FINAL

FOUNDATION INVESTIGATION AND DESIGN REPORT

REHABILITATION OF HIGHWAY 35 AT CARNARVON AND FOUR BRIDGE REHABILITATIONS ON HIGHWAY 35

PROPOSED HALLS LAKE DAM BRIDGE REMOVAL

GWP: 5288-14-00
MINISTRY OF TRANSPORTATION (MTO)
NORTHEAST REGION
Assignment No. 5018-E-0024

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PART A

FOUNDATION INVESTIGATION REPORT
HALLS LAKE DAM BRIDGE REMOVAL
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1.0 INTRODUCTION

WSP Canada Inc. (WSP Golder) has been retained by the Ministry of Transportation (MTO) to provide detailed design services for the rehabilitation of Highway 35 at Carnarvon and four bridge rehabilitations on Highway 35. As part of this assignment, WSP carried out foundation investigation to enable the design of the Halls Lake Dam Bridge (i.e. pedestrian bridge) removal and reinstatement of the surrounding area.

MTO intends to undertake the removal of the Halls Lake Dam Bridge (WP 5214-19-01), also known as the Buttermilk Falls Pedestrian Bridge, which is located immediately south of the Halls Lake Dam, and is in proximity of the Highway 35 / Kennisis River Bridge (see Key Plan on Drawing 1). Geographically, the site is approximately 7.4 km north of Carnarvon, Ontario.

During development of the preliminary structural design report for the removal of the existing pedestrian bridge, information gaps were identified with regards to existing geotechnical information. The scope of the foundation investigation was outlined in the approved change order and this foundation report is based on the results of the investigation and information supplied by WSP's Bridge Group as of April 2023. The purpose of this foundation investigation was to explore the subsurface conditions at the site to assist in closing some of the information gaps as follows:

- Assess the depth and composition of the soils behind the abutment walls of the existing pedestrian bridge and the previous highway bridge immediately downstream of the existing dam to support removal options and assess risks for landscape reinstatement options; and
- Assess the geometry of the existing Halls Lake Dam Bridge abutment walls by excavating test pits immediately behind the existing pedestrian bridge abutment walls and behind the southeast wingwall to determine backslope angle (if any), the composition of backfill material, and the depth and dimension of the abutment wall foundation.

This Foundation Investigation Report summarizes the factual results of the field and laboratory work and provides a description of the interpreted soil and groundwater conditions at the project site.

2.0 BACKGROUND INFORMATION

2.1 SITE DESCRIPTION

The Halls Lake Dam Bridge was constructed in 1925 and the original Highway 35 (including the previous bridge that crossed the Halls Lake Dam spillway just south of the Halls Lake Dam Bridge) was constructed in the early 1930's. In 1970, Highway 35 was realigned and reconstructed. This included the construction of the Highway 35 / Kennisis River Bridge (located approximately 30 m upstream from the dam), as well as the removal of the original Highway 35 bridge crossing. As per the preliminary structural design report, it was noted in the contract drawings that the previous Highway 35 bridge was to be removed to "top of footing", leaving behind a portion of the original foundation and abutment walls, which still exist today and identified as the remnants of original bridge structure on Drawing 1. It is also noted in the contract documents that the "old bridge" (Halls Lake Dam Bridge) was to remain, likely for the intended use by pedestrians and as a viewing platform for the waterway below. A detailed visual inspection report for Parks Canada (current owner / operator of the Halls Lake Dam) concluded the Halls Lake Dam bridge is in very poor condition. Significant concrete spalling and cracks were noted in the bridge soffit and T-beams, as well as notable wide cracks in the abutment and wing walls, and it was recommended the structure to be closed and that its removal be considered. The bridge was closed to the public in 2017 when it was deemed unsafe for pedestrian use (see Photographs 1 and 2 below). A detailed visual inspection completed by WSP under contract with Parks Canada (PCA Project Number: I/O# 20037961, RPA # 1368).

Photograph 1 – Looking Construction North at existing Halls Lake Dam Bridge (Dam directly on the right)

Photograph 2 – Looking Construction South at existing Halls Lake Dam Bridge Abutment Wing Wall

The Halls Lake Dam bridge includes a single span of approximately 5.3 m between the abutment walls made up of four cast-in-place T-beams, which support an exposed concrete deck. In addition to the T-beam, there is a single W-section that spans between the abutments along the centreline of the bridge. A picture of the existing Halls Lake Dam Bridge is shown in Photograph 3 below.

Photograph 3 – Looking upstream towards Halls Lake Dam Bridge (Dam in far background)

2.2 GEOLOGICAL SETTING

Site geology as per Ontario Geological Survey (OGS) Geology Map No: 2556 on the Quaternary Geology of Ontario, Southern Sheet (1:1,000,000 scale) indicates the surficial geology in the area investigated to be generally Precambrian bedrock with sections of glaciolacustrine deposits (sand, gravelly sand and gravel) and glaciofluvial ice-contact deposits (gravel and sand, minor till).

As indicated in the Physiography of Southern Ontario, the project area is mapped within the physiographic region known as the Algonquin Highlands. The Algonquin Highlands generally consists of shallow soils (sandy glacial till) underlain by granite and other Precambrian rocks. Many of the valleys are floored with outwash sand and gravel and the majority of the region is forested except for scattered open clearings of bare rock.

Bedrock geology mapping (OGS, Bedrock Geology of Ontario, Southern Sheet, Map No. 2544) indicates tectonites, straight gneisses, porphyroclastic gneisses, unsubdivided gneisses in major deformation zones, mylonites, and protomylonites primarily north of Carnarvon.

2.3 PREVIOUS GEOTECHNICAL INFORMATION

A previous foundation investigation report is available for the realigned Highway 35 / Kennisis River Bridge, located about 30 m north of the Halls Lake Dam Bridge Removal site. The Kenninis River is also referred to as Buttermilk Falls in this area. A summary of the relevant information from the "Soil Conditions and Foundations, Proposed Buttermilk Falls Crossing, Highway No. 35 – Line G, Halls Lake, Ontario, GEOCRESS No. 31E00-006, prepared by H.Q. Golder & Associates Ltd, dated June 1966" is provided below:

- The investigation consisted of advancing 2 boreholes and 2 test pits near the proposed new bridge abutment locations.
- The soil stratigraphy provided in the report typically comprised of sandy topsoil (less than 0.3 m thick) underlain by granite gneiss bedrock. The bedrock was generally in fairly sound to sound condition with exception of the upper 0.3 m to 0.9 m, which was highly weathered.
- Frequent bedrock outcrops were reported in the vicinity of the bridge. The banks of the Kennisis River consisted of exposed bedrock and were steeply sloping, ranging from near vertical to 1.5H:1V. There was some irregularity observed in the rock face crest which suggests that portions of the face have fallen away in the past;
- The water level in the open boreholes was generally consistent with the water level of Kennisis River which was at about Elevation 325.3 m at the time of the investigation. The river water level was described as being controlled by the dam at the time of the investigation which was at a level of about Elevation 325.6 m.
- It was recommended that the bridge abutments be founded in the fairly sound bedrock with an allowable bearing value of about 1 MPa (10 tons/sq. ft.).
- To ensure the stability of the near vertical rock face at the east abutment (Construction South) location, it was recommended rock fill be dumped in the stream channel adjacent to the face and up to footing level for the length of footing.
- There should not be no overall stability problem with the proposed approach embankments consisting of rock fill, some 10 feet high.

3.0 INVESTIGATION PROCEDURES

3.1 GENERAL

The subsurface exploration program consisted of a field site reconnaissance visit and a field investigation where three (3) boreholes were drilled and sampled, and three (3) test pits were excavated. A laboratory testing program on select samples obtained during the field investigation was also carried out as part of the subsurface exploration program.

For consistency with the structural design report, the north-south direction is taken to run approximately parallel to Highway 35 and the span length of the Halls Lake Dam Bridge for design and construction as indicated on Drawing 1.

3.1.1 FIELD INVESTIGATION

The site reconnaissance observations about the nature of terrain and access constraints for conventional drilling equipment were carefully considered in planning the field investigation program. During the site reconnaissance, it was observed that a rest / picnic area exists on the west side of Highway 35 and directly south of the Halls Lake Dam Bridge, and the remnants of the previous road (now a makeshift parking area for viewing of Buttermilk Falls) crossing the bridge exists on the west side of Highway 35 directly north of the Halls Lake Dam Bridge. There is an existing guide rail separating the picnic area and previous road from the crest of the bank leading down to the spillway (Buttermilk Falls). At the time of the site visit, there were no signs of slope instability of the surrounding embankments near the bridge abutments or crest of the bank (near the guide rail).

The field investigation consisted of drilling and sampling three (3) exploratory boreholes (identified as BHHL-1 to BHHL-3) within the north and south approach embankments of the existing bridge (BH HL-1 and BH HL-2), and behind the remnants of the original Highway 35 bridge south abutment substructure (BH HL-3). Three (3) test pits, identified as TP-1 to TP-3, were excavated immediately behind the existing north and south bridge abutment walls (TP-1 and TP-2) and behind the southwest wingwall (TP-3). The exploratory borehole and test pit locations are shown on the Drawing provided in **Appendix A**.

The field work was carried out on April 5 and April 13, 2022. The boreholes were advanced using a rubber track mounted CME 75 drilling rig and hollow-stem augers followed by wash bore casing. The test pits were excavated using a hydro vacuum truck.

Prior to the start of drilling and excavating activities, utility clearances were obtained for all borehole and test pit locations.

The field work was supervised on a full-time basis by members of WSP technical staff who located the boreholes and test pits in the field, directed the drilling, sampling, test pit excavation, and in-situ testing operations, and logged the boreholes and test pits. The drilling equipment was supplied and operated by Marathon Underground of Ottawa, ON. The hydro vacuum truck was supplied and operated by Centreline Hydrovac of Peterborough, ON. The borehole locations and elevations were surveyed by Tulloch Engineering of Huntsville, ON and referenced to the NAD83 MTM Zone 10 coordinate system and geodetic datum. The borehole locations, including northing and easting coordinates, ground surface elevations, and drilled depths are on the Record of Boreholes provided in **Appendix B**. The approximate location and elevation of the test pits were cross-referenced with the abutment locations and ground surface profile provided on the base plan drawings and the test pit logs are provided in **Appendix D**.

Soil samples were retrieved at regular intervals of depth with a 50 mm Outer Diameter (O.D.), split spoon sampler driven with a full weight hammer weighing 63.5 kg and dropping 760 mm in general accordance with the Standard Penetration Test (ASTM D1586) method. The SPT 'N' values are indicated on the Record of Borehole Sheets provided in **Appendix B** and are considered uncorrected. Bedrock was sampled and cored using an NQ size coring barrel. All soil and bedrock samples were labelled and transported to WSP laboratory in Peterborough, Ontario.

3.1.2 LABORATORY TESTING

Upon completion of drilling and coring activities, soil and bedrock samples were transported to WSP's laboratory for further examination, classification and testing. Three (3) grain size distribution tests were carried out on selected representative soil samples. The results of the grain size distribution tests are summarized on the individual borehole records and details are presented in **Appendix C**.

3.1.3 GROUNDWATER INVESTIGATION

Standpipe piezometers (50 mm diameter) were installed within 2 boreholes (BH HL-1 and BH HL-2) upon completion of drilling to measure groundwater levels over time. Borehole BH HL-3 encountered groundwater at a depth of about 1 m below ground surface; however, this water level is not considered to represent stabilized conditions. Although water was used to assist with advancing the test pits as part of the hydro vacuum activities, standing water was typically not observed in the test pits upon completion.

Borehole BH HL-3 and the annulus between the piezometer pipe and excavated hole above the sand filter in Boreholes BH HL-1 and BH HL-2 was backfilled with a bentonite mixture in general accordance with Regulation 903 (as amended). The shallow test pits were backfilled with a uniformly graded sand up to the existing ground surface and compacted in place.

Table 3-1 below provides information about the standpipe piezometers installed for this investigation, including ground surface elevation, depths and the approximate elevations of the screen interval, and measured groundwater levels.

Table 3-1 – Summary of Groundwater Measurements

Borehole No.	Ground Surface Elevation (m)	Well Screen Interval Depth / Elevation (m)		Groundwater Observations	
		From	To	Date	Depth / Elevation (m)
BH HL-1	326.2	1.8 / 324.4	3.4 / 322.8	April 13, 2022	1.8 / 324.4
BH HL-2	325.9	3.1 / 322.8	6.2 / 319.7	April 13, 2022	Dry

It should be noted that the groundwater levels will vary and are subject to seasonal fluctuations as well as fluctuations in response to precipitation events. The groundwater levels will also be influenced by the water level in Kennisis River which is under direct control of the existing dam operations. It is noted that the water level measured in Kennissis River (upstream of the Dam) was at about Elevation 324.7 m as observed from the water elevation marker at the dam site on Dec. 13, 2021. During the previous 1966 investigation, the water level was reported to be at about Elevation 325.6 m.

4.0 SUBSURFACE CONDITIONS

The subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in-situ testing from the investigation are shown on the borehole and drillhole records presented in **Appendix B**. The results of the geotechnical laboratory testing are presented on the borehole records as well as on figures provided in **Appendix C**. The test pit records are provided in **Appendix D**. The borehole and test pit locations and the interpreted stratigraphic profile projected along the bridge alignment are provided on the drawing provided in **Appendix A**. It is noted that the existing bridge profile shown on Drawing 1 is approximate and not to scale.

The stratigraphic boundaries shown on the borehole and drillhole records and on the interpreted stratigraphic section on the drawing is inferred from observations of the drilling progress together with non-continuous soil sampling and may represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In general, the subsurface soils consist of fill overlying bedrock. A native deposit of silty sand was encountered between the fill and bedrock in Borehole BH HL-3.

4.1 OVERBURDEN SOILS

TOPSOIL

A layer of topsoil (50 mm thick) was encountered at ground surface Borehole (BH) HL-2.

SAND TO SAND AND GRAVEL (FILL)

Non-cohesive fill was encountered at ground surface in BH HL-1, BH HL-3, TP-1, TP-2, TP-3 and below the topsoil in BH HL-2. The fill consisted of sand, gravelly sand, and sand and gravel and ranged from 0.7 m to 1.5 m thick. At the time of the investigation, the non-cohesive fill was found to be in a moist condition. The sand and gravel encountered in TP-1 to TP-3 (located adjacent to the bridge abutments and retaining wall) contained variable amounts of cobble to boulder sized rock fragments. In TP-1, some asphalt pieces were observed to be mixed with the and gravel fill. The presence of frequent tree roots / rootlets was observed within the sand and gravel in TP-3.

The SPT N-values measured in the non-cohesive fill ranged from 8 to 16 blows per 300 mm of penetration, indicating a loose to compact state of compactness.

A summary of grain size distribution results for two samples of the non-cohesive fill is presented in the table below (See **Figure C-1** in **Appendix C**).

Table 4-1 – Results of Grain Size Analyses for Sand and Gravelly Sand Fill

Borehole No.	Sample No.	Grain Size Distribution		
		% Gravel	% Sand	% Fines
BH HL-1	1	23	64	13
BH HL-2	1	11	68	21

ROCK FILL

Rock fill was encountered in Boreholes BH HL-1 and BH HL-2 and Test Pits TP-1 and TP-2, below the sand to sand and gravel fill. The top of the rock fill was encountered at depths ranging from 0.8 m to 1.5 m below ground surface and the thickness of rock fill was measured to be approximately 1.5 m and 1.9 m in BH HL-1 and BH HL-2 respectively. The test pits were terminated at the top of the rock fill. The rock fill contained frequent cobble and boulder sized pieces mixed with sand and gravel based on visual observation of the bottom of the test pits and inferred by the rock fragments collected in the split-spoon samples from the boreholes.

The SPT N-values measured in the rock fill ranged from 33 blows per 300 mm of penetration to 50 blows per 100 mm of penetration (i.e. effective refusal), suggesting a compact to very dense state of compactness.

SILTY SAND

A layer of silty sand was encountered below the sand fill in BH HL-3. The top of the silty sand was encountered at a depth of 1.1 m below ground surface and the layer was 2 m thick. The bottom of the layer transitioned to a gravelly sand at depth.

The SPT N-values measured in the silty sand ranged from 5 to 54 blows per 300 mm of penetration, indicating a loose to very dense state of compactness.

A summary of grain size distribution results for a sample of the silty sand is presented in the table below (See **Figure C-2** in **Appendix C**).

Table 4-2 – Results of Grain Size Analyses for Silty Sand

Borehole No.	Sample No.	Grain Size Distribution		
		% Gravel	% Sand	% Fines
BH HL-3	3	8	39	53

4.2 BEDROCK

The overburden soils are underlain by granite bedrock as confirmed by NQ-sized bedrock core samples (ranging from 2.5 m to 3.3 m in length) recovered in the three drilled boreholes. In addition, bedrock outcrop was observed at the bottom of the dam spillway directly downstream of the bridge as identified in Drawing 1.

At the borehole locations, the bedrock surface was encountered at depths ranging from about 3.0 m to 3.1 m below existing ground surface (Elevation 322.5 m to 323.2 m). The degree of weathering typically ranged from fresh (W1) to moderately weathered (W3), with the top 0.3 m of the bedrock surface typically inferred to have a highly weathered / fractured classification.

The bedrock is classified as a strong to very strong, grey / pink granite (granitic gneiss). The Total Core Recovery (TCR) ranged from about 75 % to 100 %. The Rock Quality Designation (RQD) values ranged from 36 % to 74 % indicating poor to fair rock quality (as per Table 3.10 in CFEM, 2006).

5.0 CLOSURE

The geotechnical fieldwork for this assignment was completed by Trent Larock, a senior technician with WSP Golder. The reporting was completed by Pouya Pishgah, P. Eng. and Principal with WSP Golder. Kevin J. Bentley, P.Eng. and MTO Foundations Designated Contact for WSP-Golder, completed a technical and quality control review of the report.

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PART B

FOUNDATION DESIGN REPORT
PROPOSED HALLS LAKE DAM BRIDGE REMOVAL
REHABILITATION OF HIGHWAY 35 AT CARNARVON AND FOUR BRIDGE REHABILITATIONS ON HIGHWAY 35

ASSIGNMENT NO. 5018-E-0024
G.W.P. 5288-14-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 GENERAL

This section of the report provides an assessment of the geotechnical conditions and provides foundation recommendations associated with the removal of the Halls Lake Dam Bridge (i.e. pedestrian bridge) and design of the associated reinstatement works to the surrounding area. The recommendations are based on interpretation of the factual data obtained from the boreholes and test pits advanced as part of the current subsurface exploration.

This Foundation Design Report (Part B of this report) including the discussion and recommendations are intended for the use of MTO and their designers for detailed design and shall not be used or relied upon for any other purpose or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in the Foundation Investigation Report (Part A of this report). Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 PROJECT UNDERSTANDING

As the main thrust of the discussion and recommendations of this report, focus will be made on the geotechnical aspects associated with the design of the reinstatement works after the Halls Lake Dam Bridge is removed.

Based on the preliminary structural design report prepared by the WSP bridge team, three options are to be considered for the removal of Halls Lake Dam Bridge and reinstatement of the site post-removal. The preliminary design for these three options is summarized below and illustrated in design sketches in **Appendix F**:

- **Option 1- minimize removal and regrade surrounding landscape as required:** In an effort to minimize construction efforts and costs, this option is intended to focus primarily on the removal of Halls Lake Dam Bridge superstructure and some localized removals of the remaining substructural elements where required. The surrounding landscape would then be regraded to the top of the structural removals. Specifically, the removals would include the bridge superstructure and the portion of the substructure above the top elevation of the original dam spillway walls. The exposed top surface of these walls could then be repaired as required, and the backfill behind the structure regraded to a 2 Horizontal:1 Vertical (2H:1V) slope with a combination of granular and rip rap protection material. A guide rail, similar to what is existing, would also be required at the top of the slope to discourage access to the spillway.
- **Option 2- complete more extensive removal and reinstate with new independent retaining structures:** Similar to Option 1, the proposed removals under this option would include the bridge superstructure, southwest wingwall, and the previous Highway 35 bridge abutments. However, for this option, the portion of the abutment/spillway wall that is original to the bridge would also be removed. Following removals, new independent retaining structures would be constructed in their place to re-establish the existing layout of the walls. These retaining structures, as an example, could include gabion walls, or similar modular systems, that could be considered in place of the removed wing walls and abutment walls, as well as behind the portion of the dam spillway/abutment walls that are to remain. These new structures would resist earth pressures while allowing the original dam spillway geometry to be maintained. The introduction of the new gabion walls (or

similar) provides a completely independent system that would remove risk and liability associated with relying on the existing substructure elements.

- **Option 3 – a hybrid solution between first two options:** Options 1 and 2 provide the upper and lower boundaries for both the minimal removal and reinstatement efforts (Option 1), as well as more extensive design (Option 2). Option 3 is intended to be a compromise to the two extremes by reducing some of the removal requirements compared to Option 2 but including some new construction (similar to Option 2) that alleviates some of the risks that arise from Option 1. This option would include the same limits of removals as Option 1, however in place of regrading, new gabion retaining systems (or similar) would be constructed above the top elevation of the removals. The purpose of the preliminary layout of these gabions is two-fold. First, the portion of the gabion that is intended to bear on top of the remaining abutment/spillway walls would improve the lateral loading resistance of these walls by contributing to the gravity wall effects. Second, the extension of the gabion wall into the fill behind the existing structure would act as an independent retaining system that would considerably reduce the soil pressure on the remaining elements. The southwest wing wall could also be replaced by gabions, simplifying the construction.

6.3 PREFERRED OPTION

Following initial consultation with MTO, the preferred solution was originally identified as Option 1, which includes minimized removal and grading to avoid significant effort and costs. Option 1 is considered to be a valid solution, however it does result in potential risks during construction, as well as long-term risk and liability concerns due to the uncertainties regarding the competency and design life of the structural elements that are to remain and their ability to remain functional despite continued degradation. The other two design options presented (Options 2 and 3) intend to control these risks by introducing new, independent structural elements that can generally remove these risks (Option 2) or reduce said risks to a more manageable level (Option 3).

From a geotechnical perspective and based on the subsurface conditions encountered, all three options presented above are feasible for the removal of Halls Lake Dam Bridge and reinstatement of the surrounding area. Given the uncertainties regarding the competency and remaining design life of the existing structural elements, and after further consultation with MTO and other stakeholders (i.e. Parks Canada), it is understood that Option 3 is the preferred option for detailed design of the Halls Lake Dam Bridge removal and reinstatement.

The preliminary General Arrangement (GA) Drawing and associated removals / reinstatement drawings (dated June 2023) were provided by the design team and used to develop the following geotechnical recommendations. A copy of the preliminary GA is provided in **Appendix F**. Gabion walls have been identified as the preferred retaining wall type for the reinstatement. Based on the GA Drawing, the existing Halls Lake Dam Bridge is to be removed along with the southwest and northwest retaining walls (footing to remain). The remnants of the previous Highway 35 north and south abutment walls are to be removed. The footing at the previous highway bridge north abutment is to remain and the footing at the south abutment is to be removed.

New gabion walls are proposed to replace the abutment walls / wingwalls at the Halls Lake Dam Bridge north and south abutments and southwest retaining wall, and the previous Highway 35 north abutment wall. The gabion walls range from about 1.5 m to 3 m high and are generally shown to be founded partially or completely on reinforced concrete slabs that are dowelled into and cantilevered on the existing concrete foundations. It is assumed the concrete slabs act as structural foundations for the gabion walls and will be designed to resist the anticipated loading. At the Halls Lake Dam Bridge north and south abutment locations, the gabion walls are shown to be founded partially on the existing concrete foundations and partially on a 300 mm thick Granular 'A' base over existing soils. At these locations, the existing fills are to be removed down to the rock fill, and backfilled with additional thickness of Granular 'A' as required.

New gabion walls are also proposed to retain the earth after removal of the previous Highway 35 south abutment wall and foundation. The new gabion wall in this area is shown to be up to about 3 m high, supported on a new concrete foundation slab dowelled into the bedrock, and set-back from the crest of the spillway (existing abutment wall). The entire footprint of the proposed new retaining wall in this area is shown to be cleared and stripped to expose the bedrock surface that will act as the foundation for the gabion wall. The integrity of the bedrock below and in front of the new gabion wall (adjacent to spillway), after removal of the previous Highway 35 south abutment foundations,

will need to be checked by visual inspection to confirm bedrock surface is competent to support the new gabion wall / spillway system. Consideration could be given to leaving the existing foundation in place (particularly any tie-backs which are assumed to be present in this area based on design drawings) in some areas to reduce disturbance to the bedrock within the new gabion wall foundation zone of influence.

6.4 GEOTECHNICAL RECOMMENDATIONS

6.4.1 OVERVIEW OF SUBSURFACE CONDITIONS

As an overview, the encountered subsurface conditions have been summarized below and have been described in greater detail in the Foundation Investigation Report (FIR).

The embankments at the Halls Lake Dam Bridge location consist of loose to compact non-cohesive fill. The fill generally consists of sand to sand and gravel containing variable amounts of cobble and boulder-sized rock fragments. A layer of native silty sand was encountered below the sand fill in the borehole advanced near the southwest retaining wall (BH HL-3).

At the bridge abutments (BH HL-1 and BH HL-2), rock fill was encountered below the sand to sand and gravel fill. The rock fill generally contains angular cobble to boulder-sized rock fragments mixed with sand and gravel.

Strong to very strong granite bedrock was encountered and confirmed below the overburden in the three boreholes. The bedrock surface ranged from Elevation 323.2 m to Elevation 322.5 m (3.0 to 3.1 m depth below existing ground surface). The degree of weathering typically ranged from fresh (W1) to moderately weathered (W3), with the top 0.3 m of bedrock generally being highly weathered / highly fractured. The Rock Quality Designation (RQD) values indicate the bedrock to be of poor to fair quality.

6.4.2 GEOTECHNICAL DESIGN

GEOTECHNICAL PARAMETER SELECTION

A geotechnical model was developed based on the subsurface conditions discussed in Section 4.0 of the FIR (as summarized in Section 6.4.1 above) and engineering judgement, as shown in **Table 6-1**Table 6-1. The purpose of the geotechnical model is to establish idealized stratigraphy and selection of geotechnical parameters to enable assessment and design of the retaining walls, open-cut / temporary shoring, and global stability associated with the bridge removal / reinstatement.

Groundwater measurements within the standpipe piezometers have been provided in **Table 3-1**.

Table 6-1 – Idealized Subsurface Conditions and Geotechnical Parameters

Depth Range (m)	Thickness Range (m)	Material / Deposit	SPT 'N' Value			Bulk Unit Weight, γ (kN/m^3)	Apparent Cohesion, C'/ Undrained Shear Strength, S_u (kPa)	Effective Friction Angle, φ' (°)	Elastic Modulus, E_s (MPa)
			Avg.	Range	No. of Tests				
0.0-1.5	0.8-1.5	Sand to Sand and Gravel Fill	12	8-16	3	19	0	32	20
1.1 – 3.1	2	Silty Sand	26	5-54	3	19	0	32	20

Depth Range (m)	Thickness Range (m)	Material / Deposit	SPT 'N' Value			Bulk Unit Weight, γ (kN/m^3)	Apparent Cohesion, C'/ Undrained Shear Strength, S_u (kPa)	Effective Friction Angle, φ' (°)	Elastic Modulus, E_s (MPa)
			Avg.	Range	No. of Tests				
0.8-3.0	1.5-2.2	Rock Fill	>50	33- >100	5	19	0	42	-
3.0-6.2	-	Granite Bedrock	-	-	-	25	Impenetrable for global stability		

Notes: SPT 'N' values are number of blows per 300 mm of penetration.

LATERAL EARTH PRESSURE

The lateral earth pressure acting on the existing retaining walls and any new gabion walls will depend on the type and method of placement of the backfill material, the nature of the soil behind the backfill, the magnitude of surcharge including construction loadings, freedom of lateral movement of structure, and the drainage conditions behind the walls.

The following recommendations are made for the design and construction of the proposed new retaining walls. The design recommendations and parameters assume level backfill and ground surface behind the wall. Where there is sloping ground behind the wall, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Free-draining fill material meeting specifications of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II should be used as backfill behind the walls.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressure for the structural design of the walls, in accordance with CHBDC (2019) Section 6.12.3 and Figure 6.8. Other surcharge loadings, including traffic loads, should be accounted for in the design as required. Compaction (including type equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (Compacting).

The lateral earth pressures may be based on the existing embankment fill and overburden soil, and the following parameters (unfactored) may be used for design. Soil parameters for imported Granular 'A' or 'B' Type II (as required) are also provided in **Table 6-2** below:

Table 6-2 – Coefficients of Lateral Earth Pressures

Material / Deposit	Bulk Unit Weight, γ (kN/m^3)	Effective Friction Angle, φ' (°)	Coefficients of Lateral Earth Pressure [1,2]		
			At-Rest, K_0	Active, K_a	Passive, K_p
Engineered Fill (Granular 'A' or 'B' Type II)	21	35	0.43	0.27	3.7
Sand to Sand and Gravel Fill	19	32	0.47	0.31	3.25
Silty Sand	19	32	0.47	0.31	3.25
Rock Fill	19	42	0.33	0.20	5.04

Notes:

1-The lateral earth pressure coefficients presented are based on a horizontal surface adjacent to the wall. If sloped surfaces are expected, the coefficients should be corrected accordingly.

2-The passive resistance coefficients presented are for estimating full passive resistances based on large wall movements and should be reduced for small movements in accordance with Figure C26.7 of the Commentary to the CHBDC (2019).

GEOTECHNICAL RESISTANCES

The geotechnical resistances provided in **Table 6-3** below may be used for the design of retaining wall foundations:

Table 6-3 – Geotechnical Resistance

Foundation Subgrade Type	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Resistance at SLS (kPa) for 25 mm Settlement	Comments
Existing Compact Sand to Sand and Gravel Fill / Compact to Very Dense Silty Sand	225	150	Free of excessive organics
Engineered Fill (Granular 'A' or 'B' Type II) or Weathered / Fractured Bedrock	500	350	Engineered fill founded on rock fill or bedrock
Bedrock	5,000	N/A[1]	Assuming bedrock surface is generally level and not sloping

[1] Assuming that the retaining walls are founded on granite bedrock, the factored serviceability geotechnical axial resistance for 25 mm of settlement will be greater that or equal to the factored ultimate geotechnical axial resistances and therefore, the serviceability condition will not apply.

The existing topsoil, loose fills and fills containing excessive organics (more than 5%) should be removed from below the foundation footprint and replaced with engineered fill, as applicable.

The geotechnical resistance values for engineered fill assume the retaining walls are founded on granular bedding soils on approved engineered fill (i.e., OPSS 1010 Granular 'A' or Granular 'B' Type II). Consideration can be given reusing the existing sand to sand gravel fill for reuse as engineered fill as discussed in Section 6.5.

It should be noted that there is expected to be some variation in the subexcavation depth required to reach the founding subgrade (i.e. existing concrete foundations, rock fill or bedrock) given the inherent variability of the existing features on site, and any adjustments to quantities will be subject to the general conditions of the standard MTO contract.

The frost depth for the project site is 1.8 m based on the MTO Foundation Frost Depths for Southern Ontario, OPSD 3090.101.

GLOBAL STABILITY / SETTLEMENT

The proposed new retaining walls (including portions of the reinforced concrete base slab at some locations) are generally to be founded partially on the existing concrete foundations and partially on existing non-cohesive fill (sand to sand and gravel fill or rock fill) or bedrock, depending on the location along the proposed alignment.

At the proposed retaining wall locations, there are no grade raises or steepening of slopes anticipated. Since the existing bridge and embankments have been in place for a relatively long time, the applied stresses on the existing bridge foundations are considered to have become fully effective and any consolidation of foundations soils has occurred.

Therefore, subject to proper construction controls and quality control / assurance, there should not be an issue with either settlement or stability, as the net increase in load that will be experienced by the new retaining walls due to replacements is effectively negligible.

Considering that the highest retaining wall (i.e. proposed 3 m high gabion basket system) is anticipated to be placed on granite bedrock at the southwest wing wall location and on a reinforced concrete slab on top of the existing concrete foundation (on bedrock) at the northwest wing wall location, the global slope stability assessment indicates critical slip surfaces would need to pass through the bedrock which is considered to be impenetrable for this assessment. Consequently, the Factors of Safety calculated for the short-term and long-term conditions for deep-seated, global failure surfaces along the new retaining wall that would impact the operation of adjacent parking area/picnic area/highway are expected to be greater than 1.5.

6.5 GABION SYSTEMS / BACKFILL AND MATERIAL REUSE

6.5.1 GABION WALLS

Gabion retaining walls should be constructed in accordance with OPSS.PROV 512 and OPSS.PROV 1430. Geotextiles should be used between the gabion baskets and backfill soils to reduce the potential for loss of materials into the gabion stones. Geotextiles should be non-woven, Class II according to OPSS 1860 with a FOS of 75-150 µm. The internal stability of the gabion retaining wall system must be designed and checked by the proprietary retaining wall designer. A minimum 0.3 m thick granular pad (levelling pad) consisting of OPSS.PROV 1010 Granular 'A' should be placed below the gabion wall / reinforced concrete slab footprint where founded above overburdens soils.

6.5.2 BACKFILL

Temporary excavations will be required for the bridge removal and reinstatement with new retaining walls. Temporary excavations are discussed in Section 7.0.

All backfill materials should consist of suitable free-draining granular fill material placed and compacted in accordance with relevant OPSS.PROV 902, 501, and 206.

To avoid damaging or laterally displacing the structures, care should be exercised at the time of compacting fill adjacent to any retaining wall structures. Compaction equipment should be restricted to an appropriate size to prevent damage to the adjacent bridge structures.

6.5.3 MATERIAL REUSE

The existing non-cohesive fill materials (sand to sand and gravel) are considered suitable for reuse as general excavation backfill provided they are free of organics. The native silty sand may also be considered suitable as backfill material. Any rock fragments greater than 150 mm in size should be removed prior to reuse as backfill. Excavated soils should be reviewed by the geotechnical engineer as construction progresses and suitable portions stockpiled for re-use where feasible.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 GROUNDWATER AND SURFACE WATER CONTROL

The groundwater level measured in the piezometers installed in Boreholes BH HL-1 and BH HL-2 was at Elevation 324.4 m (1.8 m below existing ground surface) and was dry when checked on April 13, 2022, respectively. It is noted that the dry piezometer in BH HL-2 was screened within the bedrock. The groundwater level is expected to be sensitive to changes in the water level in Kennisis River which is controlled by Halls Lake Dam, and the water level within the spillway.

Temporary excavations up to about 4 m below ground surface are anticipated to be required to expose the existing foundations, construct the reinforced concrete slab, and place and compact Granular 'A' base below the proposed gabion walls at the Halls Lake Dam southwest and northwest wing walls, and the proposed gabion wall at the previous Highway 35 north abutment. Temporary excavations to about 1.5 m below ground surface are anticipated for placement and compaction of the Granular 'A' base material for the new gabion walls at the Halls Lake Dam north and south abutment locations.

As a result, temporary excavations for the southwest and northwest wing walls and previous Highway 35 north abutment are anticipated to be up to about 2 m below the groundwater elevation (depending on dam operations and time of year). Temporary excavations at the Halls Lake Dam abutment locations are anticipated to be at or near the groundwater level.

Dewatering is anticipated to be required, particularly at the southwest and northwest wing walls. Considering removal of the existing abutments walls is required adjacent to the spillway, groundwater can likely be diverted into the watercourse in order to create and maintain a relatively dry work environment. Groundwater should be lowered to at least 0.5 m below the lowest excavation level. Any surface water flow in the spillway / watercourse will need to be temporarily halted (if flow exists at the time of construction) or will need to be temporarily diverted around the construction site. It is recommended that, if possible, construction be carried out in a period when the existing river / watercourse would be expected to be at the lowest level.

Dewatering operations should be in accordance with OPSS.PROV 517 and SP 517F01, as referenced on OPSS.PROV 902. A special provision for foundation dewatering has been included in **Appendix E** to address potential instability of the foundation subgrade, temporary flow diversion and pre-construction survey requirements.

The excavations and/or reinstatement works may require a Ministry of the Environment, Conservation, and Parks (MECP) Environmental Activity and Sector Registration (EASR – which covers construction dewatering up to 400,000 l/day) depending on the time of construction (seasonally) and the duration of the open excavation / construction. A Permit to Take Water (PTTW) is required for dewatering in excess of 400,000 l/day and is not anticipated to be required at this time. This expectation will need to be reviewed and confirmed by a hydrogeologist to confirm this preliminary assessment.

Surface water should be directed away from the excavations at all times.

To reduce erosion of the permanent embankment side slope due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the reinstated embankments as per OPSS.PROV 803. Temporary erosion protection on exposed cuts / fills must be in accordance with OPSS.PROV 804 (Temporary Erosion Control).

7.2 TEMPORARY EXCAVATION AND CUT SLOPES

All temporary excavations should be carried out in accordance with the Ontario Occupational Health and Safety Act (OHSA), O. Reg. 213/91, and OPSS.PROV 539.

In accordance with the OHSA, the following soil classifications would be applicable for the anticipated soils that will be encountered during the open excavations for removals and construction of the new retaining walls.

The existing loose to compact sand to sand and gravel fill, rock fill, and native compact to very dense silty sand can be classified Type 3 soils as per OHSA. Temporary excavations (i.e., those open for a relatively short time period) should be made with side slopes no steeper than 1H:1V in Type 3 soils. It is assumed that the Type 3 soils will be dewatered, otherwise, side slopes in saturated conditions should be made no steeper than 3H:1V.

The recommended slope angles for the above soil types are guidelines for temporary excavations for a short duration; however, the minimum requirements in OHSA must be followed. We also recommend that these slopes be visually monitored for any movement and precautions taken as required if workers are present at the toe of the slopes.

All excavations should be undertaken with care to minimize disturbance, especially to the anticipated saturated foundation subgrade. No material stockpiling should be undertaken beside the excavation within a horizontal distance equal to the depth of the excavation.

Excavations should be possible in the above soil types using equipment such as a hydraulic excavator but obstructions such as rock fill, cobbles and boulders within the excavation depths are anticipated. Bedrock removal may be required and could be accomplished by pneumatic or percussion methods, such as a hoe ram, but progress should be anticipated to be challenging and slow. Given the anticipated shallow depth and limited length of bedrock removal (for the proposed retaining wall near the previous Highway 35 south abutment) and the amount of fracturing observed in the upper portions of the bedrock, the need for blasting operations is not anticipated.

All temporary excavation should be observed by a qualified geotechnical engineer and reviewed during constriction to confirm that the soil and groundwater conditions are as anticipated in this report. If unexpected conditions are encountered, a geotechnical engineer should review the excavation plan based on the conditions encountered at that time.

7.3 OBSTRUCTIONS / ROCK FILL / BEDROCK

Frequent cobble to boulder-sized rock fill fragments were confirmed in the granular fill in the test pits, and rock fill was confirmed at the bottom of each test pit and inferred by the Standard Penetration Test refusal encountered within the rock fill in Borehole BH HL-2. The presence of bedrock outcrops along the spillway was confirmed in the vicinity of the site and it is expected that the bedrock surface is undulating and highly variable at the site and within the footprint of the new gabion walls.

Encountering cobble to boulder sized rock fill should be anticipated during excavation for the bridge removal and reinstatement activities.

Granite bedrock was encountered between Elevation 322.5 m and 323.2 m, about 3 m below the existing grade in the boreholes. Sub-excavation of the strong to extremely strong granite bedrock (as per Table 3.5 of CFEM, 2006) should be anticipated by the Contractor and is expected to be challenging. Any temporary protection systems required for staging will also need to take into consideration the rock fragments in the existing fill and relatively high bedrock elevation at the site.

An NSSP has been included in **Appendix E** to alert the Contractor of such obstructions.

7.4 BEARING SUBGRADE

Prior to retaining wall installation, the existing bridge abutments and portions of the existing foundations must be removed. This operation should be undertaken carefully to minimize disturbance to the foundation subgrade. Given the presence of the loose sands at some locations, which could be prone to construction disturbance, to enhance the bearing subgrade, these soils should be compacted to densify these soils to facilitate trafficability and improve bearing capacity. If these soils become unstable, they should be subexcavated and replaced with at least 300 mm of Granular 'A' as per OPSS.PROV 1010.

The transportation and placement of the gabion wall elements will need to proceed with caution to ensure the newly constructed granular base / levelling pad and/or the underlying subgrade are not disturbed.

The new retaining wall near the previous Highway 35 south abutment is to be founded on bedrock and is shown to be setback at a distance of about 1 m to 5 m from the near vertical bedrock face anticipated to be present after removal of the remnants of the Highway 35 south foundation. Prior to constructing the retaining wall at this location, the vertical face (anticipated to be up to about 3 m in height and possibly disturbed during removal of the existing foundation and/or previous installation of the assumed tie-back / rock anchor system) should be inspected by a rock engineer to check that the retaining wall foundation is competent.

A geotechnical engineer who is familiar with the findings of this investigation should evaluate all bearing surfaces to confirm that the founding conditions are consistent with the recommendations given in the report. All organic, loose/soft/disturbed or otherwise unsuitable soils or bedrock should be removed and/or improved prior to placing granular base, pouring the concrete slab, and/or placement of the gabion walls.

7.5 SOIL DISPOSAL/SITE RESTORATION ISSUES

The unsuitable excavated materials should be checked for contamination prior to removal/disposal off-site, in order to determine which disposal option is suitable for the excavated materials in accordance with the latest regulations, and as per OPSS.PROV 180. Site restoration should be in general conformance to OPSS.PROV 492.

A total of 2 monitoring wells (designated BH HL-1 and BH HL-2) were installed to permit monitoring of the groundwater level at the site. Ontario Regulation (O. Reg.) 903 (as amended) of the Ontario Water Resources Act requires that monitoring wells are properly abandoned/decommissioned by qualified personnel. The decommissioning of the wells should be included in the Contract Documents and an NSSP "Well Decommissioning" has been provided in **Appendix E** for this purpose.

8.0 CLOSURE

Engineering analyses and preparation of this report was carried out by Mr. Pouya Pishgah, P.Eng., and Principal with WSP Golder. A technical and quality control review was carried out by Kevin J. Bentley, P.Eng., and MTO Foundations Designated Contact for WSP-Golder.

WSP Golder

Report prepared by:

Pouya Pishgah, P. Eng.
Principal Geotechnical Engineer

Reviewed by:

Kevin J. Bentley, P. Eng.
MTO Foundations Designated Contact

REFERENCES

Barnett, P.J., Cowen, W.R. and Henry, A.P., Ministry of Northern Development and Mines, *Quaternary Geology of Ontario, Ontario Geological Survey, Southern Sheet*, Map M2556, 1991.

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6-14. 2014. CSA Special Publication, S6.1 14. Canadian Standard Association.

Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

Chapman, L.J. and D.F. Putnam. The Physiography of Southern Ontario, Ontario Geological Survey Special Volume 2, Third Edition, 1984

C. Gao, J. Shirota, R.I. Kelly, F.R. Brunton and S. van Haaften, Ontario Geological Survey, Bedrock Topography and Overburden Thickness Mapping, Southern Ontario, Miscellaneous Release Data 207, 2006.

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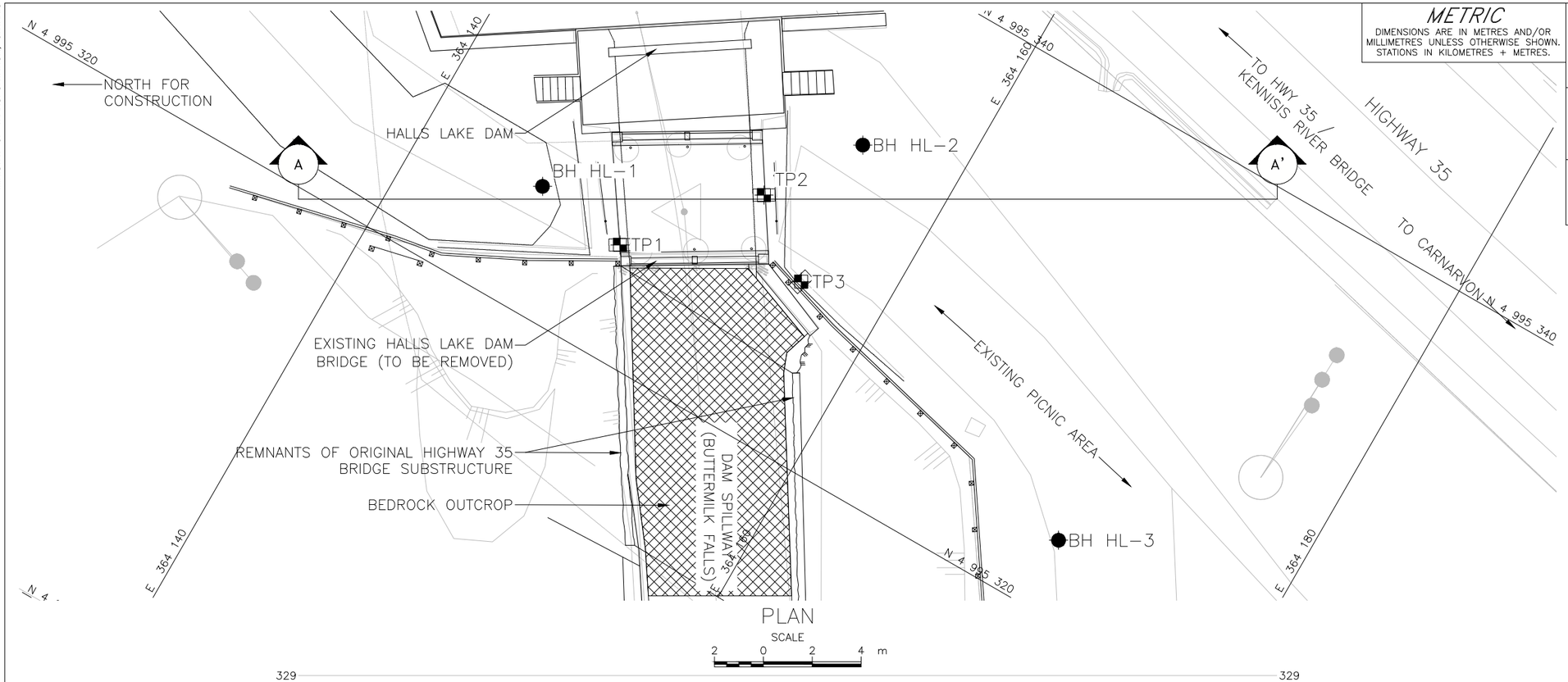
Ontario Geological Survey, Ministry of Northern Development and Mines, Bedrock Geology of Ontario, Southern Sheet, Map M2544, 1991.

APPENDIX

A DRAWING

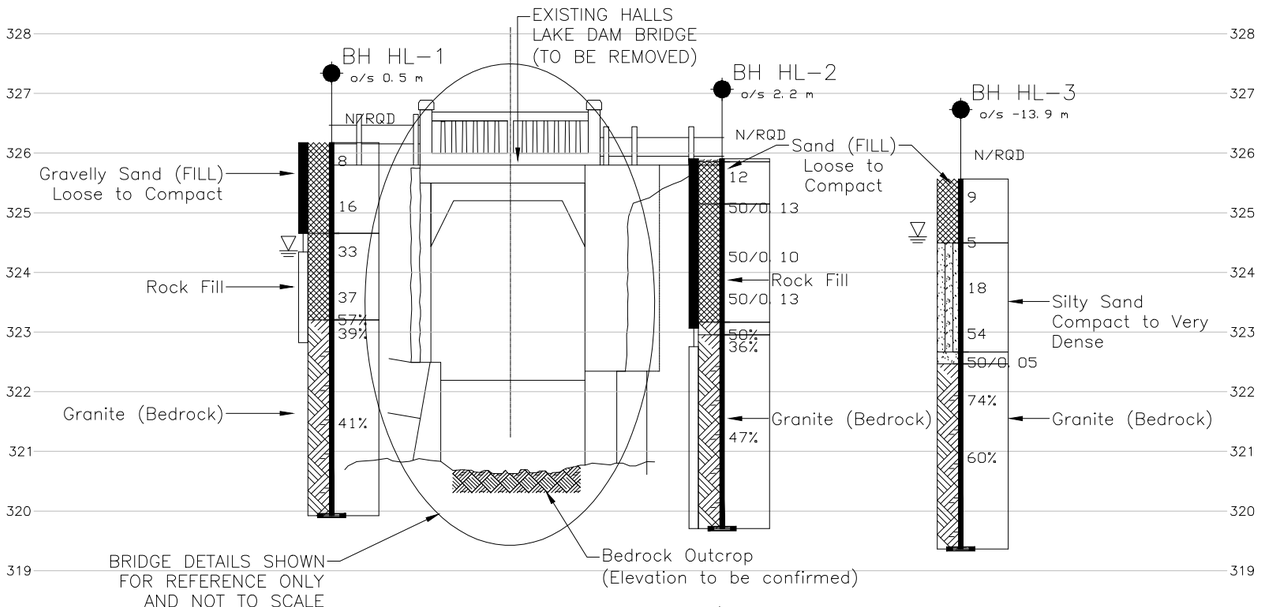
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE

2 0 2 4 m



PROFILE A–A'

VERTICAL SCALE

1 0 1 2 m

HORIZONTAL SCALE

2 0 2 4 m

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.

GWP No. 5288-14-00

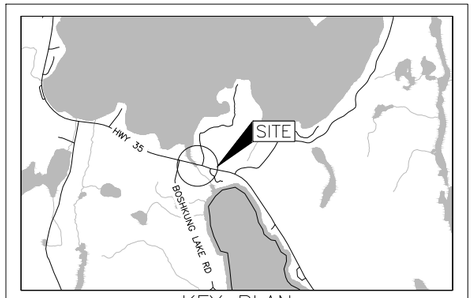
HIGHWAY 35

HALLS LAKE DAM BRIDGE REMOVAL

BOREHOLES LOCATION PLAN AND SOIL STRATA

SHEET

wsp



KEY PLAN

SCALE

500 0 500 1000 m

LEGEND

- Borehole
- Test Pit
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- WL in piezometer, measured on April 13, 2023
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH HL-1	326.2	4995325.0	364145.4
BH HL-2	325.9	4995333.0	364155.9
BH HL-3	325.6	4995323.0	364170.9
TP1	326.2	4995324.5	364149.3
TP2	326.2	4995329.2	364153.4
TP3	325.7	4995326.9	364156.5

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by WSP, drawing file nos. 19M-01435-00-XB1.dwg and 19M-01435-00-001-GA.dwg, received April 14, 2023.

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31E-423

HWY. 35	PROJECT NO. 22519794		DIST. CENTRAL
SUBM'D. PP	CHKD. PP	DATE: 06/27/2023	SITE: .
DRAWN: DD	CHKD. KJB	APPD. KJB	DWG. 1

LICENSED PROFESSIONAL ENGINEER P. PISHGAH-GILANI 100189545 June 29, 2023 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER K. J. BENTLEY June 29, 2023 PROVINCE OF ONTARIO

PLOT DATE: June 27, 2023
FILENAME: S:\Clients\MTO\Hwy_35_Carnarvon\ENGR\22519794\40_PROD\0002_Halls_Lake_Dam_Bridge_Removal\22519794-0001-BD-0001.dwg

APPENDIX

B

BOREHOLE RECORDS

Explanation of Terms Used in the Record of Boreholes

Sample Type

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Dimension type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Spoon sample
SH	Shelby tube Sample
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

Penetration Resistance

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in) required to drive a 50 mm (2 in) drive open sampler for a distance of 300 mm (12 in).

WH – Samples sinks under "weight of hammer"

Dynamic Cone Penetration Resistance, N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in) to drive uncased a 50 mm (2 in) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in).

Textural Classification of Soils

Classification	Particle Size
Boulders	> 200 mm
Cobbles	75 mm - 200 mm
Gravel	4.75 mm - 75 mm
Sand	0.075 mm – 4.75 mm
Silt	0.002 mm-0.075 mm
Clay	<0.002 mm

Coarse Grain Soil Description (50% greater than 0.075 mm)

Terminology	Proportion
Trace	0-10%
Some	10-20%
Adjective (e.g. silty or sandy)	20-35%
And (e.g. sand and gravel)	> 35%

Soil Description

a) Cohesive Soils(*)

Consistency	Undrained Shear Strength (kPa)	SPT "N" Value
Very soft	<12	0-2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very stiff	100-200	15-30
Hard	>200	>30

(*) Hierarchy of Shear Strength prediction

1. Lab triaxial test
2. Field vane shear test
3. Lab. vane shear test
4. SPT "N" value
5. Pocket penetrometer

b) Cohesionless Soils

Density Index (Relative Density)	SPT "N" Value
Very loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Soil Tests

w	Water content
w_p	Plastic limit
w_l	Liquid limit
C	Consolidation (oedometer) test
CID	Consolidated isotropically drained triaxial test
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement
D_R	Relative density (specific gravity, Gs)
DS	Direct shear test
ENV	Environmental/ chemical analysis
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified proctor compaction test
SPC	Standard proctor compaction test
OC	Organic content test
U	Unconsolidated Undrained Triaxial Test
V	Field vane (LV-laboratory vane test)
γ	Unit weight

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering

Faintly Weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	>2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	<6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	>3 m
Wide	1 – 3 m
Moderately close	0.3 – 1 m
Close	50 – 300 mm
Very close	<50 mm

GRAIN SIZE

Very Coarse Grained	>60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns - 2mm
Fine Grained	2 – 60 microns
Very Fine Grained	<2 microns

Note: *Grains >60 microns diameter are visible to the naked eye.

O:\ Templates\Rock Description Terminology

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including naturally occurring fractures but not including mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^0 angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B -	Bedding	Ca -	Calcite
FO -	Foliation/Schistosity	P	Polished
CL -	Cleavage	S	Slickensided
SH -	Shear Plane/Zone	SM	Smooth
VN -	Vein	R -	Ridged/Rough
F -	Fault	ST -	Stepped
CO -	Contact	PL -	Planar
J -	Joint	FL -	Flexured
FR-	Fracture	UE -	Uneven
MF -	Mechanical	W -	Wavy
A-	Angular	C -	Curved
BP-	Bedding Plane	H -	Hackly
BL-	Blast Induced	SL -	Sludge Coated
ll -	Parallel To	TCA -	To Core Axis
⊥ -	Perpendicular To	STR -	Stress Induced

PROJECT 22519794

RECORD OF BOREHOLE No BH HL-1

SHEET 1 OF 1

METRIC

G.W.P. 5288-14-00 LOCATION N 4995325.0; E 364145.4 MTM NAD 83 ZONE 10 (LAT. 45.095423; LONG. -78.746009) ORIGINATED BY TL

DIST NER HWY 35 BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Coring COMPILED BY PP

DATUM Geodetic DATE April 13, 2022 CHECKED BY KB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
326.2	GROUND SURFACE						326				
0.0	GRAVELLY SAND, some silt (FILL) Loose to compact Brown Moist		1	SS	8						23 64 (13)
			2	SS	16		325				
324.7											
1.5	ROCK FILL, some to trace sand Dense		3	SS	33						
			4	SS	37		324				
323.2											
3.0	BEDROCK - GRANITE Bedrock cored from depths of 3.0 m to 6.3 m For coring details refer to Record of Drillhole BHHL-1		1	RC	REC 78%		323				RQD = 57%
			2	RC	REC 79%		322				RQD = 39%
			3	RC	REC 100%		321				RQD = 41%
320.0							320				
6.3	END OF BOREHOLE NOTES: 1. Borehole was terminated at 6.3 m below the existing grade. 2. Borehole caved to a depth of 3.3 m upon completion of drilling. 3. 50 mm diameter monitoring standpipe piezometer at 3.4 m below the existing grade. 4. Groundwater level in monitoring standpipe piezometer measured as follows: Date Depth (m) Elev. (m) 13-Apr-22 1.81 324.39										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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PROJECT: 22519794

RECORD OF DRILLHOLE: BH HL-1

SHEET 1 OF 1

LOCATION: N 4995325.00 ;E 364145.40

DRILLING DATE: April 13, 2022

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75Truck Mount

DRILLING CONTRACTOR: Marathon Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATH-ERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole BHHL-1		323.20															
3	NQ Coring	Fresh, slightly to moderately weathered, grey/pink, strong to very strong, GRANITE (BEDROCK)		2.97	1		80 60 40 20	80 60 40 20	80 60 40 20	5 10 15 20	0 30 60 90	BR,UN,RO,0				W1 W2 W3 W4 W5 W6	2 4 6		Screen
4												BR,UN,RO,0 FR,UN,RO,0							
					2							BR,UN,RO,0 FR,PL,RO,G							
5												FR,UN,RO,G							
					3							FR,UN,RO,G							
6				319.92								FR,UN,RO,0 FR,UN,RO,G FR,UN,RO,G/0							
		END OF DRILLHOLE		6.25															
7																			
8																			
9																			
10																			
11																			
12																			

DEPTH SCALE
1 : 50

LOGGED: TL
CHECKED: PP

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Run 1: 9'9" ~ 10'6" (2.97m ~ 3.2m)
Run 2: 10'6" ~ 15'6" (3.2m ~ 4.72m)
Run 3: 15'6" ~ 20'6" (4.72m ~ 6.25m)
*Notes: (suspected fractures / voids at start of Run 2 due to lost water return)

Client:	MTO			Title:	Core Photograph BH HL-1, RUN #1 to RUN #3
Project#:	19M-01435-00	Figure #:	BH HL-1	Project:	Foundation Investigation Rehabilitation of Halls Lake Dam Pedestrian Bridge
Drawn:	TL	Approved:			
Date:	April 2022	Scale:	N. T. S.		
Size:	Letter	Rev:	0		

PROJECT 22519794

RECORD OF BOREHOLE No BH HL-2 SHEET 1 OF 1 METRIC

G.W.P. 5288-14-00 LOCATION N 4995333.0; E 364155.9 MTM NAD 83 ZONE 10 (LAT. 45.095494; LONG. -78.745874) ORIGINATED BY TL

DIST NER HWY 35 BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Coring COMPILED BY PP

DATUM Geodetic DATE April 13, 2022 CHECKED BY KB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
325.9	GROUND SURFACE										
0.0 / 0.1	TOPSOIL (50 mm)										
	SAND, some silt, some gravel (FILL) Compact Moist		1	SS	12						11 68 (21)
325.1											
0.8	ROCK FILL, some sand, inferred from split-spoon refusal and rock fragments in split spoon		2	SS	50/0.13		325				
			3	SS	50/0.10		324				
			4	SS	50/0.13						
323.2											
	Transition zone from rock fill to weathered BEDROCK		1	RC	REC 75%		323				RQD = 50%
3.0	BEDROCK - GRANITE Bedrock cored from depths of 3.0 m to 6.2 m For coring details refer to Record of Drillhole BHHL-2		2	RC	REC 95%		322				RQD = 36%
			3	RC	REC 100%		321				RQD = 47%
319.7							320				
6.2	END OF BOREHOLE										

NOTES:

1. Borehole was terminated at 6.2 m below the existing grade.
2. Borehole caved to a depth of 3.3 m upon completion of drilling.
3. 50 mm diameter monitoring well installed at 6.2 m below the existing grade.
4. Groundwater level in monitoring well measured as follows:

Date	Depth (m)	Elev. (m)
13-Apr-22	Dry	-

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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PROJECT: 22519794

RECORD OF DRILLHOLE: BH HL-2

SHEET 1 OF 1

LOCATION: N 4995333.00 ;E 364155.90

DRILLING DATE: April 13, 2022

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75Truck Mount

DRILLING CONTRACTOR: Marathon Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATH-ERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole BHHL-2		322.96															
3	NQ Coring	Slightly to moderately weathered, grey/pink, strong to very strong GRANITE (BEDROCK)		2.95	1							CO,UN,SM,O BR,UN,RO,O FR,UN,RO,O							Sand
4					2							BR,UN,RO,O BR,UN,RO,O							
5					3							BR,UN,RO,O BR,UN,RO,O FR,PL,RO,G							Screen
6				319.71								FR,PL,RO,G BR,UN,RO,O							
		END OF DRILLHOLE		6.20															
7																			
8																			
9																			
10																			
11																			
12																			

GTA-RCK 046 S:\CLIENTS\MTO\HWY_35_CARNARVON\02_DATA\GINT\HWY_35_CARNARVON.GPJ GAL-MISS.GDT 6/27/23

DEPTH SCALE
1 : 50

LOGGED: TL
CHECKED: PP

Run 1: 9'8" ~ 10'4" (2.95m ~ 3.15m)
Run 2: 10'4" ~ 15'4" (3.15m ~ 4.67m)
Run 3: 15'4" ~ 20'4" (4.67m ~ 6.20m)

Client:	MTO			Title:	Core Photograph BH HL-2, RUN #1 to RUN #3
Project#:	19M-01435-00	Figure #:	BH HL-2	Project:	Foundation Investigation Rehabilitation of Halls Lake Dam Pedestrian Bridge
Drawn:	TL	Approved:			
Date:	April 2022	Scale:	N. T. S.		
Size:	Letter	Rev:	0		

PROJECT 22519794

RECORD OF BOREHOLE No BH HL-3 SHEET 1 OF 1 METRIC

G.W.P. 5288-14-00 LOCATION N 4995323.0; E 364170.9 MTM NAD 83 ZONE 10 (LAT. 45.095403; LONG. -78.745685) ORIGINATED BY TL

DIST NER HWY 35 BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Coring COMPILED BY PP

DATUM Geodetic DATE April 13, 2022 CHECKED BY KB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
325.6	GROUND SURFACE										
0.0	SAND, trace gravel (FILL) Loose Brown Moist		1	SS	9		325				
324.5			2A 2B	SS	5	▽					
1.1	SILTY SAND, trace to some gravel, trace rootlets, sand pockets Compact to very dense Brown Moist		3	SS	18		324				8 39 (53)
322.7			4	SS	54		323				
	Gravelly SAND, some to trace silt, rock fragments in tip of spoon Brown with black Moist		5	SS	50/0.05						
3.1	BEDROCK - GRANITE Highly to moderately weathered where penetrated with casing from 3.1 m to 3.7 m depth Bedrock cored from depths of 3.7 m to 6.2 m For coring details refer to Record of Drillhole BHHL-3		1	RC	REC 90%		322				RQD = 74%
			2	RC	REC 100%		321				RQD = 60%
319.4							320				
6.2	END OF BOREHOLE NOTES: 1. Borehole was terminated at 6.2 m below the existing grade. 2. Borehole caved to a depth of 1.06 m upon completion of drilling. 3. Water level measured at 0.97 m below ground surface upon completion of drilling.										

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 22519794

RECORD OF DRILLHOLE: BH HL-3

SHEET 1 OF 1

LOCATION: N 4995323.00 ;E 364170.90

DRILLING DATE: April 13, 2022

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75Truck Mount

DRILLING CONTRACTOR: Marathon Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATH-ERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Continued from Record of Borehole BHHL-3		321.86															
4	NQ Coring	Slightly to moderately weathered, grey/pink, strong to very strong, GRANITE (BEDROCK)		3.71	1		80 60 40 20	80 60 40 20	80 60 40 20	5 10 15 20	0 30 60 90	BR,UN,RO,O FR,PL,RO,G FR,PL,RO,G				W1 W2 W3 W4 W5 W6	2 4 6		
5					2							FR,UN,RO,G BR,UN,RO,G FR,UN,RO,G FR,UN,RO,G FR,UN,RO,G							
6				319.37								FR,UN,RO,G							
		END OF DRILLHOLE		6.20															
7		NOTE:																	
		1. For Run 1, highly weathered in upper 0.3 m and slightly weathered below.																	
8																			
9																			
10																			
11																			
12																			
13																			

DEPTH SCALE

1 : 50

LOGGED: TL

CHECKED: PP

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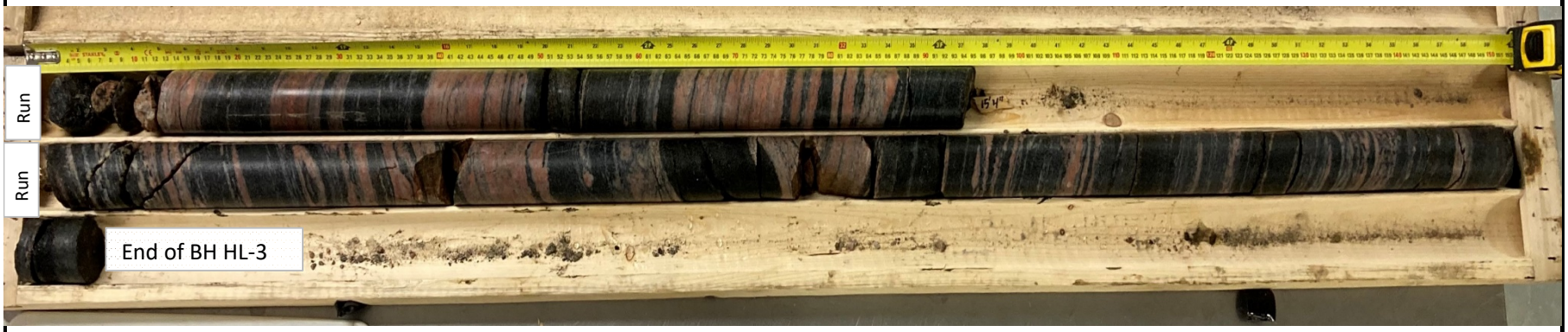


Run 1: 12'2" ~ 15'4" (3.71m ~ 4.67m)
Run 2: 15'4" ~ 20'4" (4.67 ~ 6.20m)

Client:	MTO			Title:	Core Photograph BH HL-3, RUN #1 to RUN #2
Project#:	19M-01435-00	Figure #:	BH HL-3	Project:	Foundation Investigation Rehabilitation of Halls Lake Dam Pedestrian Bridge
Drawn:	TL	Approved:			
Date:	April 2022	Scale:	N. T. S.		
Size:	Letter	Rev:	0		

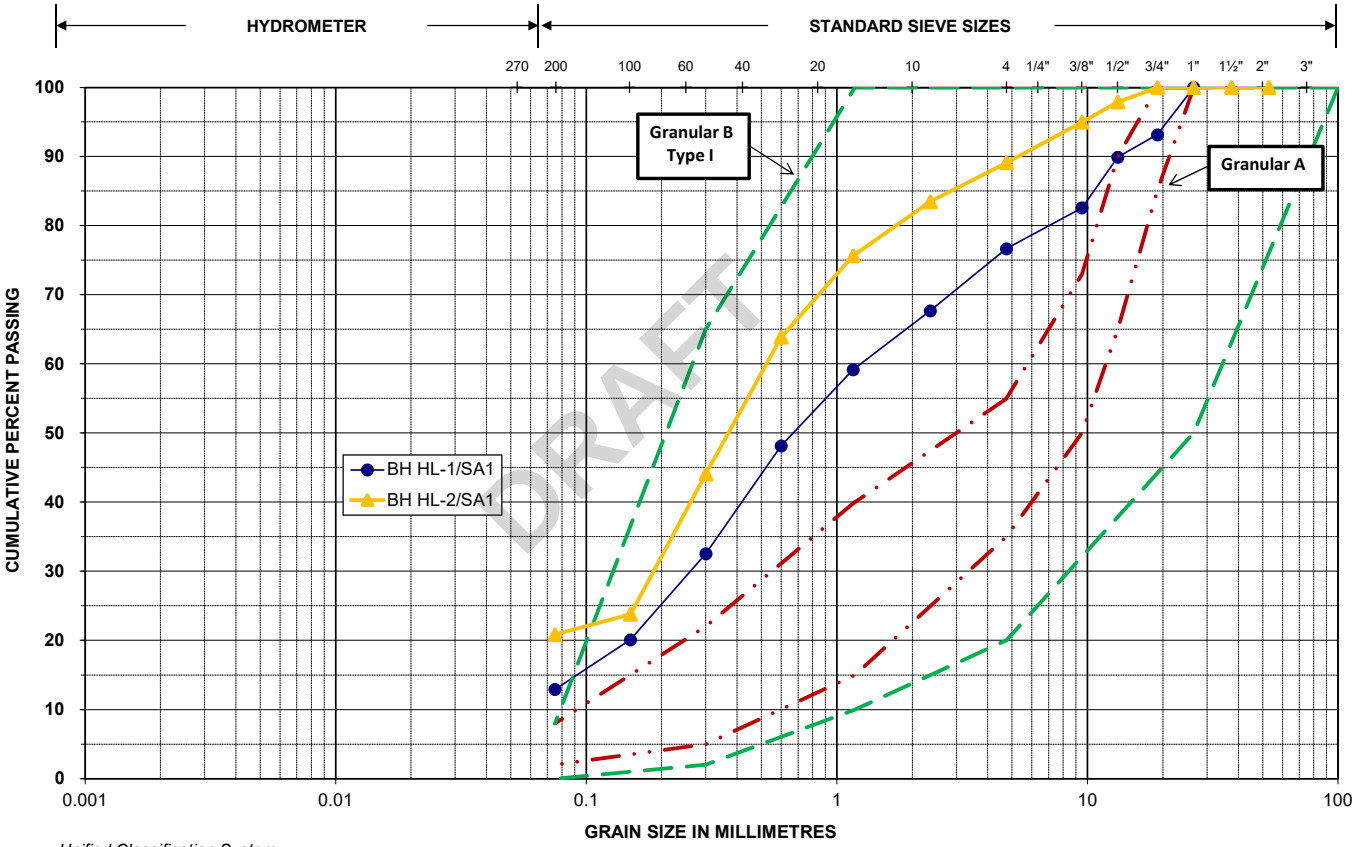
APPENDIX

C

LABORATORY TESTING RESULTS

FIGURE C-1 - SAND TO GRAVLLEY SAND (FILL)

PARTICLE SIZE DISTRIBUTION



Unified Classification System

SILT AND CLAY	SAND	GRAVEL

Project Name: Highway 35 - Halls Lake Dam **Project No.:** 19M-01435-00

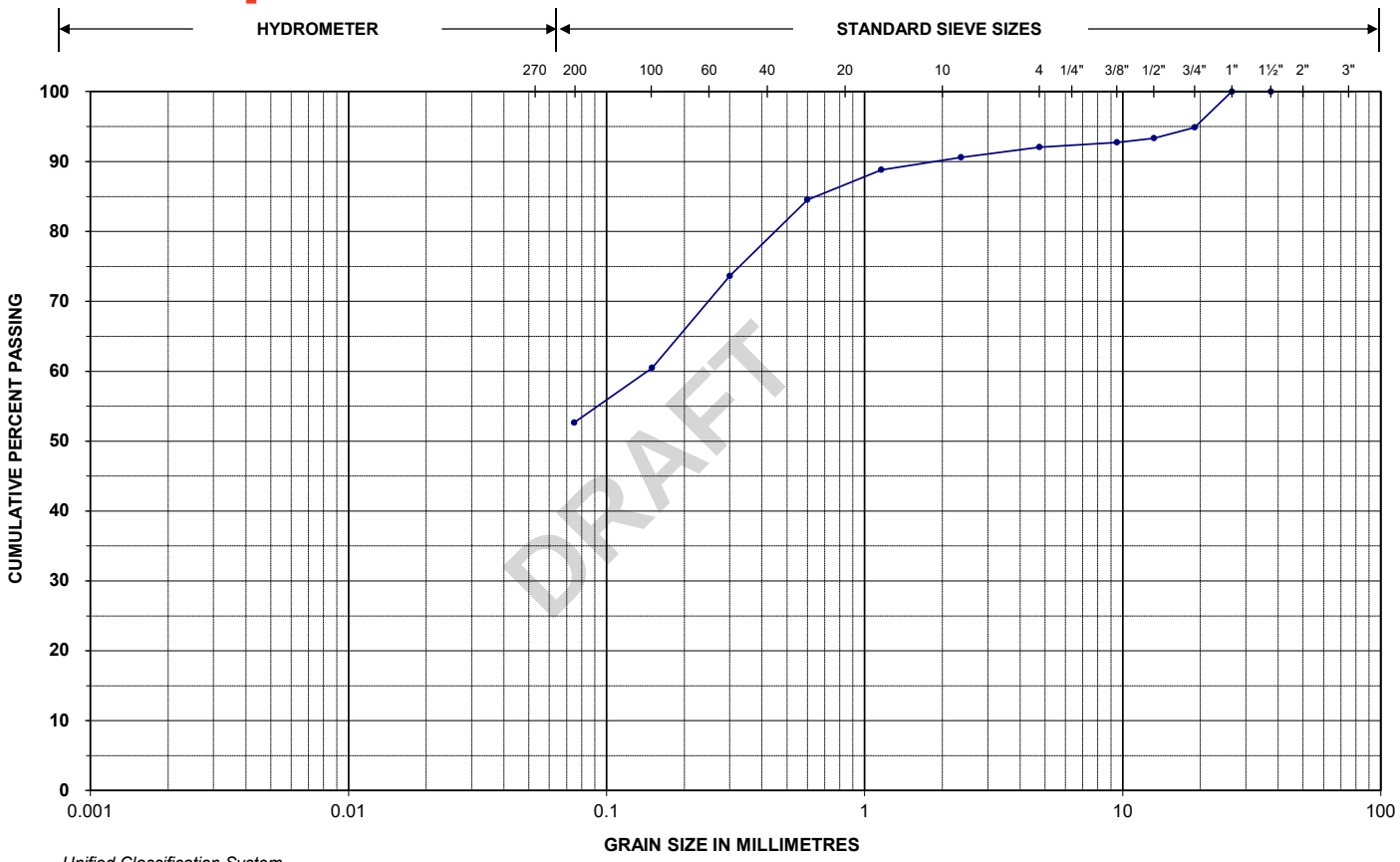
Location ID BH HL-1 and HL-2 **sample size does not meet OPSS/LS602 criteria **Sample No./Depth:** BH HL-1/SA1 and BH HL-2/SA1

Sieve Size	% Passing Coarse		Sieve Size	% Passing Fine	
	BH HL-1/SA1	BH HL-2/SA1		BH HL-1/SA1	BH HL-2/SA1
37.5 mm	100.0	100.0	**2.36 mm**	67.7	83.5
26.5 mm	100.0	100.0	**1.16 mm**	59.2	75.6
19.0 mm	93.1	100.0	**0.60 mm**	48.2	63.9
13.2 mm	89.9	97.9	**0.30 mm**	32.5	44.1
9.5 mm	82.6	95.0	**0.15 mm**	20.1	23.8
4.75 mm	76.7	89.1	**0.075 mm**	12.9	20.8

Note: More information is available upon request. Tested by: WGH Reviewed by: Date: 9-Jun-22

FIGURE C2 - SILTY SAND

PARTICLE SIZE DISTRIBUTION



Unified Classification System

SILT AND CLAY	SAND	GRAVEL

Project Name: Highway 35 - Halls Lake Dam **Project No.:** 19M-01435-00

Location ID.: BH HL-3 **Sample No./Depth:** SA3

Sieve Size	% Passing Coarse	Sieve Size	% Passing Fine
37.5 mm	100.0	**2.36 mm**	90.6
26.5 mm	100.0	**1.16 mm**	88.8
19.0 mm	94.9	**0.60 mm**	84.5
13.2 mm	93.3	**0.30 mm**	73.6
9.5 mm	92.7	**0.15 mm**	60.5
4.75 mm	92.0	**0.075 mm**	52.7

Note: More information is available upon request. Tested by: WDY Reviewed by: Date: 9-Jun-22

APPENDIX

D

TEST PIT LOGS

RECORD OF TEST PIT

Job Number:	19M-01435-00	**Location:**	West (Construction North) Approach	**Date:**	April 5, 2022
Test Pit No:	TP-1	**Test Pit Size:**	See Photo	**Elevation:**	326.174
Machine Type:	Hydrovac Truck	**Contractor:**	Centreline Hydrovac	**Datum:**	Geodetic
Temperature:	5°C	**Weather:**	Sun and Cloud		

Depth (m)		Soil Description	Samples			Remarks
From	To			No.	Depth (m)	
0.0	0.3	brown SAND and GRAVEL (FILL), trace silt, occasional cobbles and boulders, moist, some asphalt chunks		GS1	0.3	
0.3	0.9	brown SAND and GRAVEL (FILL), trace silt, frequent cobbles and boulders, moist, trace asphalt chunks				
0.9	-	TP-1 terminated @ 0.9 mbgs on Rockfill – No Further Progress (NFP)				

END OF TP

Looking West

Looking Downhole and East

Comments: *Test Pit was extended to locate bridge structural elements. No further progress due to the presence of cobbles and boulders used as backfill around approach. Approximately 0.2 m of sand and gravel fill on surface of slab. Cross sectional sketch was completed showing further details. Elevation surveyed was approximate location.*

Technician: TL

RECORD OF TEST PIT

Job Number:	19M-01435-00	**Location:**	East (Construction South) Approach	**Date:**	April 5, 2022
Test Pit No:	TP-2	**Test Pit Size:**	See Photo	**Elevation:**	326.153
Machine Type:	Hydrovac Truck	**Contractor:**	Centreline Hydrovac	**Datum:**	Geodetic
Temperature:	5°C	**Weather:**	Sun and Cloud		

Depth (m)		Soil Description	Samples		Remarks
From	To		No.	Depth (m)	
0.00	1.0	brown SAND and GRAVEL (FILL), trace silt, occasional cobbles and boulders, moist	GS1	1.0	
1.0	1.25	brown SAND and GRAVEL (FILL), trace silt, frequent cobbles and boulders, moist			
1.25	-	TP-2 terminated at 1.25 mbgs on Rockfill – NFP			

END OF TP

TP-2 Location Looking South West

Looking Downhole at Exposed I-Beam and Rockfill

Comments: *No further progress due to the presence of cobbles and boulders used as backfill around approach. Approximately 0.2 m of sand and gravel fill on surface of slab. Cross sectional sketch was completed showing further details. Elevation surveyed was approximate location.*

Technician: TL

RECORD OF TEST PIT

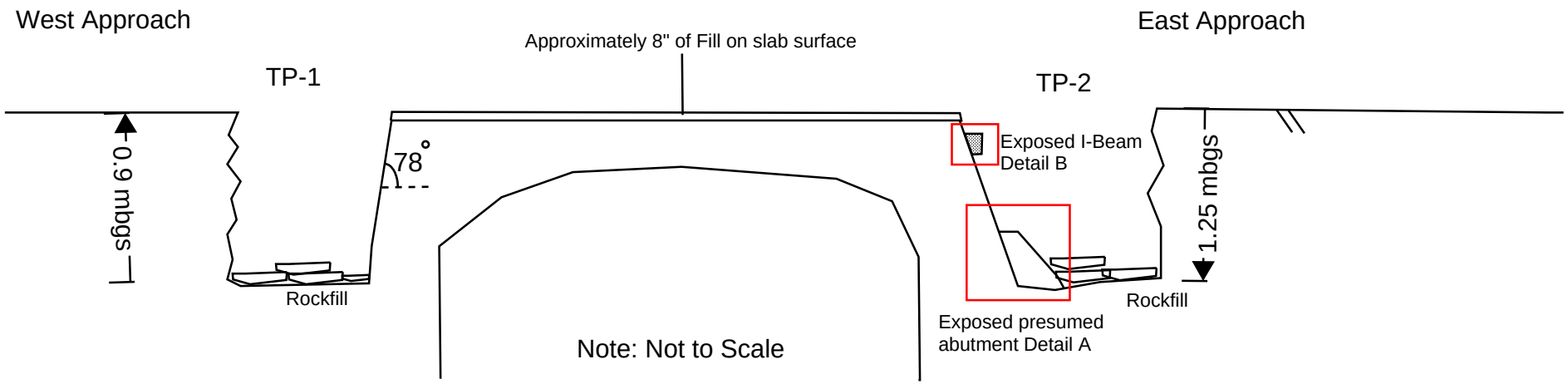
Job Number:	19M-01435-00	**Location:**	South East (Construction Southwest) Wingwall	**Date:**	April 5, 2022
Test Pit No:	TP-3	**Test Pit Size:**	See Photo	**Elevation:**	325.699
Machine Type:	Hydrovac Truck	**Contractor:**	Centreline Hydrovac	**Datum:**	Geodetic
Temperature:	5°C	**Weather:**	Sun and Cloud		

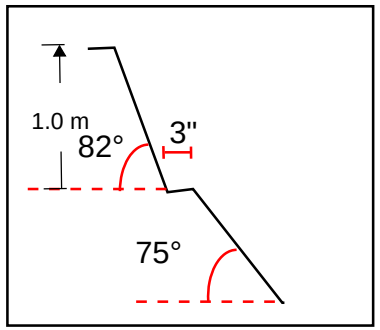
Depth (m)		Soil Description	Samples			Remarks
From	To			No.	Depth (m)	
0.00	0.5	brown SAND and GRAVEL (FILL), some silt, contains tree roots / rootlets, wet from hydrovacing, occ cobbles, boulders		GS1	0.5	
0.5	1.35	brown SAND and GRAVEL (FILL), some silt, contains tree roots / rootlets, wet from hydrovacing, frequent cobbles, boulders		GS2	1.0	
1.35	-	TP-3 terminated at 1.35 mbgs on Rockfill – NFP				
END OF TP						

Looking Downhole Along SE Wingwall

Comments: *No further progress due to the presence of cobbles and boulders used as backfill around wingwall. Elevation surveyed was approximate location.*

Technician: TL





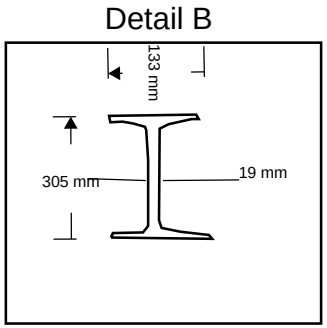


Figure D1 : Sketch of observations at Test Pits TP-1 and TP-2.

APPENDIX

E LIST OF OPSS, OPSD AND NSSP

List of OPSSs, OPSDs and NSSPs Referenced in the Report

OPSS	180	GENERAL SPECIFICATION FOR THE MANAGEMENT OF EXCESS MATERIALS
OPSS	206	GRADING
OPSS	401	CONSTRUCTION SPECIFICATION FOR TRENCHING, BACKFILLING, AND COMPACTING
OPSS	501	CONSTRUCTION SPECIFICATION FOR COMPACTING
OPSS	517	CONSTRUCTION SPECIFICATION FOR CONTROL OF WATER FROM DEWATERING OPERATIONS
OPSS	803	VEGETATIVE COVER
OPSS	804	TEMPORARY EROSION CONTROL
OPSS. PROV	902	CONSTRUCTION SPECIFICATION FOR EXCAVTATING AND BACKFILLING - STRUCTURES
OPSS.PROV	539	CONSTRUCTION SPECIFICATION FOR TEMPORARY PROTECTION SYSTEMS
OPSS.PROV	1010	AGGREGATES – BASE, SUBBASE, SELECT SUBGRADE, AND BACKFILL MATERIAL
OPSD	3090.101	FROST PENETRATION DEPTHS - SOUTHERN ONTARIO
SP	517F01	TEMPORARY DEWATERING / FLOW DIVERSION
NSSP	--	OBSTRUCTIONS
NSSP	--	TEMPORARY GROUNDWATER CONTROL
NSSP	--	DECOMISSION OF PIEZOMETERS

OBSTRUCTIONS

Non-Standard Special Provision

The presence of rock fill (cobble to boulder sized) and/or sand and gravel fill containing rock fragments (cobbles to boulder sized) have been observed, confirmed, and/or inferred as indicated in the Foundation Investigation Report and Record of Borehole Sheets at Halls Lake Dam Bridge site. The surface of granite bedrock has been confirmed at all three drilled borehole locations within the Halls Lake Dam Bridge site. The rock fill and bedrock is classified as strong to extremely strong and interpreted to be of similar characteristics to the bedrock outcrops / cuts along the existing highway corridor within the site. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for removals, sub-excavation and subgrade preparation and construction of the proposed retaining walls and reinstatement works, including any associated temporary shoring. Such obstructions may impede excavation progress and/or shoring installation. The Contractor shall be prepared to remove, advance through and/or penetrate these obstructions to achieve the intent of the design.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

TEMPORARY GROUNDWATER CONTROL

Non-Standard Special Provision

The interception of groundwater and surface water is anticipated for excavation and/or construction related to the bridge removal and reinstatement (i.e. construction of new retaining walls) at the Halls Lake Dam Bridge site as detailed in the Foundation Investigation Report and Record of Borehole Sheets. The groundwater levels and permeability of the soils / fractured bedrock at the site is highly variable depending on the time of year, precipitation events, and excavation level. Consideration of these highly variable permeabilities must be made in the selection of appropriate equipment and procedures for excavation and removal or reinstatement for the proposed works / retaining walls. The groundwater inflow, if not properly controlled, may impede excavation progress and/or the selected construction technique and may cause instability or 'piping' of the foundation soils / fractured bedrock. The Contractor shall be prepared to design and supply adequate dewatering systems and/or flow diversion systems, equipment and procedures to maintain dry conditions to at least 0.5 m below the design subgrade / subexcavation level to allow for removals, placement and compaction of granular base, placement and curing of concrete, and placement of the gabion wall systems in the dry.

Basis of Payment

No payment will be made for this item since it is considered temporary works. Cost related to temporary dewatering should be include in other contract items.

DECOMMISSION OF PIEZOMETERS - Item No.

Non-Standard Special Provision

Standpipe piezometers were installed in boreholes designated BH HL-1, and BH HL-2 as part of the Foundation Investigation for the Halls Lake Dam Bridge removal and reinstatement. Details of the standpipe piezometers can be found within the Foundation Investigation Report included in the contract documents.

The standpipe piezometers have been left in place to allow for monitoring of groundwater levels up to the start and during construction.

As part of the construction activities and prior to any bridge removal and reinstatement, the contractor shall properly decommission the standpipe piezometers. The abandonment method for standpipe piezometers shall be in general accordance with the requirements of Ontario Regulation 903 Wells, as amended under the Ontario Water Resources Act. In addition, the contractor shall provide a written record of the decommissioning procedure to the Contract Administrator.

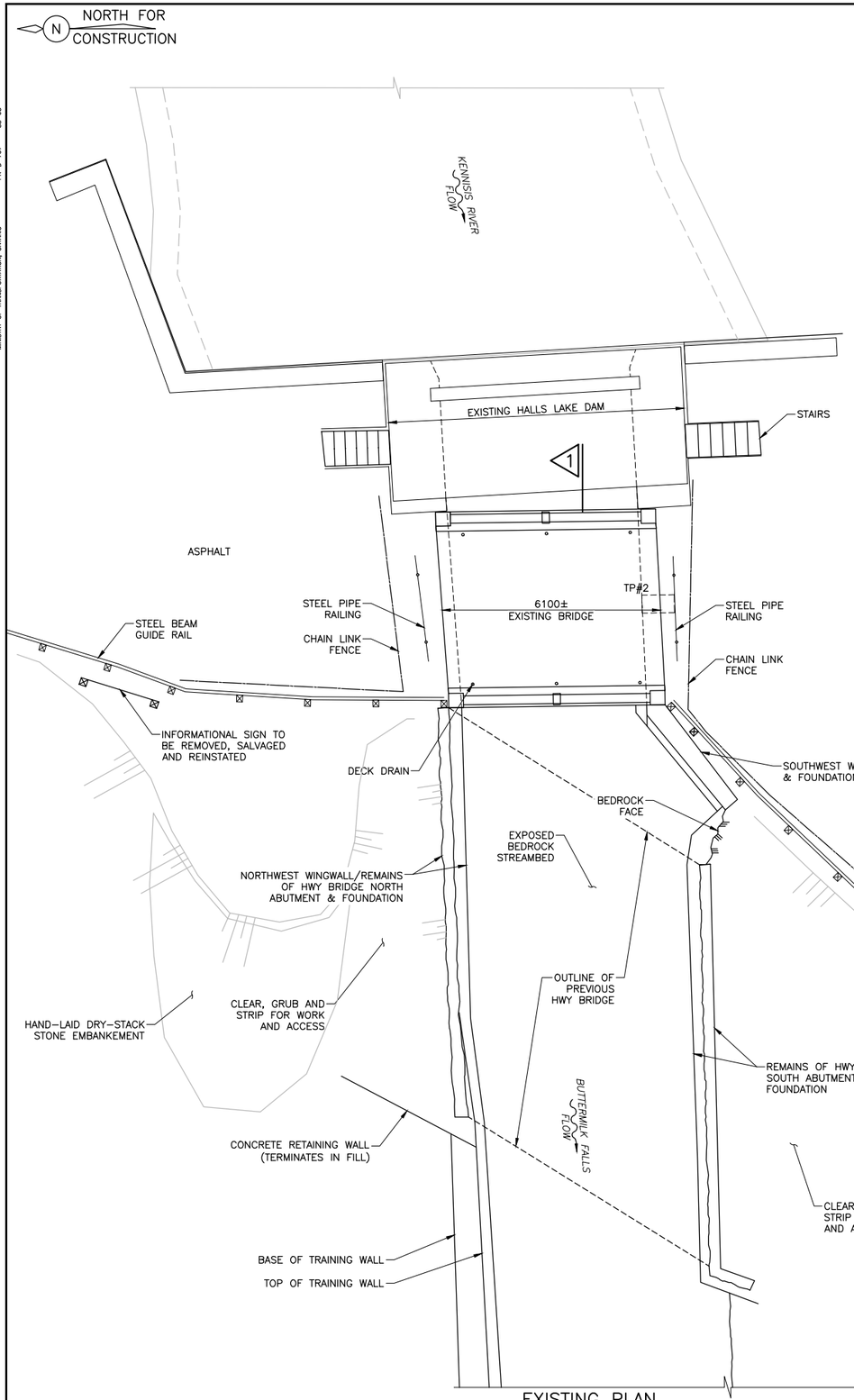
Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

APPENDIX

F

REFERENCE DOCUMENTS



EXISTING PLAN
1:75

DEMOLITION SCOPE OF WORK

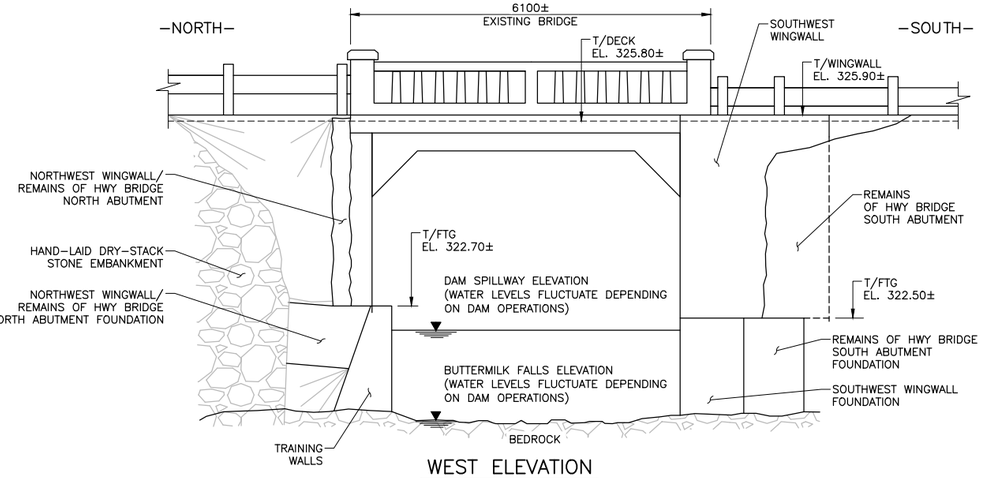
THE 'SCOPE OF WORK', AS PROVIDED ON THIS DRAWING, IS FOR GENERAL INFORMATION ONLY AND SHALL NOT BE CONSTRUED AND EXHAUSTIVE OR AS A SEQUENCE OF WORK. REFER TO REMOVAL DRAWINGS FOR ADDITIONAL NOTES AND DETAILS.

REMOVALS

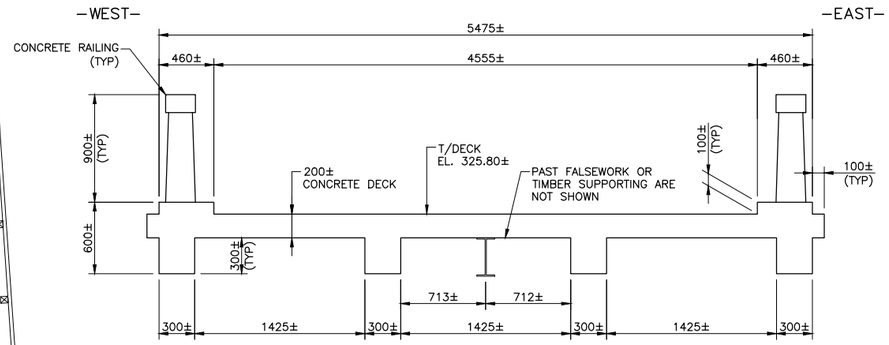
- (A) IMPLEMENT DEWATERING, COFFERDAM, ENVIRONMENTAL PROTECTION AND SEDIMENT CONTROL SYSTEM.
- (B) REMOVE CHAINLINK FENCE AND STEEL TUBE RAILING.
- (C) REMOVE STEEL BEAM GUARD RAIL TO EXTENTS REQUIRED FOR DEMOLITION, REMOVAL AND REINSTATEMENT WORKS.
- (D) REMOVE SUPERSTRUCTURE WHILE MAINTAINING EXISTING SUBSTRUCTURE.
- (E) REMOVE TREES AND VEGETATION ON SOUTHWEST AND SOUTHEAST EMBANKMENTS.
- (F) EXCAVATE AND REMOVE (FULL DEPTH) SOUTHWEST WINGWALL AND SOUTHEAST WINGWALL.
- (G) REMOVE OLD BRIDGE ABUTMENT AND FOOTING AT SOUTHWEST.
- (H) REMOVE HAND-LAID DRY-STACK STONE EMBANKEMENT.
- (J) CARRY OUT BEDROCK REMOVALS AS REQUIRED FOR INSTALLATION OF NEW GABION BASKET RETAINING WALLS.

NEW CONSTRUCTION

1. REFACE/REPAIR TOP HORIZONTAL SURFACE OF REMAINING ABUTMENT WALL FOLLOWING REMOVALS.
2. PLACE ROCK FILL AT TOE OF SLOPE AT NORTHWEST.
3. PLACE COMPACTED GRANULAR A BASE FOR NEW GABIONS AT ABUTMENT WALLS.
4. PLACE GABIONS AT ABUTMENT WALLS.
5. PLACE COMPACTED GRANULAR A BASE FOR CONCRETE SLAB BELOW GABIONS.
6. INSTALL DOWELS INTO TOP OF SOUTHWEST AND NORTHWEST WINGWALL FOOTINGS.
7. INSTALL DOWELS INTO BEDROCK AT NEW SOUTHWEST RETAINING WALL.
8. PLACE REINFORCED CONCRETE SLABS FOR GABIONS.
9. INSTALL GABION WALLS AT NORTHWEST AND SOUTHWEST.
10. BACKFILL GABION WALLS.
11. PLACE RIP-RAP ON SLOPE BEHIND NORTHWEST GABION WALL.
12. PLACE ROCK PROTECTION AT END OF SOUTHWEST GABION WALL.
13. PLACE NEW ASPHALT WHERE REMOVED ON NORTH APPROACH TO BRIDGE.
14. RESTORE ALL DISTURBED AREAS WITH TOPSOIL AND HYDROSEED.
15. INSTALL NEW CHAIN LING FENCE AND GUIDE RAIL.



WEST ELEVATION
1:50



1 EXISTING BRIDGE SUPERSTRUCTURE
1:25

HWY 35
CONT. No.
WP No. 5214-19-01

HALLS LAKE DAM
PEDESTRIAN BRIDGE
REMOVAL AND ASSOCIATED SITE WORK

GENERAL ARRANGEMENT

SHEET 93

METRIC

GENERAL NOTES:

1. CLASS OF CONCRETE

   CLASS OF CONCRETE SHALL BE 30 MPa

2. CLEAR COVER TO REINFORCING STEEL

   DECK:

   ALL SURFACES 70±20 UNLESS OTHERWISE NOTED

3. REINFORCING STEEL

   REINFORCING STEEL SHALL BE GRADE 400W.

   UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS B.

4. GENERAL NOTES

   THE CONTRACTOR IS RESPONSIBLE FOR THE COMPLETE DESIGN OF ANY REQUIRED TEMPORARY SUPPORT SYSTEMS INCLUDING: PROTECTION SYSTEMS, COFFERDAMS, BRACING AND DEBRIS CONTAINMENT SYSTEMS FOR THE WORK. INFORMATION SHOWN ON THESE DRAWINGS IS SCHEMATIC ONLY ARE INTENDED FOR SCOPE OF WORK ONLY.

   THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE AND TEMPORARY SUPPORTS THAT ARE RELEVANT TO THE WORK PRIOR TO COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK REQUIRED TO MATCH THE EXISTING STRUCTURE BE SUBMITTED FOR APPROVAL.

   THE CONTRACTOR SHALL BE AWARE THAT THE FOLLOWING DOCUMENTS ARE AVAILABLE FOR THEIR REFERENCE DURING THE DESIGN AND COMPLETION OF THE REMOVALS/DEMOLITION, THESE WILL BE MADE AVAILABLE UPON REQUEST:

   A. HALLS LAKE DAM BRIDGE – PRELIMINARY DESIGN REPORT

   THE CONTRACTOR SHALL ENSURE STABILITY OF THE EXISTING STRUCTURE DURING ALL STAGES OF REMOVAL/DEMOLITION.

   THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING UTILITY LOCATES AS REQUIRED PRIOR TO REMOVALS/DEMOLITION. ANY DAMAGE TO EXISTING UTILITIES SHALL BE REPAIRED BY THE CONTRACTOR AT NO ADDITIONAL COST TO THE OWNER AND TO THE SATISFACTION OF THE CONTRACT ADMINISTRATOR.

   THE CONTRACTOR IS RESPONSIBLE FOR ALL REMOVALS WITHIN THE LIMITS SPECIFIED ON THE DRAWINGS AND WILL NOT BE COMPENSATED FOR ANY REMOVALS OUTSIDE OF THOSE SPECIFIED. IF CONTRACTOR REMOVES/DAMAGES MATERIALS OUTSIDE OF THE LIMITS SPECIFIED, THE CONTRACTOR SHALL BE RESPONSIBLE FOR RETURNING THOSE AREAS TO ORIGINAL CONDITION SUBJECT TO THE APPROVAL OF THE OWNER AND AT NO COST TO THE OWNER.

   THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE SAFE REMOVAL AND DISPOSAL OF ANY HAZARDOUS MATERIALS SUPERIMPOSED ON THE STRUCTURE OR EMBEDDED WITHIN.

   IN-WATER WORKS WINDOW IN JULY 15TH TO SEPTEMBER 30TH OF ANY YEAR.

LIST OF DRAWINGS:

LIST OF ABBREVIATIONS

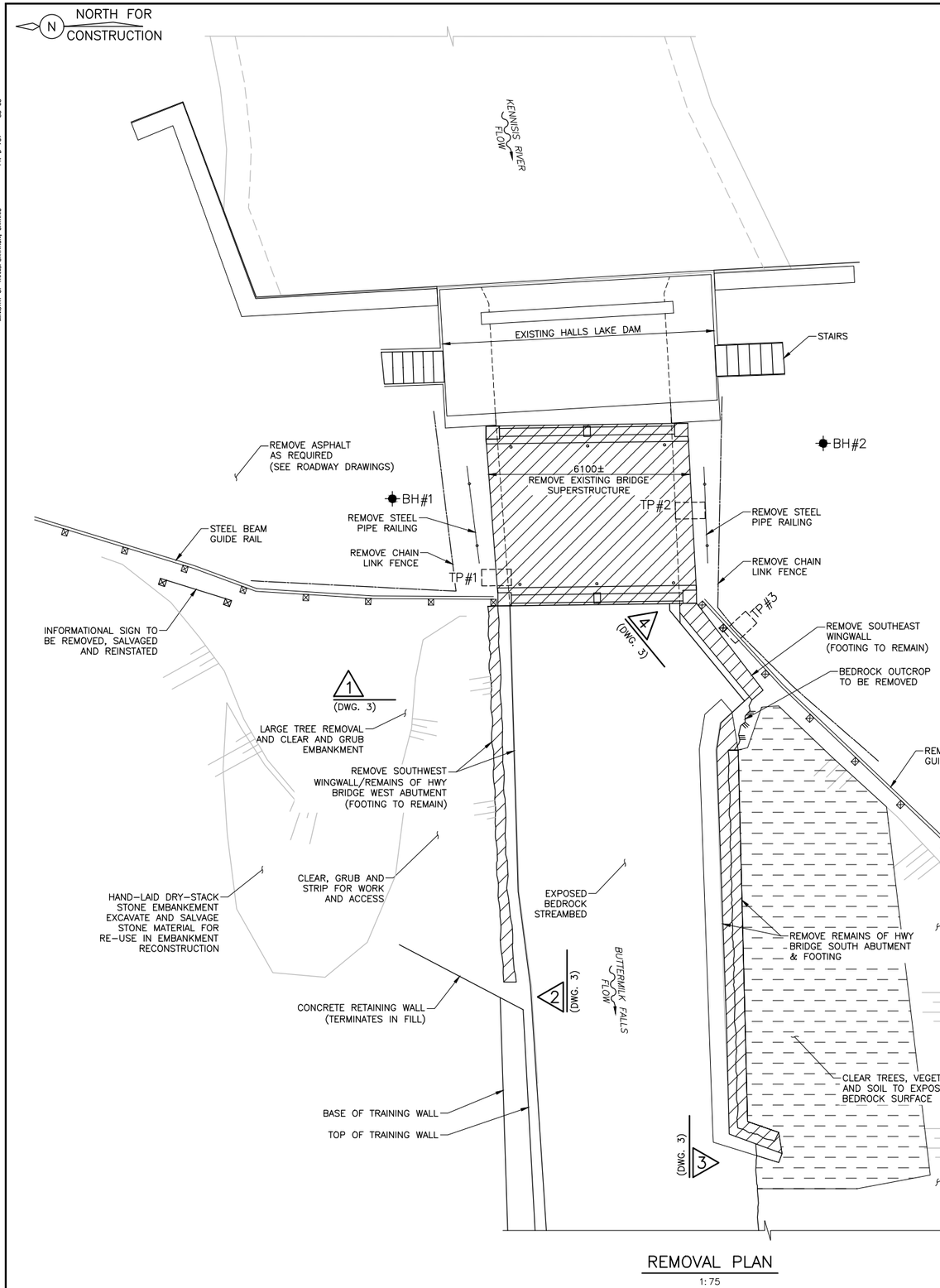
APPROX.	DENOTES APPROXIMATE
BH	DENOTES BOREHOLE
FTG	DENOTES FOOTING
TP	DENOTES TEST PIT
T/	DENOTES TOP OF

APPLICABLE STANDARD DRAWINGS

OPSD 972.130	CHAIN LINK FENCE
OPSD 912.256	GUIDE RAIL SYSTEM, STEEL BEAM TYPE M20 AND M30 LEAVING END TREATMENT RAIL COMPONENTS
OPSD 973.130	FENCE, STEEL BEAM BARRICADE INSTALLATION

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS			DESCRIPTION			
DESIGN	MT	CHK	FW	CODE CHBDC 2019	LOAD CL-625-ONT	DATE JUN 2023
DRAWN	GM	CHK		SITE		DWG 1



REMOVAL PLAN

1: 75

HWY 35 CONT. No. WP No. 5214-19-01	
HALLS LAKE DAM PEDESTRIAN BRIDGE REMOVAL AND ASSOCIATED SITE WORK	SHEET 94
REMOVALS I – PLAN	
wsp	METRIC

NOTES:

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH DRAWING 1 AND 3.
2. CONTRACTOR SHALL INSTALL ACCESS PLATFORM AND ADEQUATE DEBRIS CONTAINMENT TO ENSURE THAT NO MATERIAL OR DEBRIS ENTERS THE WATERWAY DURING THE COURSE OF THE WORK.

LEGEND

REMOVALS

CLEAR TREES, VEGETATION AND SOIL TO EXPOSE BEDROCK SURFACE

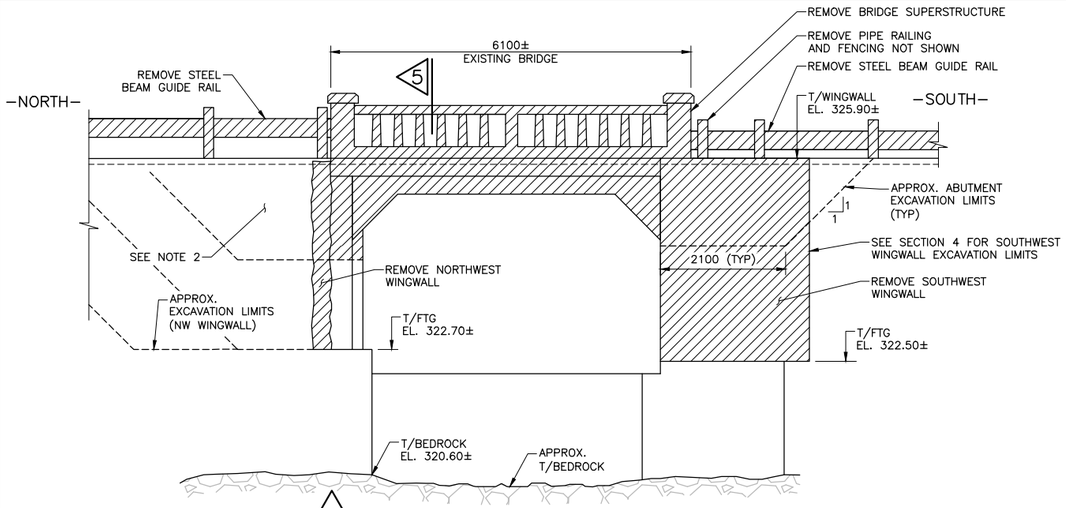
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DESCRIPTION

DESIGN MT	CHK FW	CODE CHBDC 2019	LOAD CL-625-ONT	DATE JUN 2023
DRAWN GM	CHK	SITE		DWG 2

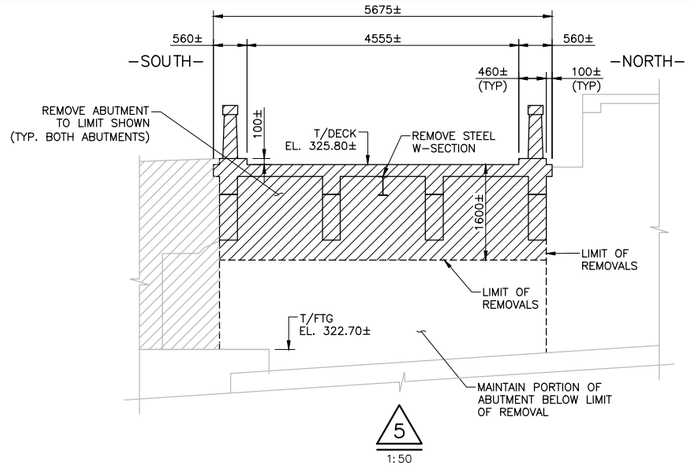
MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

CAD FILE LOCATION AND NAME: Y:\19M-01435-00 - MTO Hwy 35 and 4 Bridge Rehabs\4 - Halls Lake Dam Bridge\19M-01435-00-002-REMOVALS_I-PLAN.dwg
MODIFIED: 6/19/2023 9:32:11 AM BY: GUILHERME.MOTA
DATE PLOTTED: 6/23/2023 10:10:32 AM BY: GUILHERME.MOTA



1 REMOVALS AT PEDESTRIAN BRIDGE

1:50 (DWG. 2)
(OLD BRIDGE ABUTMENT AT SOUTHWEST NOT SHOWN FOR CLARITY)



HWY 35
CONT. No.
WP No. 5214-19-01

HALLS LAKE DAM
PEDESTRIAN BRIDGE
REMOVAL AND ASSOCIATED SITE WORK

REMOVALS II – SECTIONS

SHEET 95

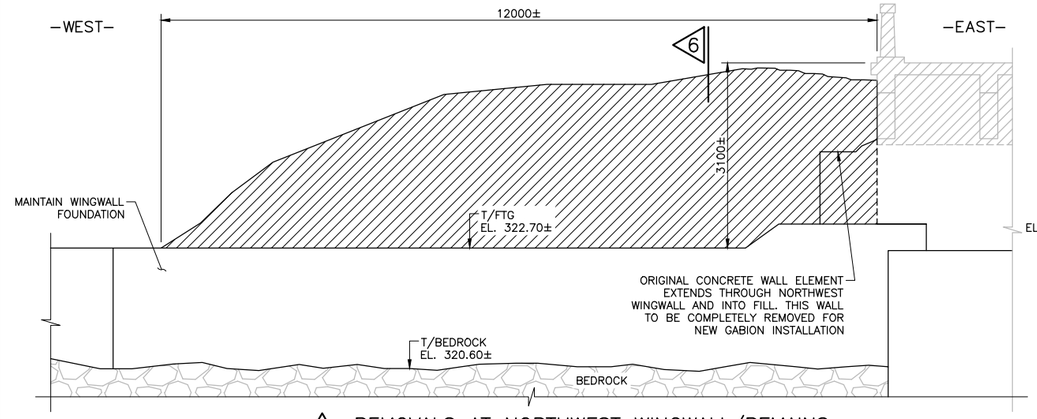
METRIC

NOTES:

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH DRAWING 1 AND 2.
2. CONTRACTOR SHALL INSTALL ACCESS PLATFORMS AND ADEQUATE CONTAINMENT TO ENSURE THAT NO MATERIAL OR DEBRIS ENTERS THE WATERWAY DURING THE COURSE OF THE WORK.
3. TEST PITS BEHIND PEDESTRIAN BRIDGE ABUTMENT WALLS INDICATE ROCK FILL PRESENT AT DEPTH OF 1.0–1.25m BELOW SURFACE.

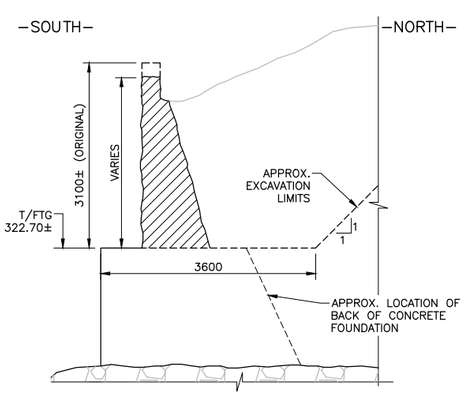
LEGEND

REMOVALS

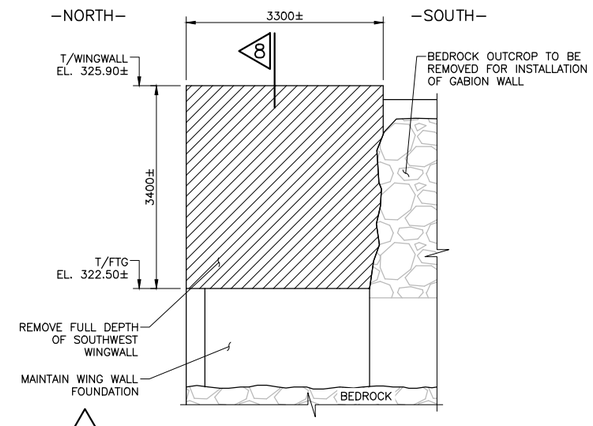


2 REMOVALS AT NORTHWEST WINGWALL/REMAINS OF HWY BRIDGE NORTH ABUTMENT

1:50 (DWG. 2)

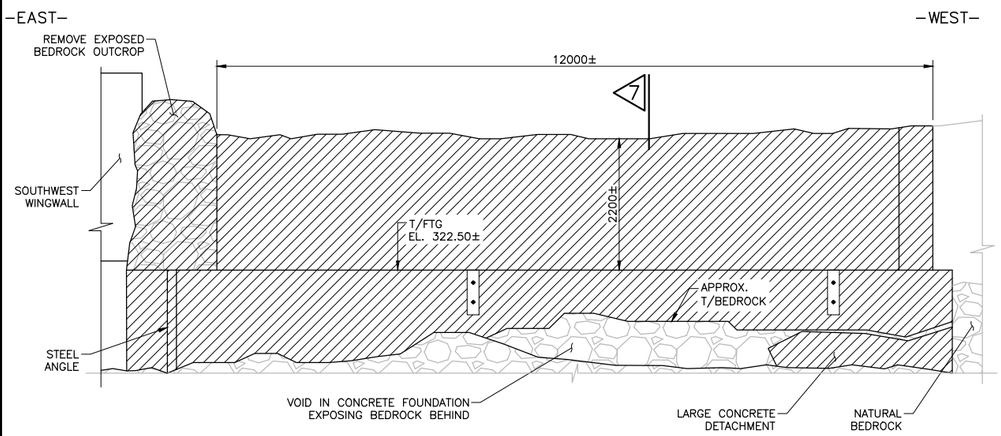


6
1:50



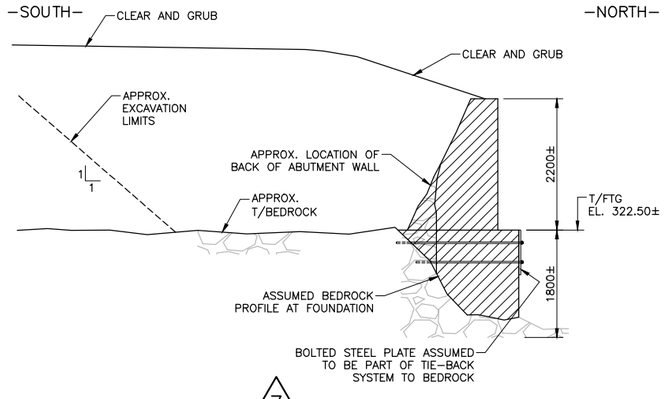
4 REMOVALS AT SOUTHWEST WINGWALL

1:50 (DWG. 2)
(PEDESTRIAN BRIDGE NOT SHOWN FOR CLARITY)

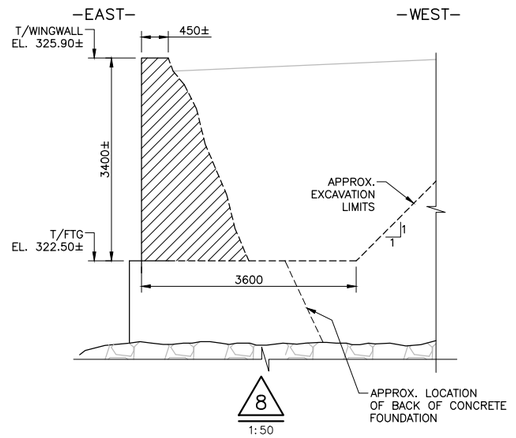


3 REMOVALS AT REMAINS OF HWY BRIDGE SOUTH ABUTMENT

1:50 (DWG. 2)



7
1:50



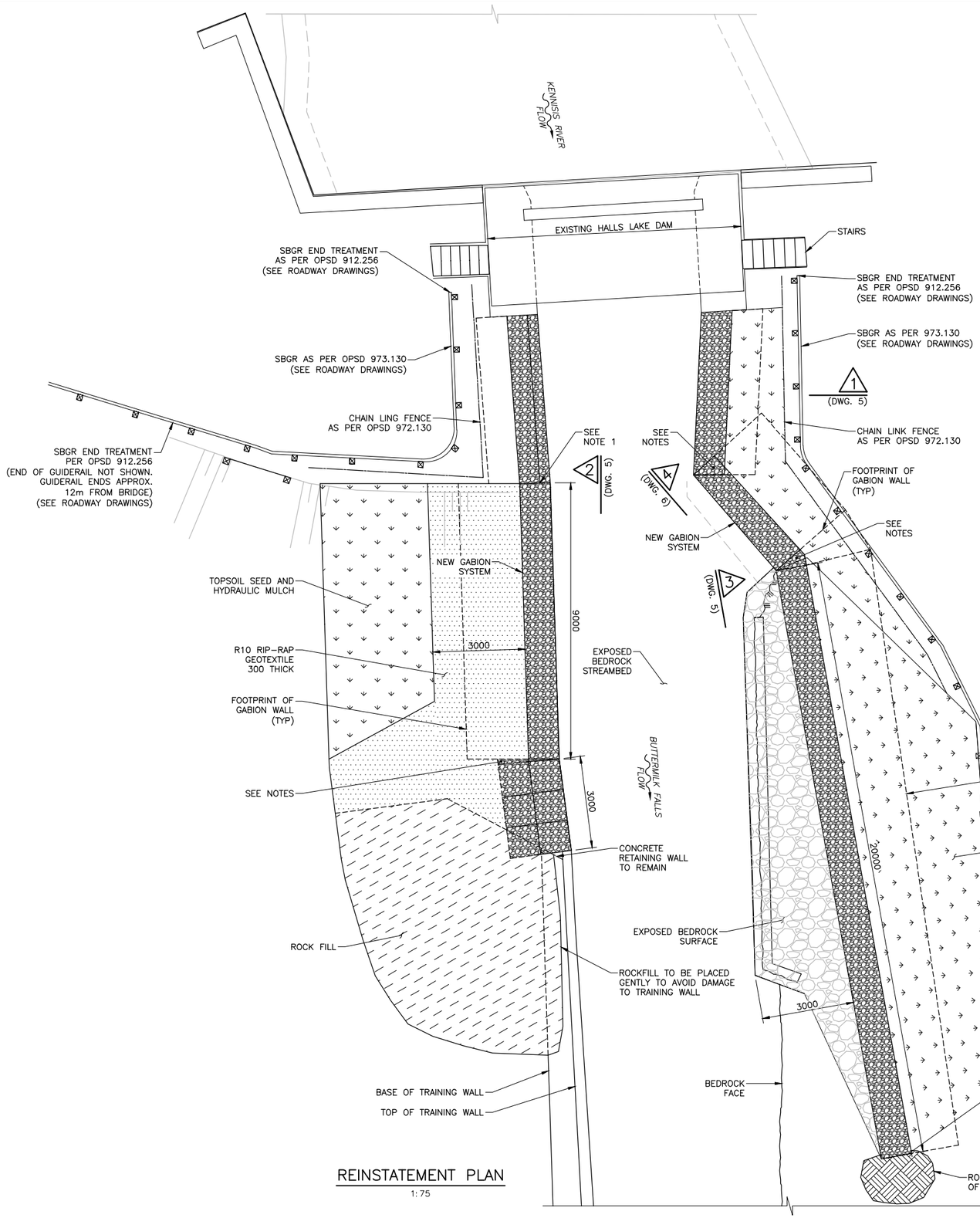
1:50

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS			DESCRIPTION			
DESIGN MT	CHK FW	CODE CHBDC 2019	LOAD CL-625-ONT	DATE JUN 2023		
DRAWN GM	CHK	SITE		DWG 3		

CAD FILE LOCATION AND NAME: Y:\19M-01435-00 - MTO Hwy 35 and 4 Bridge Rehabs\4 - Halls Lake Dam Bridge\19M-01435-00-003-REMOVALS_II-SECTIONS.dwg
MODIFIED: 6/19/2023 9:32:22 AM BY: GUILHERME.MOTA
DATE PLOTTED: 6/23/2023 10:10:43 AM BY: GUILHERME.MOTA
MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

NORTH FOR CONSTRUCTION



REINSTATEMENT PLAN

1:75

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

HWY 35
CONT. No.
WP No. 5214-19-01

HALLS LAKE DAM
PEDESTRIAN BRIDGE
REMOVAL AND ASSOCIATED SITE WORK

REINSTATEMENT I – PLAN

SHEET 96

METRIC

NOTES:

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH DRAWING 1, 2, 3, 5 AND 6.
2. MODIFY ABUTMENT AND WINGWALL BASKETS AT CORNERS AS REQUIRED TO ENSURE TIGHT FIT.
3. SW WINGWALL BASKETS TO BE INSTALLED TIGHT AGAINST REMAINING PORTION OF SOUTH ABUTMENT.
4. CONTRACTOR SHALL INSTALL ACCESS PLATFORMS AND ADEQUATE DEBRIS CONTAINMENT TO ENSURE THAT NO MATERIAL OR DEBRIS ENTERS THE WATERWAY DURING THE COURSE OF THE WORK.

LEGEND

- TOPSOIL SEED AND HYDRAULIC MULCH
- R10 RIP-RAP GEOTEXTILE 300 THICK
- NEW GABION SYSTEM
- ROCK FILL
- EXPOSED BEDROCK SURFACE
- ROCK PROTECTION AT THE END OF NEW GABION WALL

REVISIONS			DESCRIPTION			
DESIGN MT	CHK FW	CODE CHBDC 2019	LOAD CL-625-ONT	DATE JUN 2023		
DRAWN GM	CHK	SITE		DWG 4		

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05

CAD FILE LOCATION AND NAME: X:\19M-01435-00 - MTO Hwy 35 and 4 Bridge Rehabs\4 - Halls Lake Dam Bridge\19M-01435-00-004-REINSTATEMENT_I-PLAN.dwg
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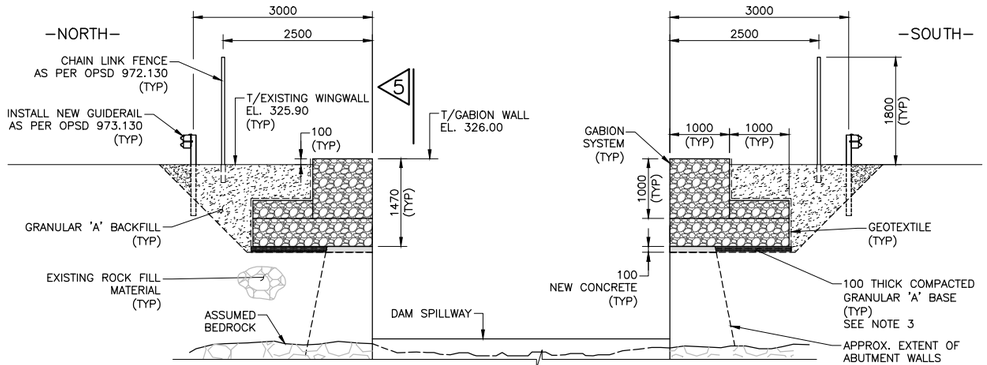
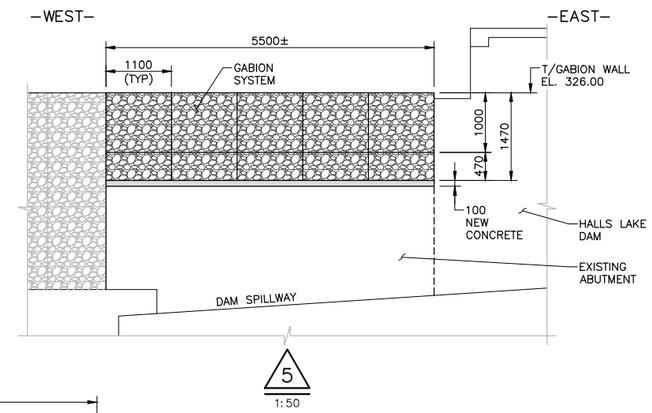
DATE PLOTTED: 6/23/2023 10:10:53 AM BY: GUILHERME.MOTA



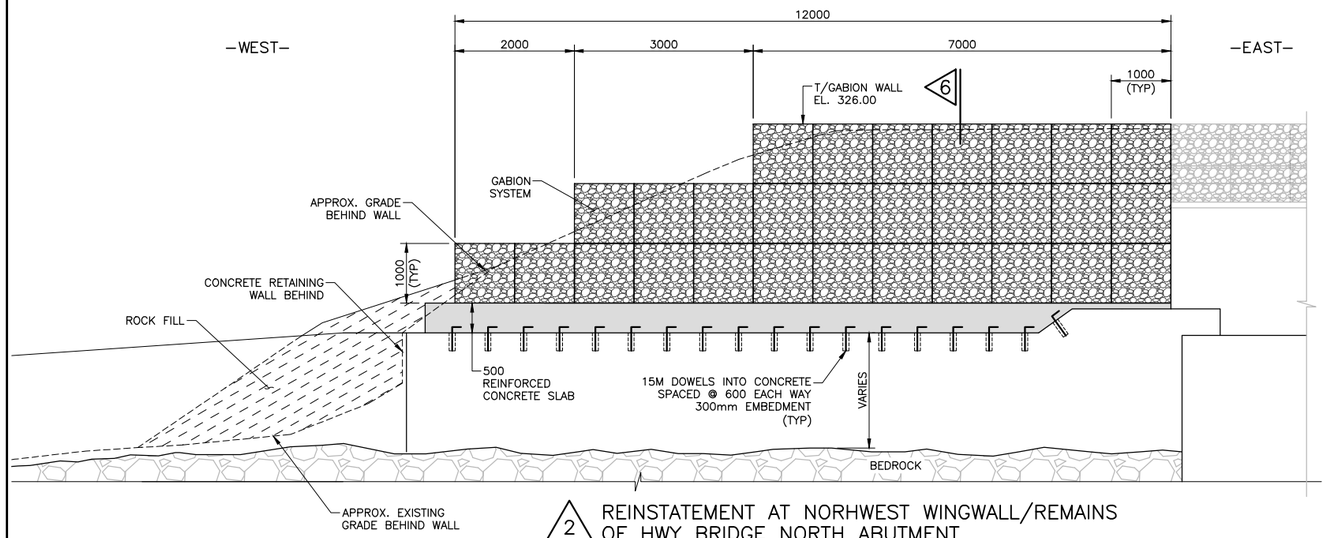
1 REINSTATEMENT AT PEDESTRIAN BRIDGE ABUTMENT

1:50 (DWG. 4)



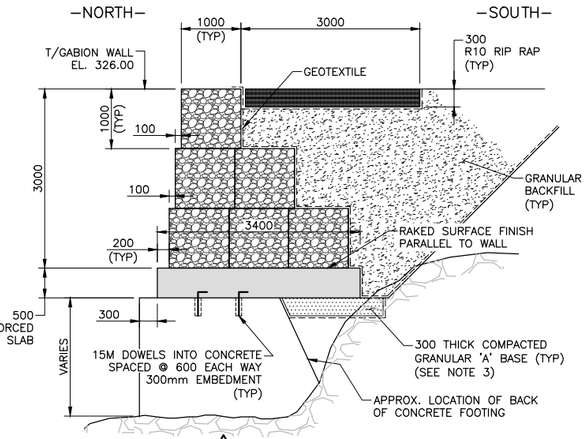
5

1:50



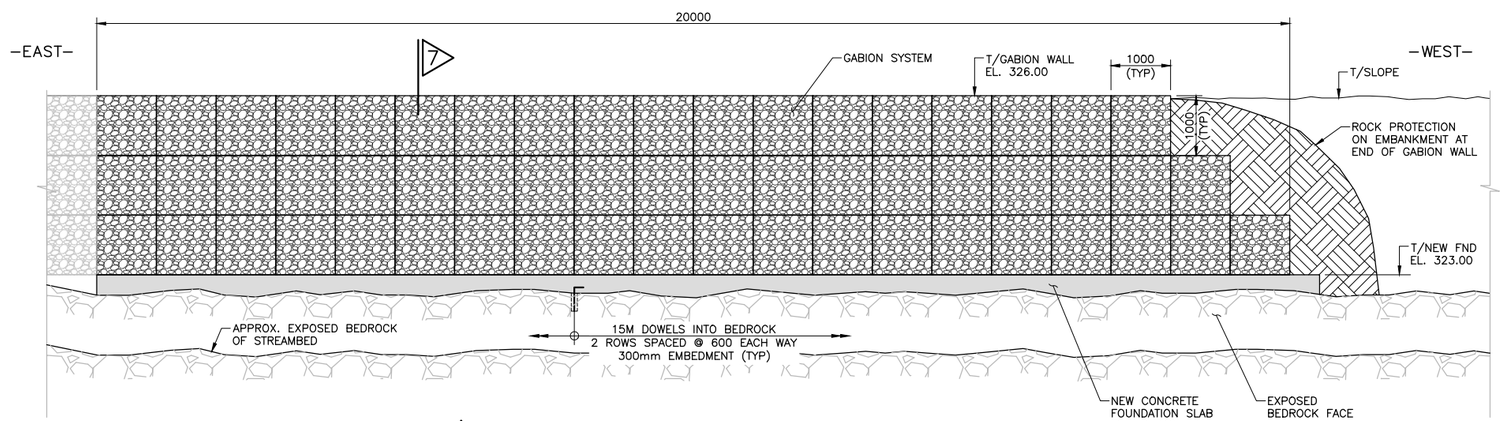
2 REINSTATEMENT AT NORHWEST WINGWALL/REMAINS OF HWY BRIDGE NORTH ABUTMENT

1:50 (DWG. 4)



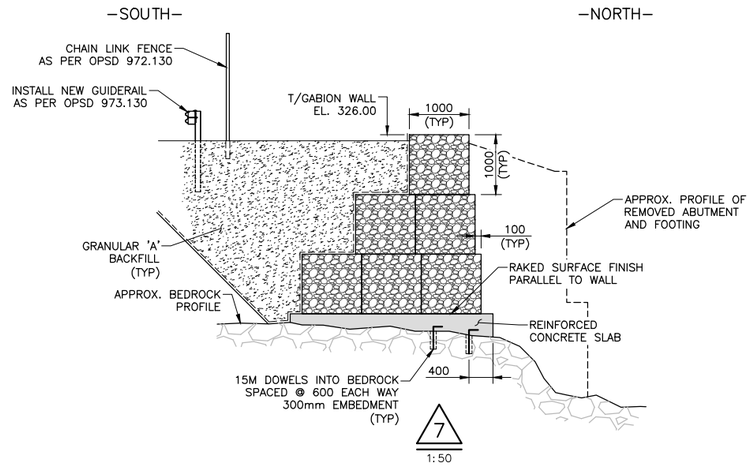
6

1:50



3 REMOVALS AT SOUTHWEST (FORMER DRIDGE ABUTMENT LOCATION)

1:50 (DWG. 4)



7

1:50

LEGEND

- NEW CONCRETE
- NEW GABION SYSTEM
- GRANULAR 'A' BACKFILL
- ROCK PROTECTION ON EMBANKMENT AT END OF GABION WALL
- ROCK FILL

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

HWY 35 CONT. No. WP No. 5214–19–01	
HALLS LAKE DAM PEDESTRIAN BRIDGE REMOVAL AND ASSOCIATED SITE WORK	SHEET
REINSTATEMENT II – SECTIONS	97
wsp	METRIC

NOTES:

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH DRAWING 1, 3, 4 AND 6.
2. CONTRACTOR SHALL INSTALL ACCESS PLATFORMS AND ADEQUATE DEBRIS CONTAINMENT TO ENSURE THAT NO MATERIAL OR DEBRIS ENTERS THE WATERWAY DURING THE COURSE OF THE WORK.
3. EXISTING SOIL/ROCK CONDITIONS FOR NEW GABION RETAINING WALLS TO BE INSPECTED BY THE CONTRACT ADMINISTRATOR. GRANULAR BASE MAY BE REPLACED WITH MASS CONCRETE, OR OTHER SUITABLE MATERIAL TO SUIT SITE CONDITIONS.

REVISIONS			DESCRIPTION			
DESIGN	MT	CHK	FW	CODE	CHBDC 2019	LOAD CL–625–ONT	DATE JUN 2023
DRAWN	GM	CHK		SITE			DWG 5

MINISTRY OF TRANSPORTATION, ONTARIO PR–D–707 88–05

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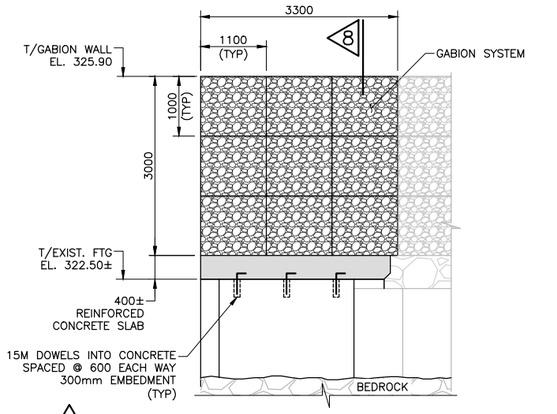
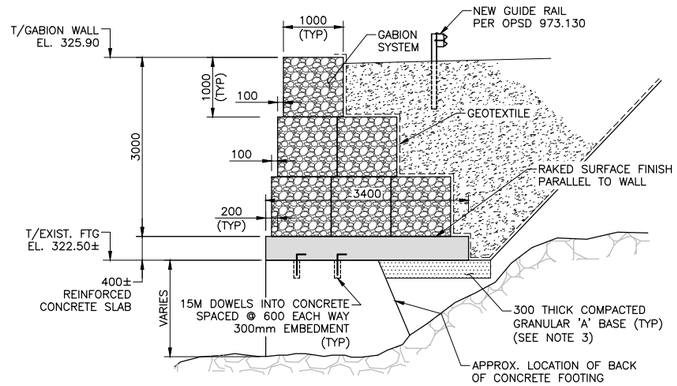
DATE PLOTTED: 6/23/2023 10:11:03 AM BY: GUILHERME.MOTA



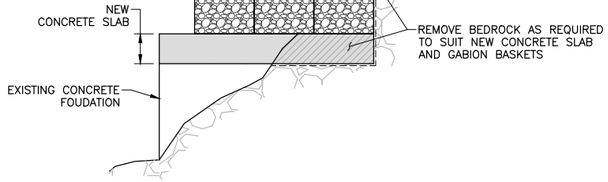
4 REINSTATEMENT AT SOUTHWEST WING WALL

1:50 (DWG. 4)



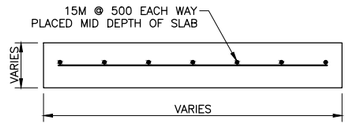
8

1:50



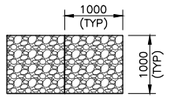
A TYPICAL DETAIL
BEDROCK INTERFERE WITH GABION WALL

1:50



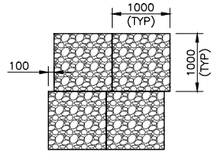
B TYPICAL DETAIL
GABION FOUNDATION SLAB

1:50



TYPICAL 1.0m HIGH WALL
GABION CONFIGURATION

1:50



TYPICAL 2.0m HIGH WALL
GABION CONFIGURATION

1:50

HWY 35
CONT. No.
WP No. 5214-19-01

HALLS LAKE DAM
PEDESTRIAN BRIDGE
REMOVAL AND ASSOCIATED SITE WORK

REINSTATEMENT III – SECTIONS AND DETAILS

SHEET 98

METRIC

NOTES:

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH DRAWING 1, 3, 4 AND 5.
2. CONTRACTOR SHALL INSTALL ACCESS PLATFORMS AND ADEQUATE DEBRIS CONTAINMENT TO ENSURE THAT NO MATERIAL OR DEBRIS ENTERS THE WATERWAY DURING THE COURSE OF THE WORK.
3. EXISTING SOIL/ROCK CONDITIONS FOR NEW GABION RETAINING WALLS TO BE INSPECTED BY THE CONTRACT ADMINISTRATOR. GRANULAR BASE MAY BE REPLACED WITH MASS CONCRETE, OR OTHER SUITABLE MATERIAL TO SUIT SITE CONDITIONS.

LEGEND

NEW CONCRETE

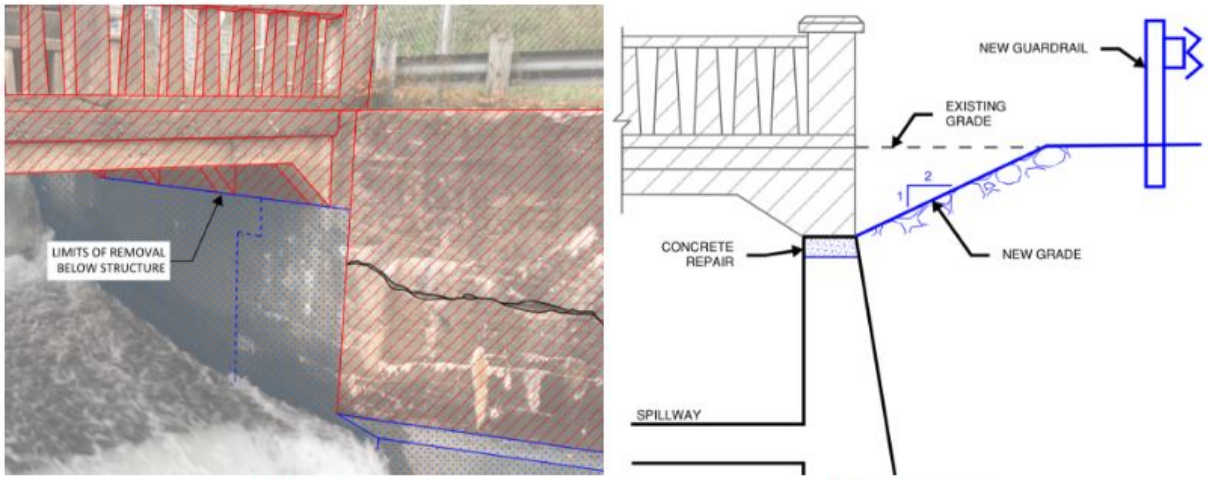
NEW GABION SYSTEM

GRANULAR 'A' BACKFILL

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

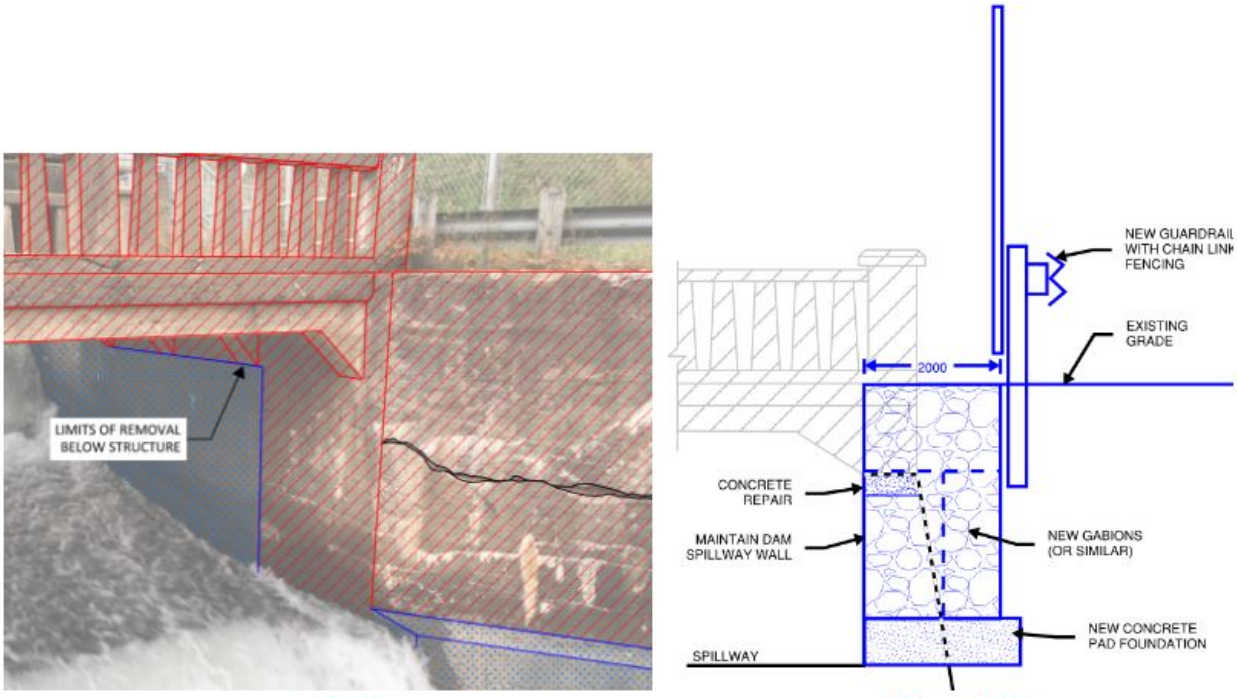
REVISIONS			DESCRIPTION			
DESIGN MT	CHK FW	CODE CHBDC 2019	LOAD CL-625-ONT	DATE JUN 2023		
DRAWN GM	CHK	SITE		DWG 6		

Design Sketches for Options 1 to 3 extracted from "Halls Lake Dam Bridge – Preliminary Design Report – Draft" prepared by WSP, Dated August 31, 2021



a) Removals b) Reinstatement

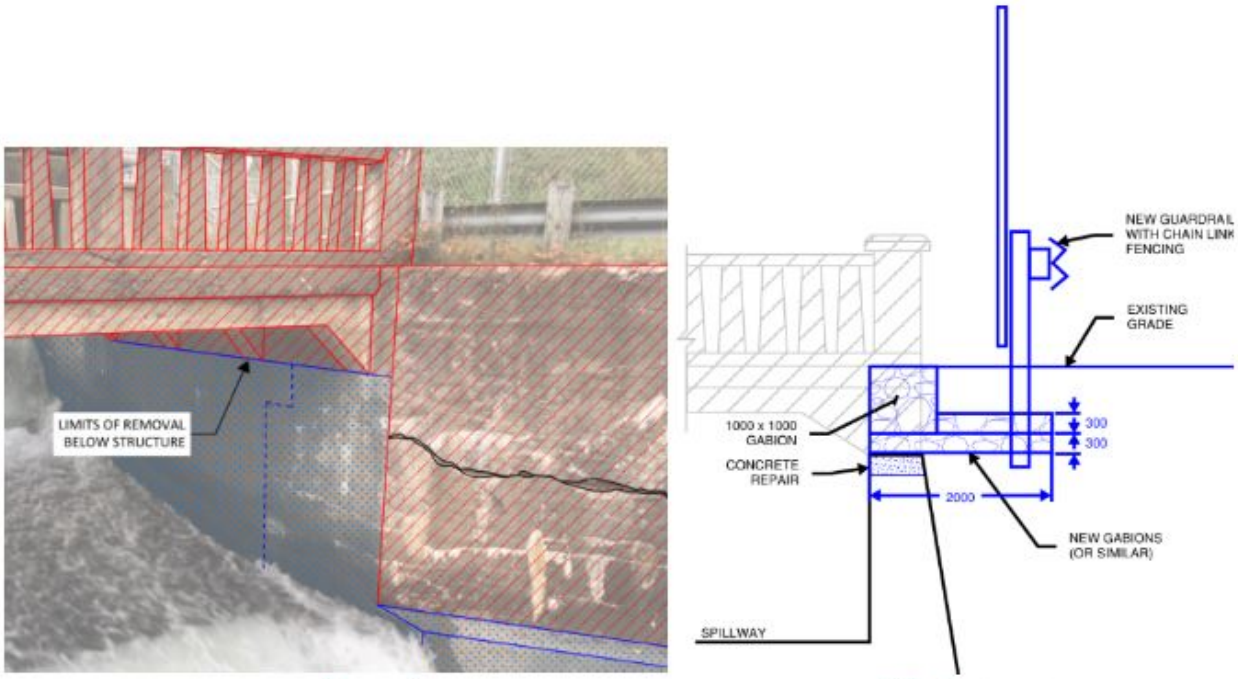
Figure 3: Preliminary design for Option 1



a) Removals b) Reinstatement

Figure 4: Preliminary design for Option 2

Design Sketches for Options 1 to 3 extracted from "Halls Lake Dam Bridge – Preliminary Design Report – Draft" prepared by WSP, Dated August 31, 2021



a) Removals b) Reinstatement

Figure 5: Preliminary design for Option 3

Note, like shown in Options 1 and 2, Figure 5 includes a preliminary sketch of the cross section through the abutment walls and a photograph depicting the structural elements on the south side of the waterway. Again, similar methods would be applied to the north.