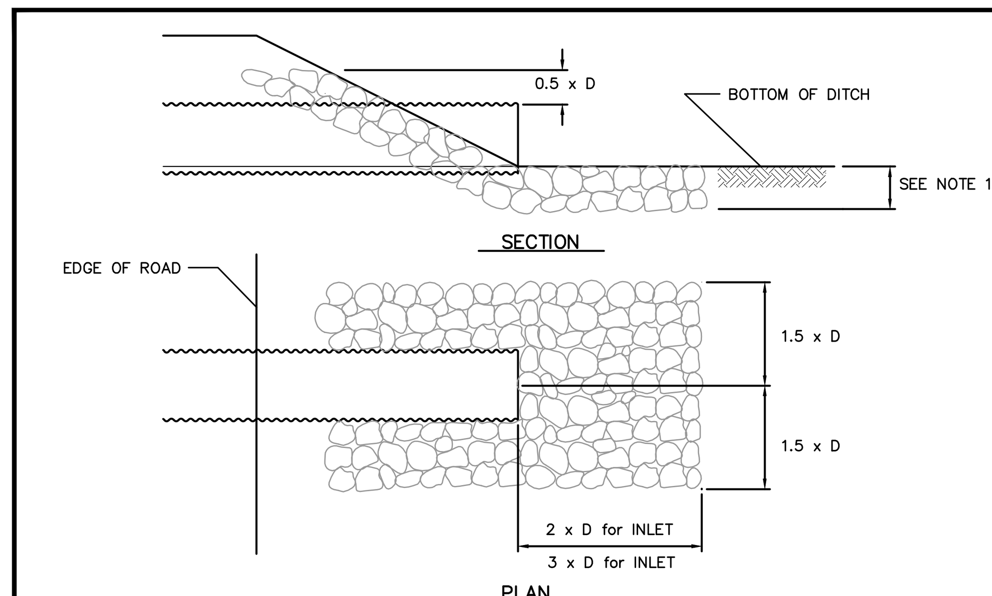
N.T.S.



1. RIP RAP TO BE HAND PLACED.
2. NOMINAL SIZE OR RIP RAP TO BE 0.5 THICKNESS.
3. FILTER CLOTH TO BE INSTALL UNDER ENTIRE RIP RAP APRON.

5 RIP RAP TREATMENT – ON DITCH OUTLET

N.T.S.

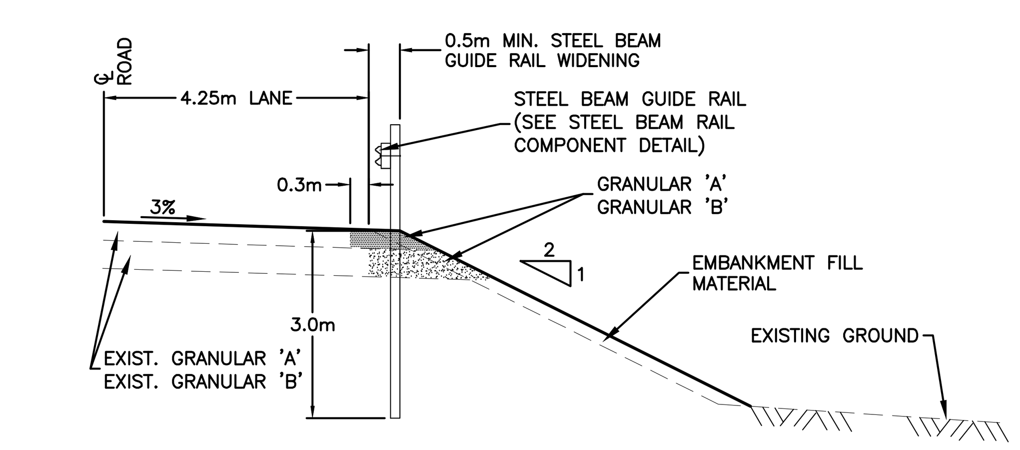


NOTES:

1. RIP RAP THICKNESS TO BE 300mm FOR DIA. LESS THAN 1400mm, AND 600mm FOR DIA. GREATER THAN 1400mm
2. RIP RAP TO BE HAND PLACED.
3. MINIMUM CULVERT DIA. TO BE 400mm.
4. NOMINAL SIZE OR RIP RAP TO BE 0.5 THICKNESS.
5. FILTER CLOTH TO BE INSTALL UNDER ENTIRE RIPRAP APRON.

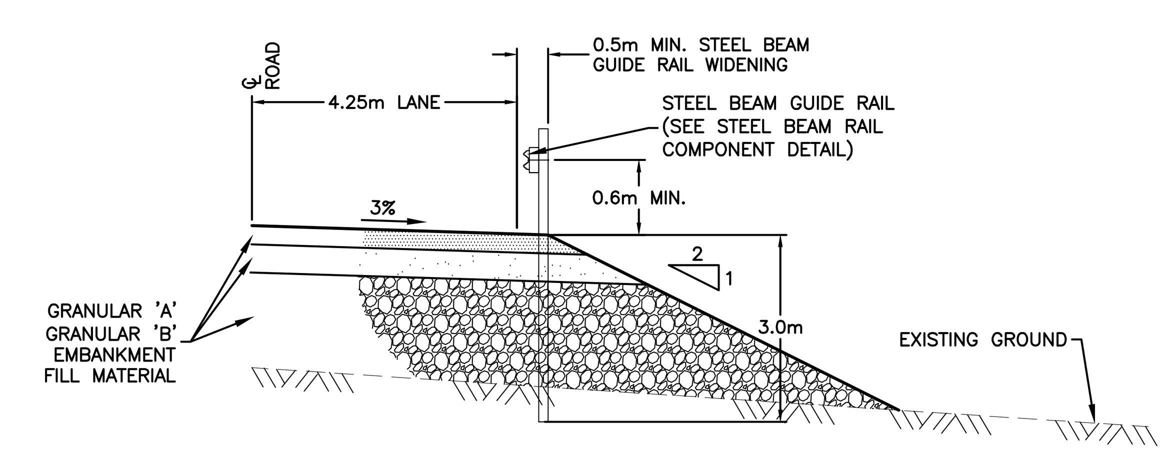
6 CULVERT APRON

N.T.S.



7 GUIDE RAIL – EXISTING EMBANKMENT

N.T.S.



8 GUIDE RAIL – PROPOSED EMBANKMENT

N.T.S.

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CITY OF IQALUIT

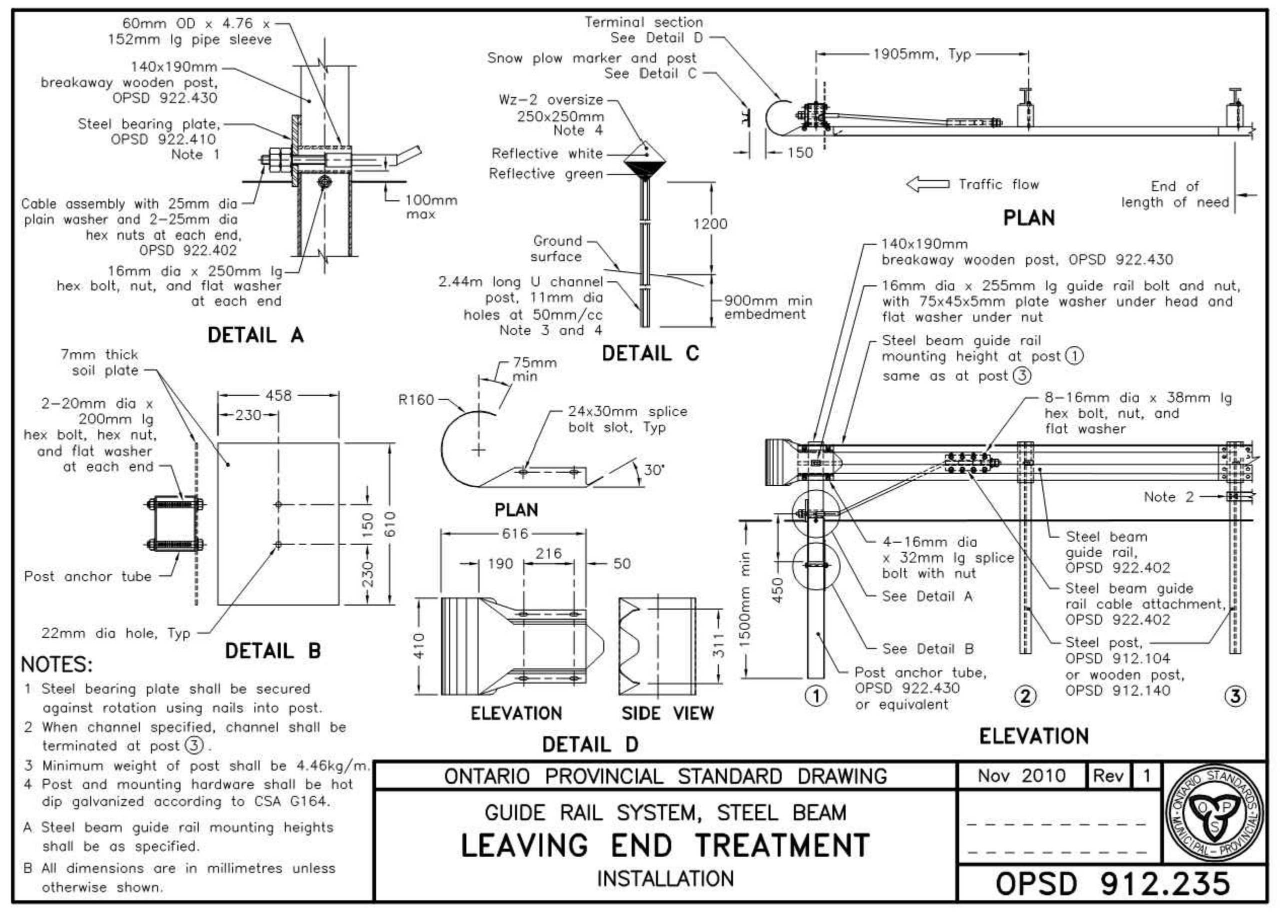
PROJECT

PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE

ROAD DETAILS

design by	A.B.Z	project no.	OTT–00219428–A0
drawn by	A.B.Z	drawing no.	DE–1
checked by	S.L.B.		
date	30/05/14		
scale	N.T.S.		



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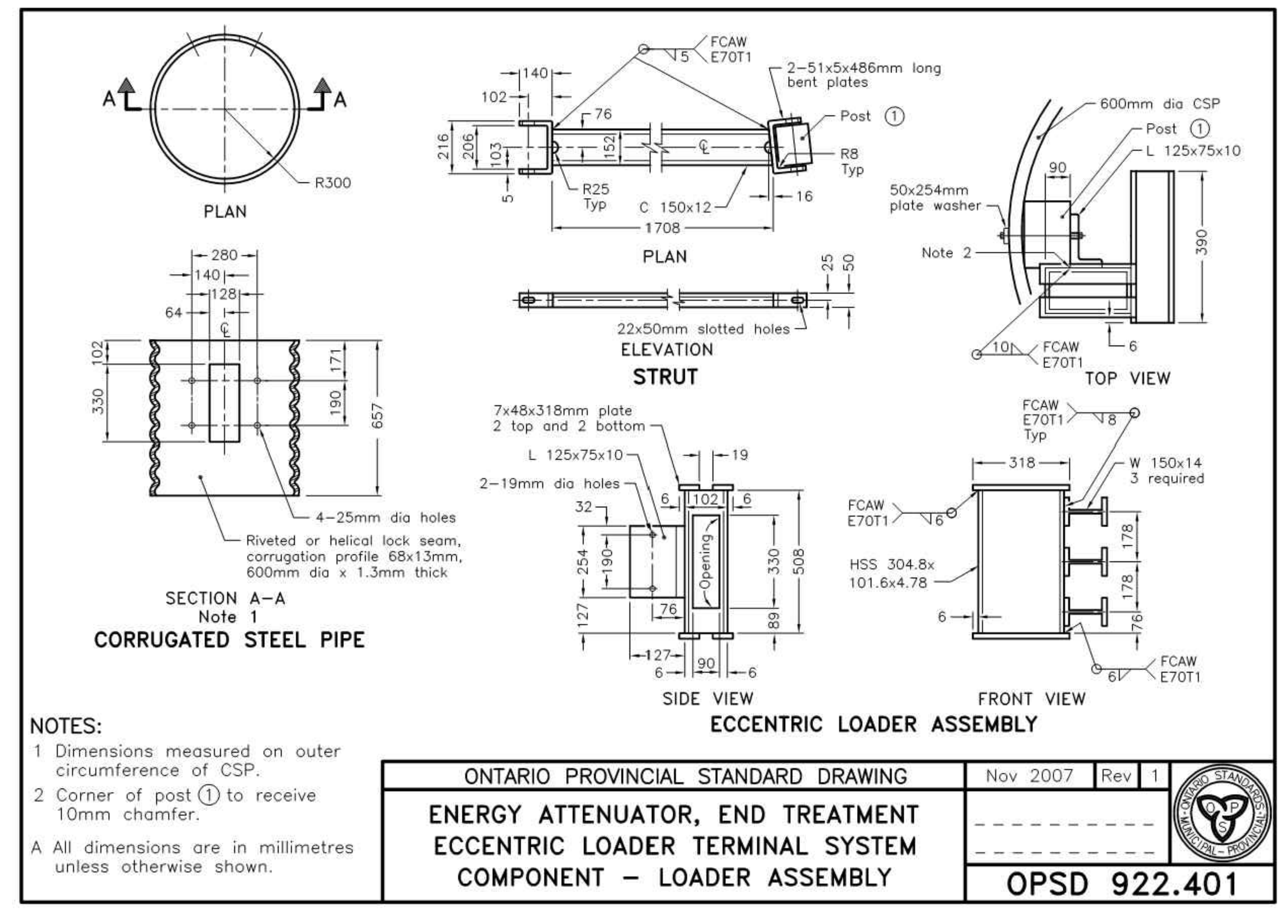

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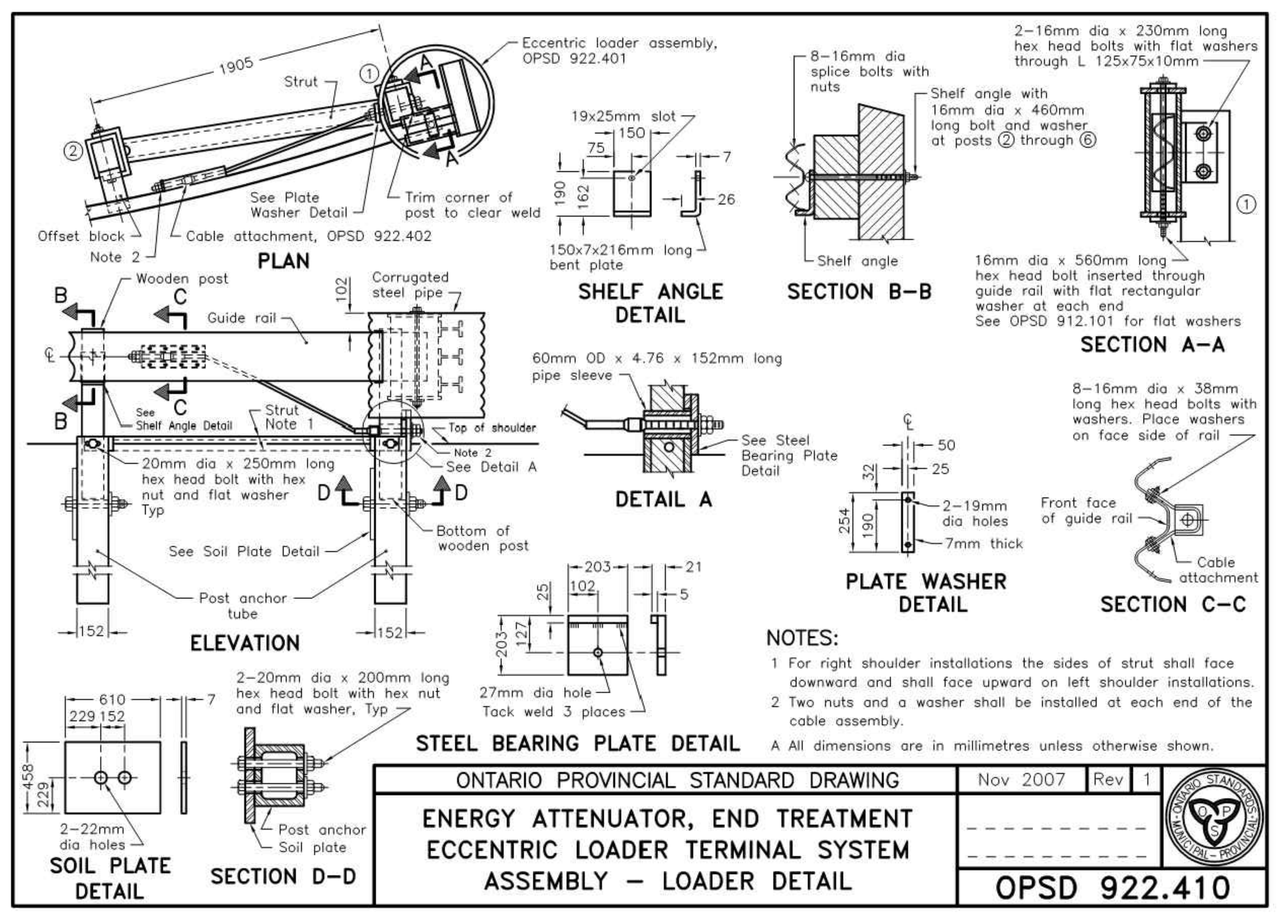

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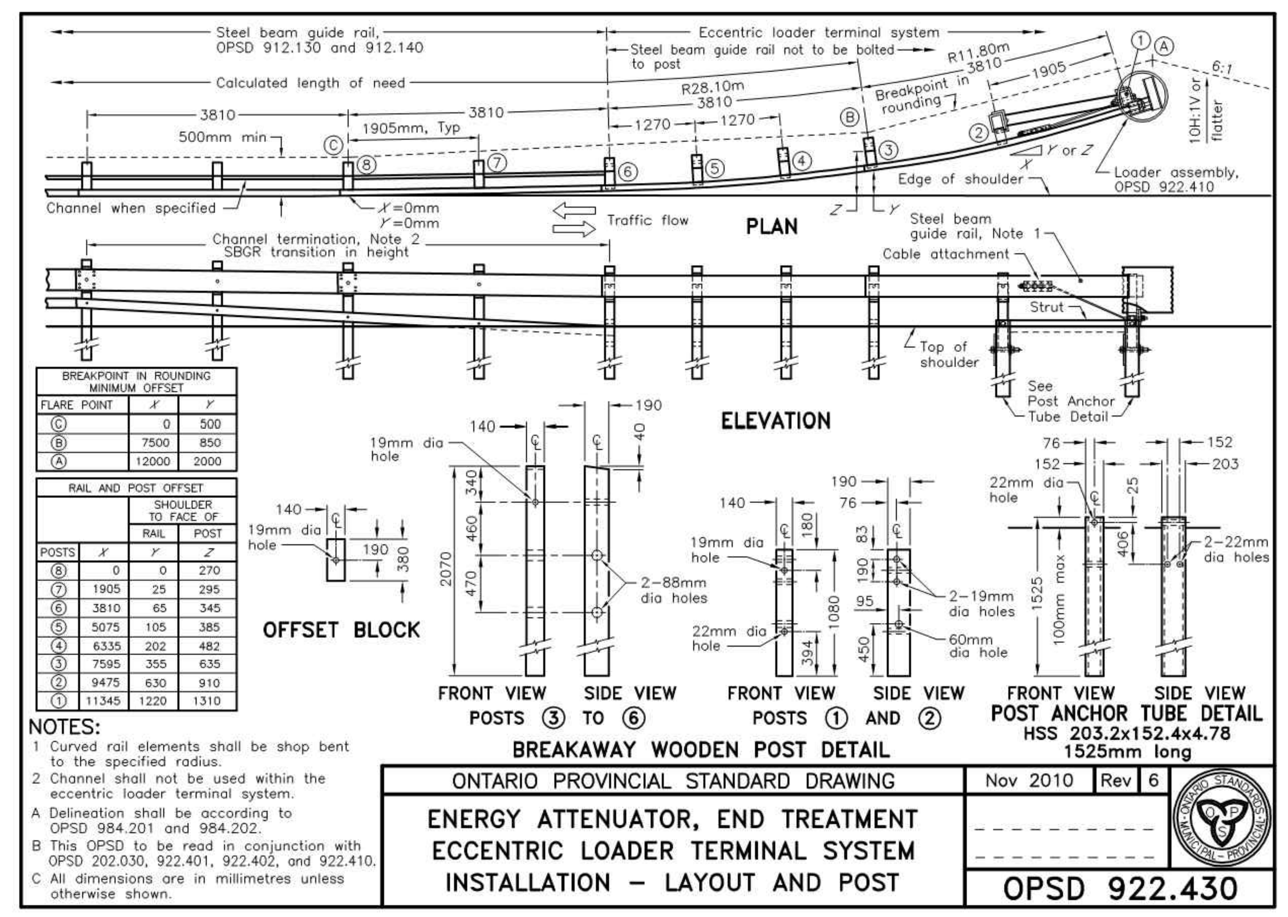

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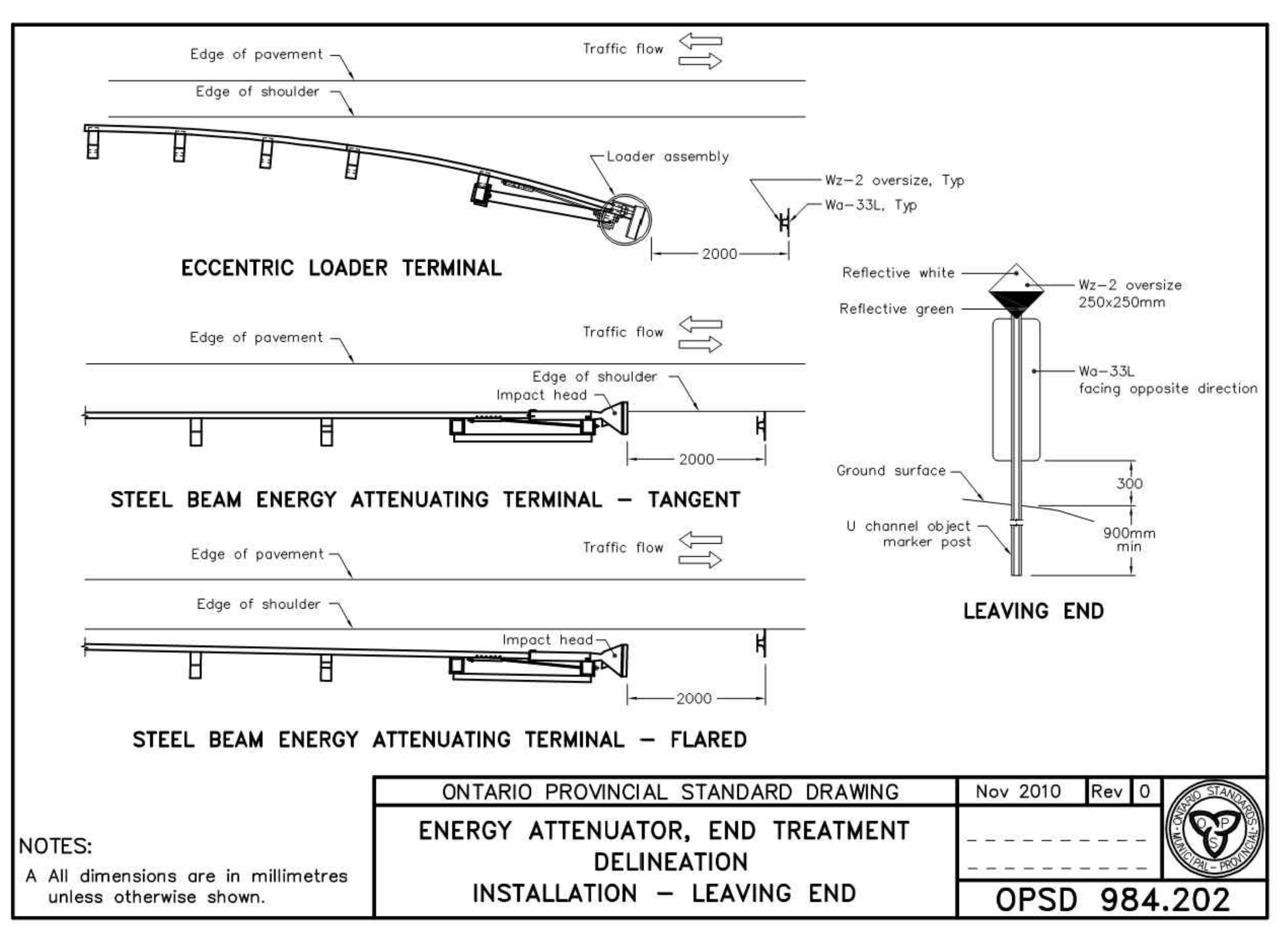

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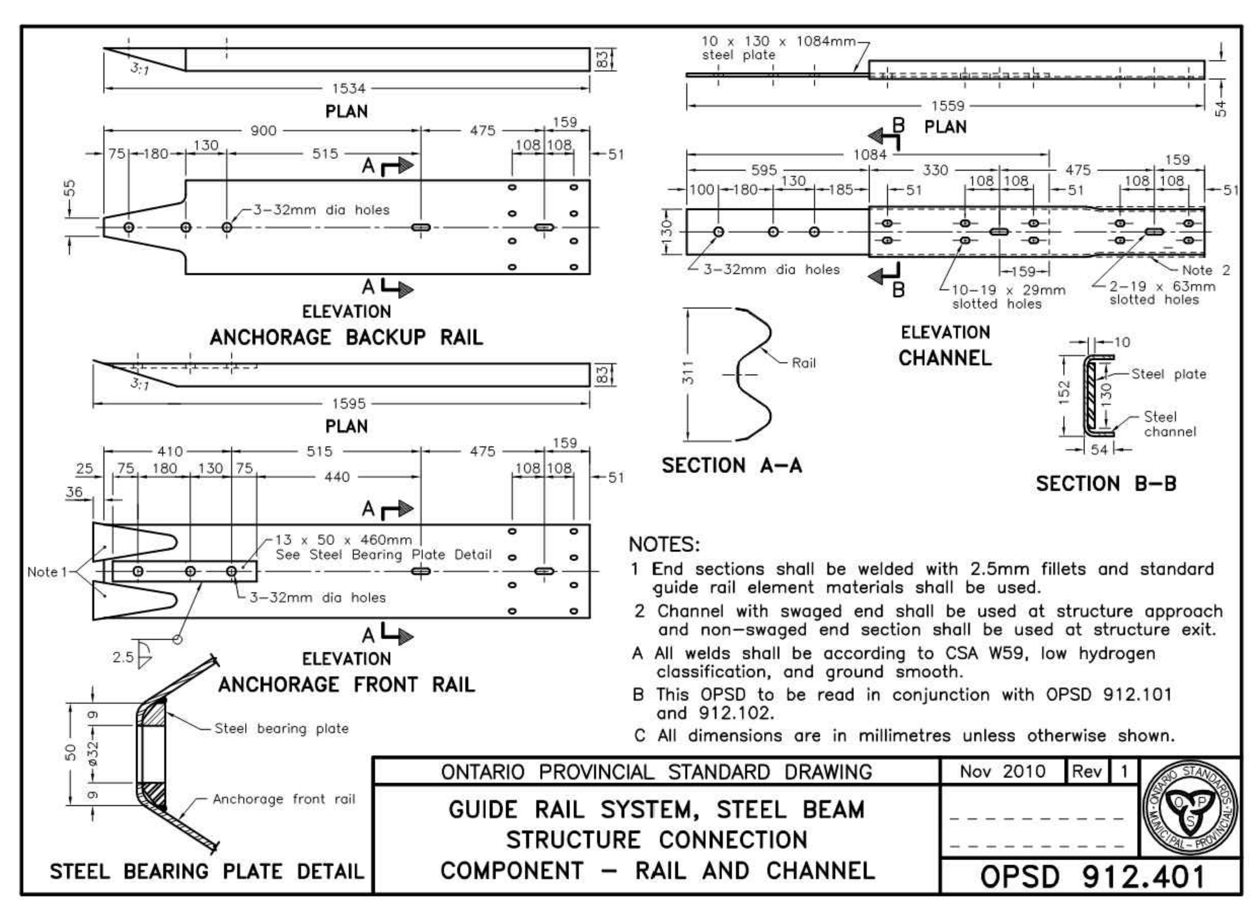

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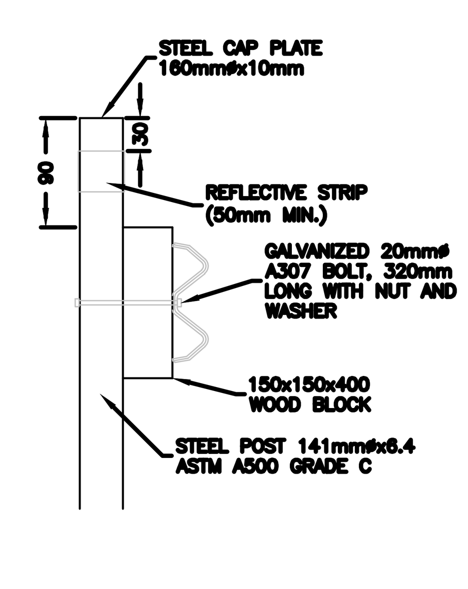

7 STEEL BEAM RAIL COMPONENT
N.T.S.

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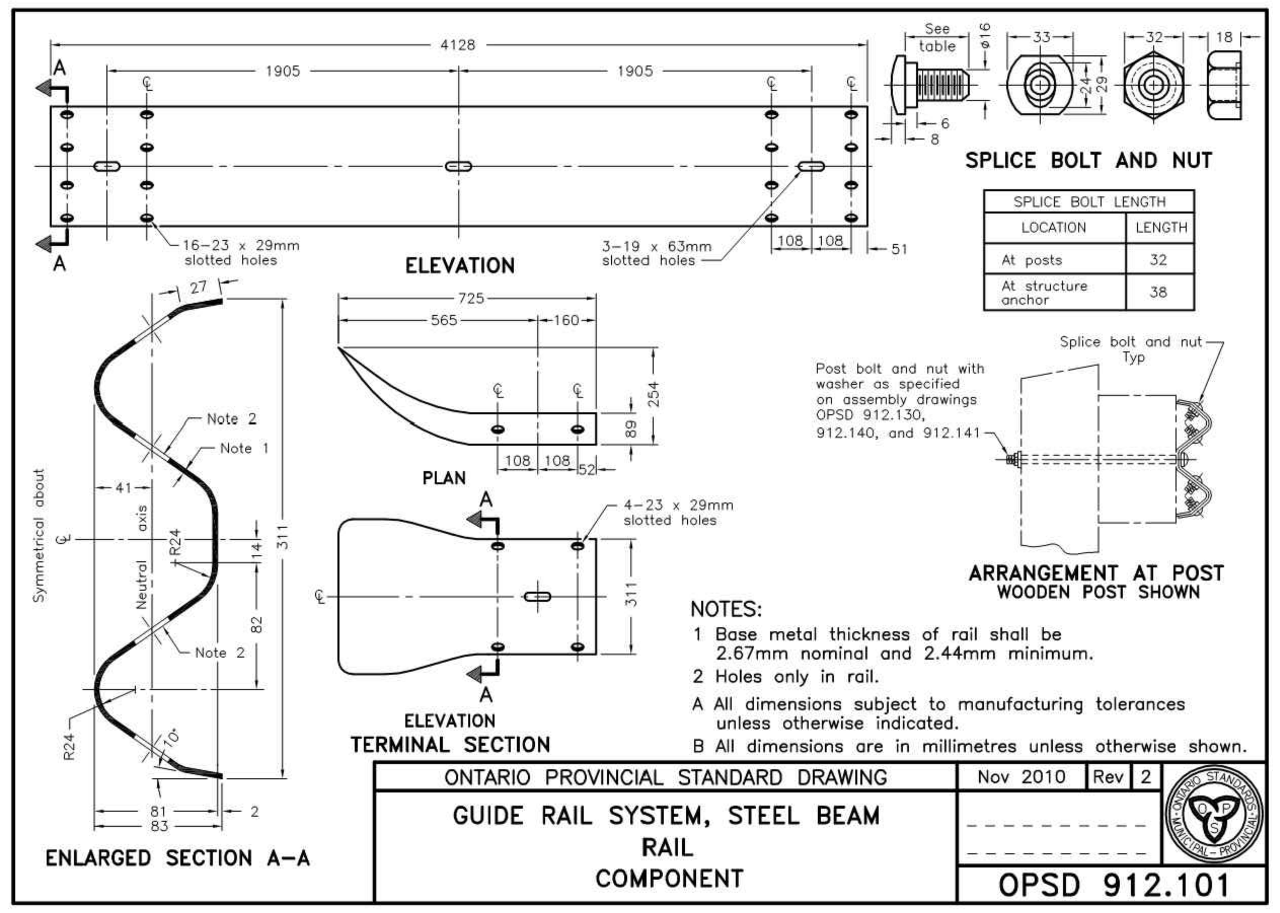
PROJECT
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE
GUIDERAIL DETAILS

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	DE-2
checked by	S.L.B.		
date	30/05/14		
scale	N.T.S.		



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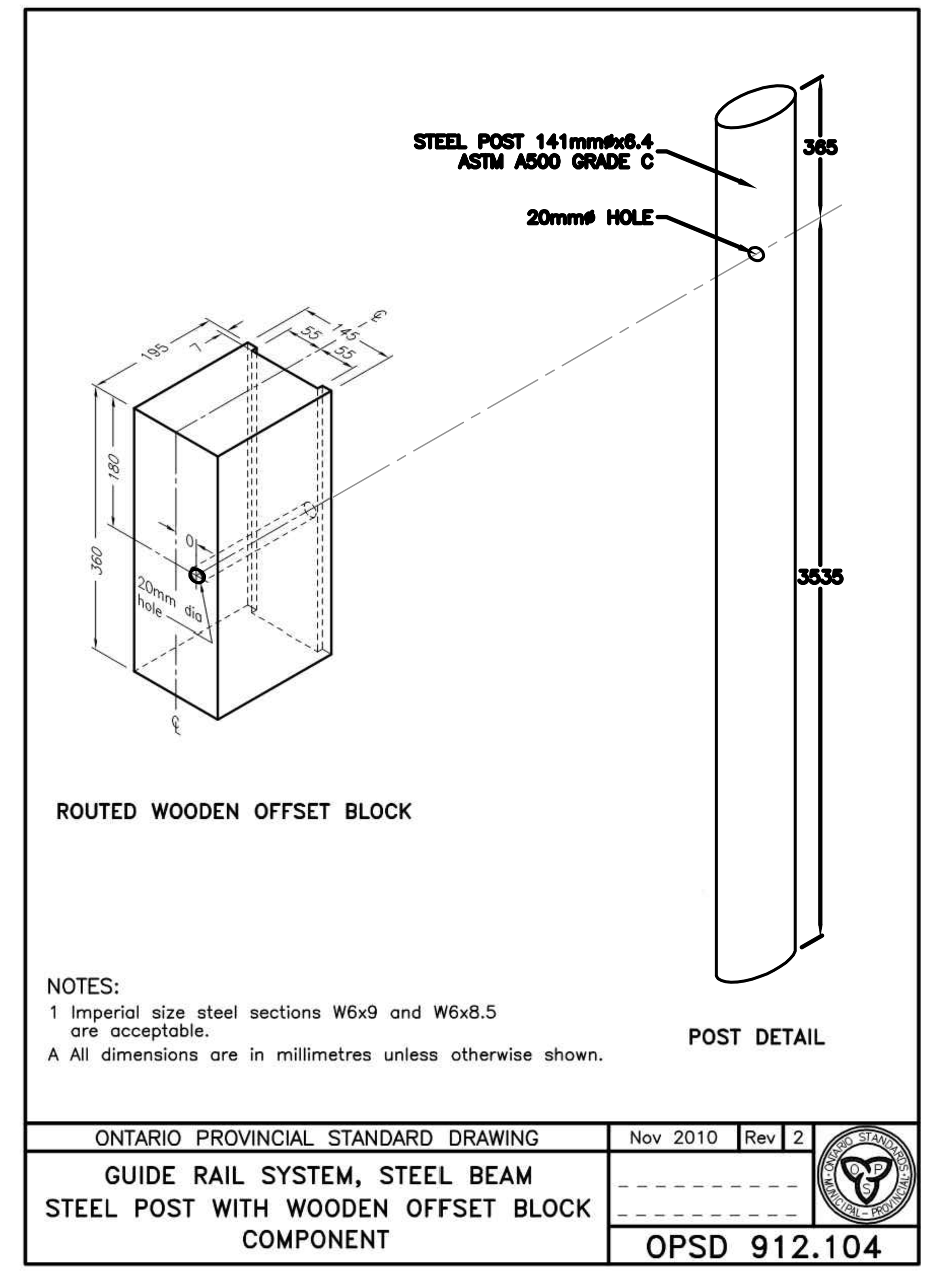

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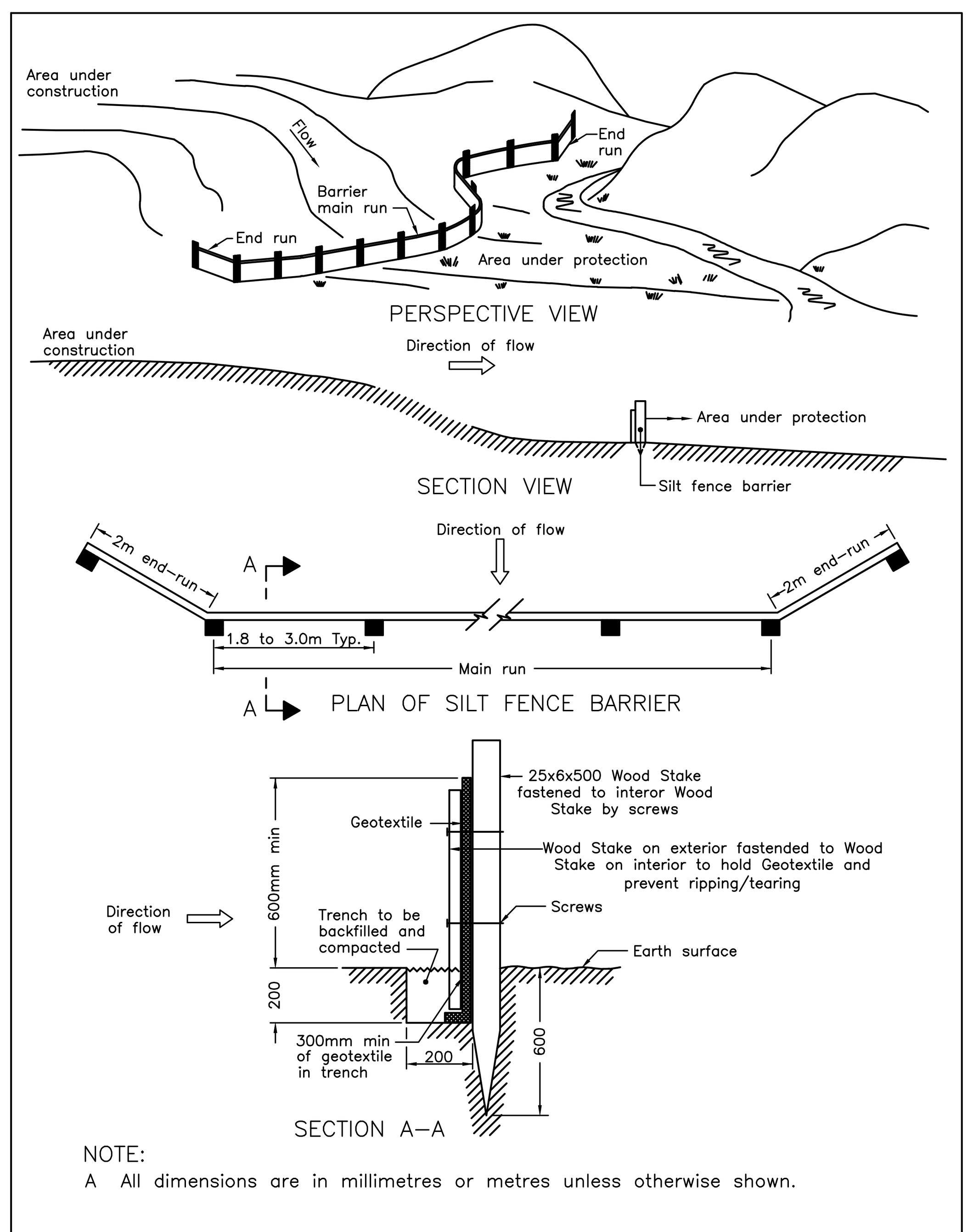
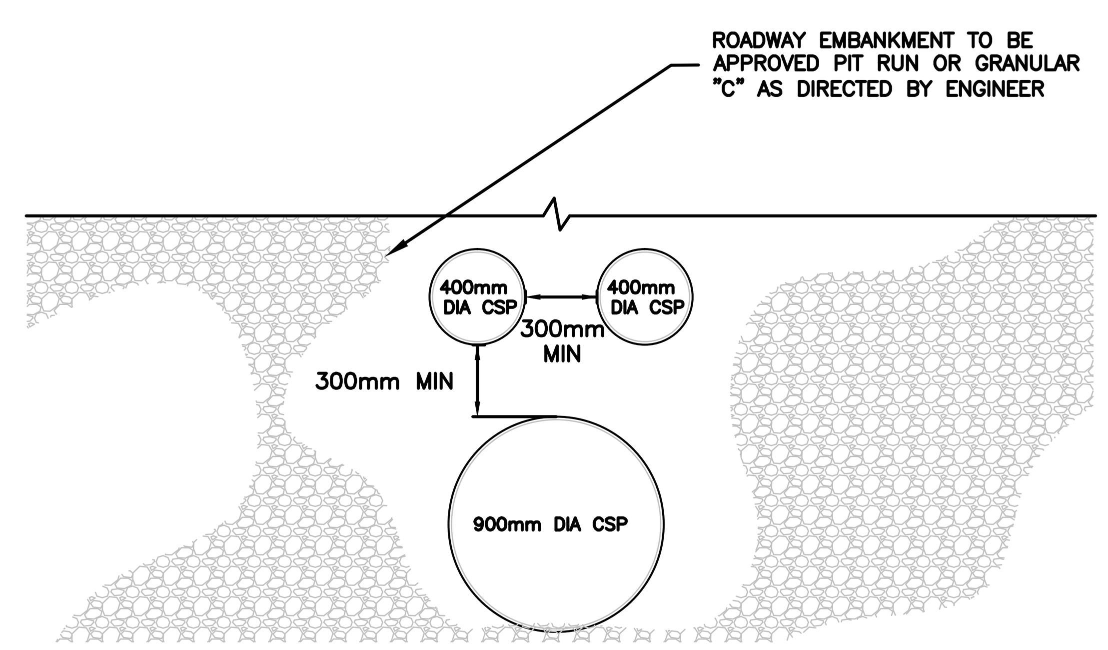


3 SILT FENCE BARRIER

N.T.S.



4 2x400mm WITH 1x900mm CULVERT CROSSING

N.T.S.

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PROJECT
PROPOSED ROAD TO NORTHWEST AGGREGATE DEPOSIT

TITLE
MISC. DETAILS

design by	A.B.Z	project no.	OTT-00219428-A0
drawn by	A.B.Z	drawing no.	DE-3
checked by	S.L.B.		
date	30/05/14		
scale	N.T.S.		

Appendix F

Facility Operations and Maintenance Manual

CITY OF IQALUIT

Operations and Maintenance Manual (Draft)

Landfill and Waste Transfer Station

June 2019 | 19-9543 – Version 1.0

Table of Contents

DILLON CONSULTING

Figures

Tables

Appendices

1.0 Introduction

1.1 Background

The City of Iqaluit (City) is in the process of implementing its Solid Waste Management Strategy to service their near and long-term (75 years) municipal solid waste disposal requirements. Founded on a previously completed conceptual design and facility siting exercise, key elements of the project include a solid waste transfer station (WTS) within the immediate urban area of the City, where residential and commercial waste will be hauled to, processed, and compacted in bales, or in the case of waste wood and cardboard, shredded and pelletized for use as a fuel source for an on-site biomass boiler. Tires, metal, and some construction and demolition (C&D) wastes will also be shredded and/or baled for landfilling or transported south for recycling. The resulting solid waste bales and possibly a smaller amount of unbaled C&D waste will be trucked to an engineered balefill landfill site (Landfill) located approximately 6 km from the WTS.

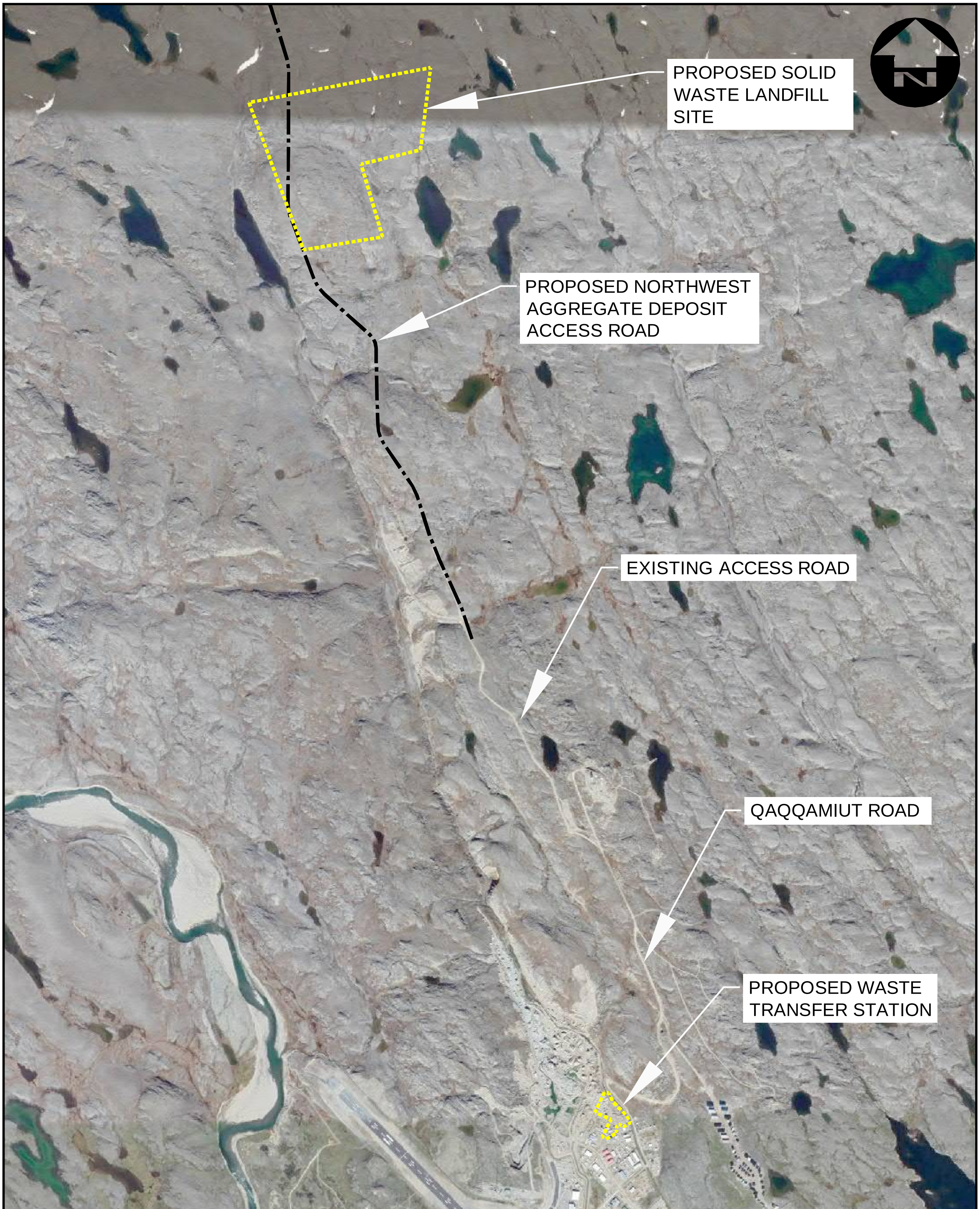
The overall site locations are presented on **Figure 1-1**, with the layouts for the WTS and the Landfill being provided on **Figures 1-2** and **1-3**, respectively.

Other planned features of the WTS include a public drop off area for household hazardous wastes (HHW) and a vehicle logger/compactor unit; in both instances allowing for the preparation of waste materials, prior to shipping to approved management facilities in the south.

The access road that will be used to reach the new Landfill has been designed by EXP Services Inc., who will also be providing Construction Contract Administration services for the construction of the road. It is anticipated that the construction of the road will be included in the new Landfill and WTS Contractor's scope of work.

To address their objectives, and following a competitive proposal process, the City engaged Dillon Consulting Limited (Dillon) to provide design and construction contract administration services to support the establishment of the WTS/baling facility and the engineered Landfill. The engineered Landfill will be designed for 75 years of operation but for the construction/build portion of the project only the first stage of the Landfill (Stage 1 Operational Landfill) will be constructed (e.g., first two cells and ancillary components to meet five and 10 year operational requirements, e.g., five years per cell).

Development of the proposed facilities is scheduled to occur during the 2020 and 2021 construction seasons, with facility commissioning in the fall of 2021.



DILLON CONSULTING	PROJECT IQALUIT LANDFILL AND WASTE TRANSFER STATION	PROJECT NO. 19-9543
DATE JUNE 2019	TITLE SITE LOCATIONS	FIGURE NO. 1-1

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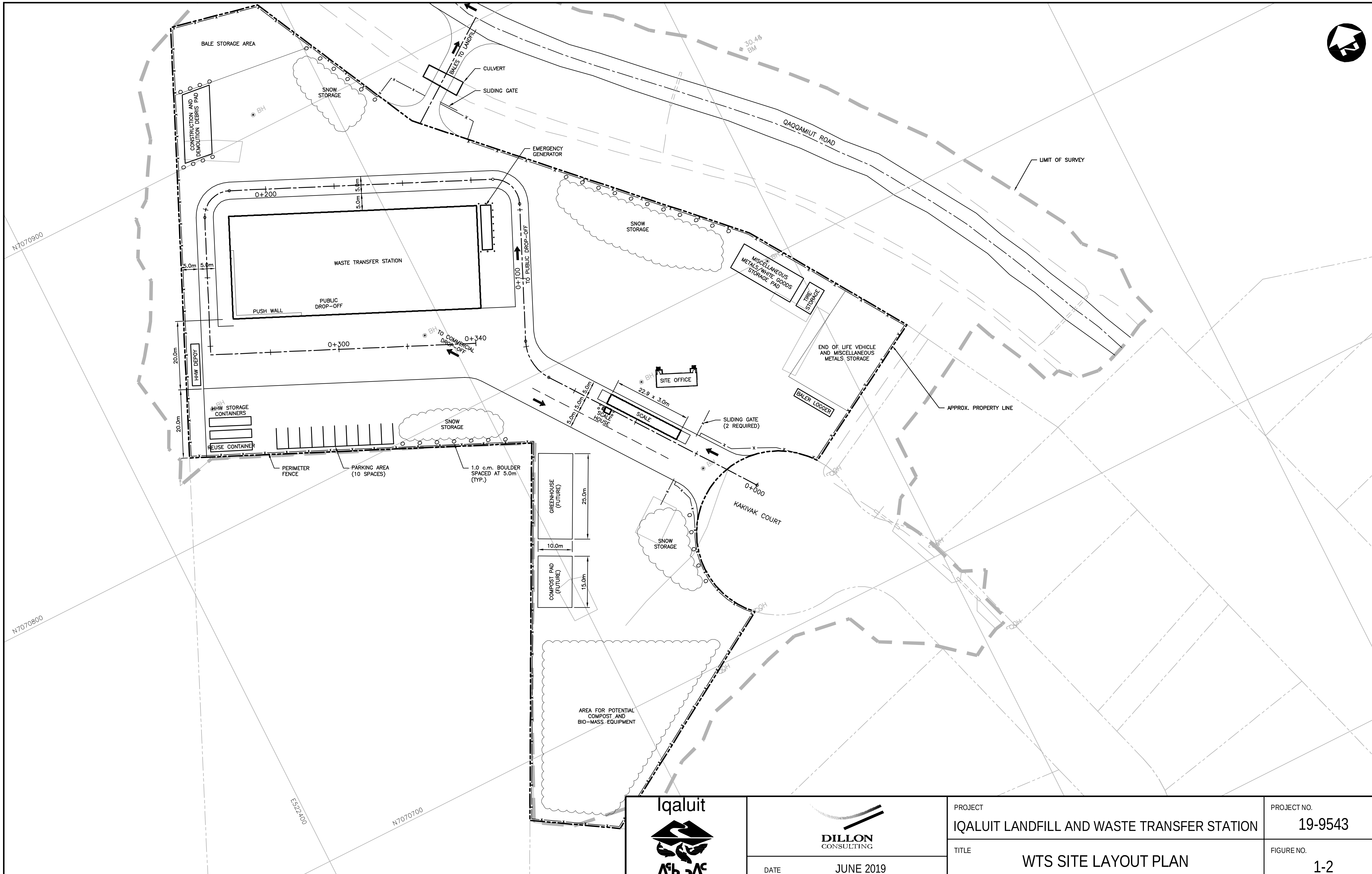

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DILLON CONSULTING

DATE JUNE 2019

PROJECT
IQALUIT LANDFILL AND WASTE TRANSFER STATION

PROJECT NO.
19-9543

TITLE
WTS SITE LAYOUT PLAN

FIGURE NO.
1-2

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