CCI

Government of Northwest Territories

Dempster Highway – Culvert Replacement Project

Design Memo – KM 147.0

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Revision Log

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1 INTRODUCTION

The Government of the Northwest Territories has retained CCI Inc. (CCI) (GNWT) to analyze and design the replacement and decommissioning of three (3) existing culverts located along the Dempster Highway No.8 in the Northwest Territories. Culvert locations, as well as basic details regarding the existing culverts, are shown below in Table 1:

Table 1: Existing Culvert Details

Location (HWY Chainage)	Coordinates		Length (m)	Diameter (m)	Cover
KM 266.1	68º 20' 9.0."	133º 39 20.5."	43.2	2.5	5.5
KM 147.0	**67º 29' 1.7"**	**133º 46' 0.7"**	**61.6**	**1.8**	**11.3**
KM 40.2	67º 13' 5.9"	135º 30' 15.9"	44.2	2.0	8.6

This report addresses the proposed culvert installation and rehabilitation of the existing culvert located at KM 147.0 only.

2 KILOMETRE POINT 147.0 CULVERT

2.1.1 Location Summary

Kilometre Point 147.0 of the Dempster Highway (KM147.0) is located along HWY 8 approximately 3.5 km north of the Mackenzie River crossing near Tsiigehtchic, NWT. The existing culvert at this location has a nominal diameter of 1.8 m and an installed length of 61.6 meters. The depth of cover (DOC) from the top of the pipe to the road centreline is 11.3 m. The culvert has west to east alignment, with upstream situated on the east side of the culvert. Drainage flow ultimately feeds into the Mackenzie River. After a structural and hydraulic assessment by GNWT, the culvert at this location has been selected for replacement and decommissioning.

The survey at this location was performed by White Bear Geometrics Ltd. and can be found in Appendix A. The imagery of the site location can be seen below:

Figure 1: KM147.0 Crossing Location

2.1.2 Geotechnical Information

Tetra Tech Canada Inc. was retained by GNWT, Department of Infrastructure to complete a geotechnical investigation to conduct a geotechnical site investigation at the culvert crossing at KM 147.0 on the Dempster Highway (HWY 8). As part of the project, two (2) boreholes, labelled as BH-08 and BH-09, were drilled near the KM147.0 culvert location. A summary of the information garnered from drilling and sampling of these boreholes is listed below in Table 2:

Table 2: KM147.0 Boreholes

Borehole	Depth (m)	Location UTM (NAD 83 UTM Z8°)	Description	Primary Geotechnical Concerns
BH-08	20.7m	N:7485826 E:552685	13 m Sand (Fill) 7.7 m Clay (Fill)	High plastic clay, potential ice rich zones
BH-09	20.7m	N:7485829 E:552684	16 m Sand (Fill) 4.7 m Clay	High plastic clay, potential ice rich zones

The road embankment will require a trenchless installation technique for the culvert replacement. This will be discussed further in the Design Considerations section of this report.

Tetra Tech's Borehole Logs as part of Project No.: ENG.YARC03234-01 "*Geotechnical Investigation of Existing Culverts"* completed by Tetra Tech can be found in Appendix B of this report

3 ENGINEERING

3.1 HYDROTECHNICAL DESIGN

3.1.1 Hydrology

3.1.1.1 Flood Design Discharge

As outlined in the Project Design Basis, the new culvert "shall be able to accommodate a 100-year return period flow." As well, "climate change shall be accounted for while calculating flow rates."

The Flood Design Discharge for the KM147.0 watercourse was calculated using the a hydraulic gauge station (Environment Canada Gauge Station - 10LC017 Havipak Creek Near Inuvik) and compared to the results found in Stantec Consulting Ltd.'s *"Dempster Highway KM 147 Creek Hydrotechnical Assessment"* Document No.: 144930112. The 10LC017 Gauge Station provided accuracy in calculating the various Design Discharges for the KM147.0 watercourse as it has similar slope and terrain characteristics and is of similar size (15.2 km^2 vs 14.7 km^2), despite the distance between the station and crossing location. The 10LC017 Havipak Creek Near Inuvik gauge station recorded continuous data from 1995 to 2017.

The largest flows for the KM147.0 watercourse are associated with the spring thaw that typically occurs within the May to June timeframe. Using a Log Pearson Type III probability distribution, the following instantaneous flood design discharges were calculated:

1) Q100 = 5.9 m^3/s
2) Q200 = 6.8 m^3/s
3) Q500 = 8.0 m^3/s

A flood design discharge of 8.0 m^3/s was selected. This allows for a 36% increase to the Q100 to accommodate climate change impacts.

3.1.1.2 Safe Fish Design Discharge

To determine the Safe Fish Passage Design Discharge, the 3Q10 design discharge was specified as part of the Project Design Basis.
Utilizing Environment Canada Gauge Station - 10LC017 Havipak Creek Near Inuvik and pro-rating for the KM147.0 watercourse, a 3Q10 Fish Passage Design Discharge (FPDD) of 1.74 m^3/s was calculated.

The catchment basin is very "peaky" as indicated by the short-lived flow peaks presented in Figure 2. To further illustrate, it is noted that the 7Q10 discharge is 0.86 m^3/s.

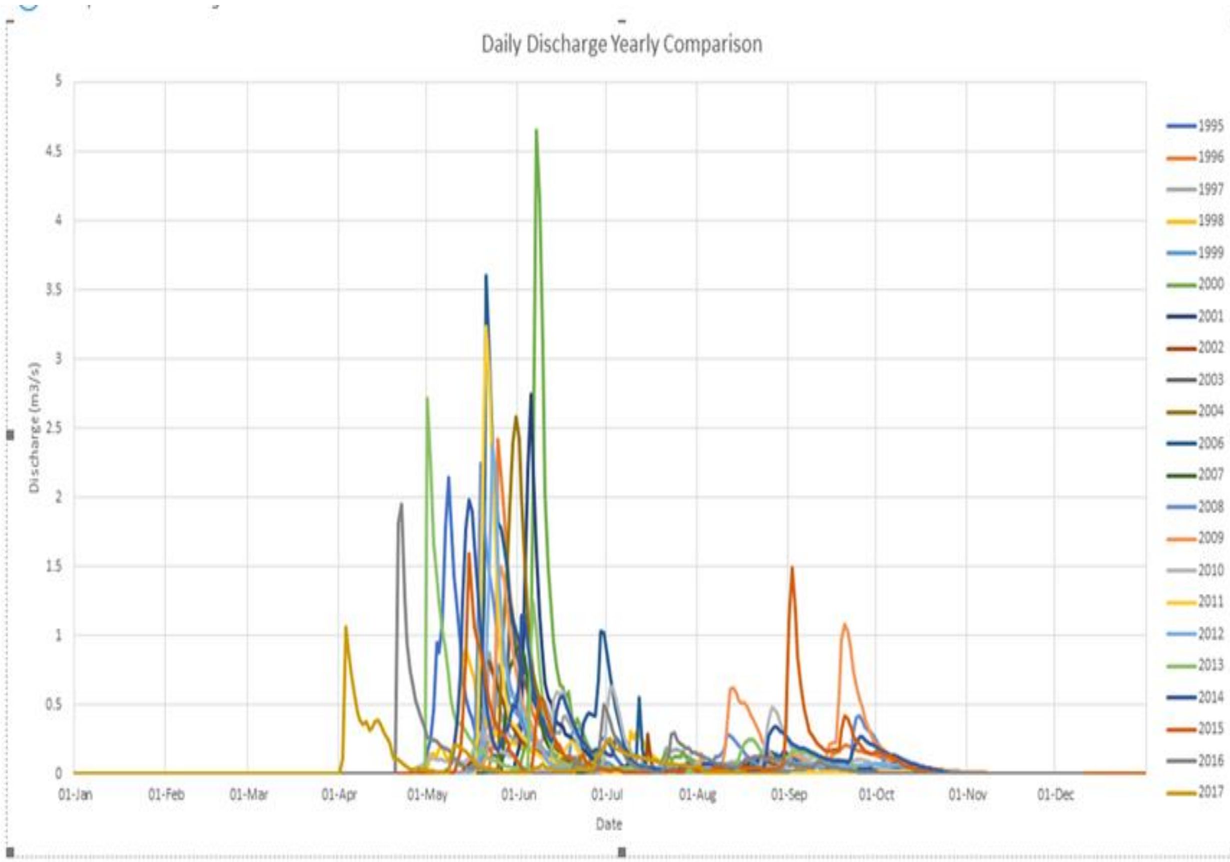


Figure 2: Yearly Discharge Comparison

3.1.1.3 Low Flow Design Discharge

Low flow conditions were considered as part of the design. During the summer/fall season (determined to be July 15 to October 31), the flow is typically very low. Utilizing Environment Canada Gauge Station - 10LC017 Havipak Creek Near Inuvik, the Average Daily Discharge for the KM147.0 watercourse was determined to be 0.04 m^3/s for the summer/fall season.

Between November and April water discharge is negligible due to frozen conditions.

3.1.1.4 Construction Design Discharge

The construction of the new 3.0m culvert is expected to commence in mid-July and be completed in the fall. As part of the design, the water flows expected during the construction timeframe will be managed as part of the isolation procedure to ensure safe fish passage and minimize any potential siltation caused by construction activities.

To determine a construction design discharge for the KM0147.0 watercourse, Environment Canada Gauge Station - 10LC017 Havipak Creek Near Inuvik was used. It was noted that daily discharges have recently increased significantly which is understood to be attributed to climate change. The Highest Annual Daily Discharge from July 15 to October 31 has increased significantly from 0.2 m^3/s (1995 to 2004) to 1.49 m^3/s (2008 to 2017). Upon reviewing the flow data, a deterministic rather than probabilistic approach was used to arrive at a Construction Design Discharge of 1.0 m3/s.

3.1.2 Culvert Hydraulics

The culvert hydraulics are modelled using the US Department of Transportation Federal Highway Administration HY-8 Culvert Hydraulic Analysis Program.

From the hydrology analysis described above, the following design discharges were selected for the hydraulic analysis.

- Flood Discharge = 8.0 m^3/s
- Safe Fish Passage Design Discharge (3Q10) = 1.74 m^3/s
- Low Flow Design Discharge = 0.04 m^3/s
- Construction Design Discharge = 1.0 m^3/s (July 15 to November 1)

Upon completion of the hydraulic analysis, a technical risk, a cost assessment, and a construction logistical analysis was completed the results were provided to the Government of the Northwest Territories. It was determined that a single 3.0 m diameter smooth steel bored culvert which will be embedded 0.6 m with substrate holders to promote safe fish passage was the preferred option.

Table 4 summarizes the output of the hydraulic analysis.

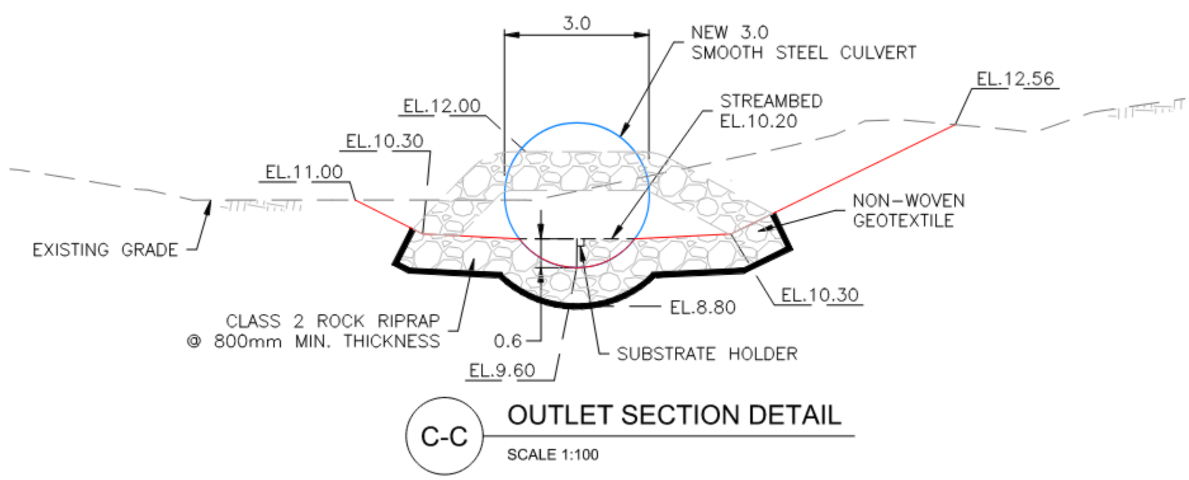


Figure 3 Culvert Geometry (Outlet)

Table 3 Hydraulic Analysis Output

Design Discharge	Culvert Outer Diameter (m)	Culvert Length (m)	Apportioned Discharge (m3/s)	Headwater Elevation from Invert (m)	Outlet Depth from Invert (m)	Outlet Velocity (m/s)
Flood Condition ($Q=8.0\ m^3/s$)	3.0	65.4	7.53	2.36	1.56	2.97
Safe Fish Passage ($Q = 1.74\ m^3/s$)	3.0	65.4	1.25	1.27	1.04	1.48
Low Flow Condition ($Q = 0.04\ m^3/s$)	3.0	65.4	0.04	0.82	0.67	0.24

The following sub-sections describe the various design variables, assumptions and considerations used in the design of the culvert.

3.1.2.1 Culvert Diameter

3.0 m smooth steel bored culvert (embedded 0.6 m for safe fish passage).

Given the approximately 10.6 m depth of cover between the proposed 3.0 m culvert and the highway surface, it is believed that the best construction method will be a trenchless bored smooth steel culvert. A bored installation will negate the need for a large conventional excavation and associated traffic disruptions. A review of trenchless vendors was conducted, and it was determined that the largest commercially available trenchless bore diameter would be 3.0 m. Accordingly, the culvert size has been selected based on a maximum 3.0 m diameter.

Based on field survey data (Q2, 2021), it was determined that the existing culvert had deformed to such an extent that it would not be practical to place a culvert liner within the existing culvert of any size that would significantly enhance flow capacity.

3.1.2.2 Culvert Slope

The slope of the 3.0 m culvert will be 1%.

The existing 1.8 m corrugated culvert has a slope of 1%. Since the installation of the culvert in 1973, it appears that the culvert slope has adequately provided sediment transportation as evidenced by only minor bed aggradation and degradation immediately upstream and downstream of the culvert. Accordingly, the design of the new bored 3.0 m culvert will occur at a slope of 1%.

3.1.2.3 Culvert Length

The length 3.0 m culvert is 65.4 m.

3.1.2.4 Safe Fish Passage Design Measures

To accommodate fish passage for a range of flow conditions, various design measures have been included in the design including:

4) Embedment of the 3.0 m culvert.
5) Substrate holders in the 3.0 m culvert.
6) Resting area immediately upstream of the culvert.

Initially, as part of the pre-engineering design phase, a safe fish passage design approach using more natural stream characteristics such as embedding the 3.0 m culvert to a depth of 20% and using large rock and natural bed material to provide resting areas within the culvert. This design approach has been implemented by Alberta Transportation in certain instances.

To determine the potential level of acceptance that DFO may have for this approach, a series of informal meetings and preliminary design information was shared with DFO staff.

DFO staff reiterated that their design criteria for reviewing culverts for safe fish passage is by comparing the average velocity in the culvert as determined from the 3Q10 discharge and comparing these average velocities with fish swimming performance curves.

DFO staff were aware of the present limitations to fish swimming performance curves given the limited data available. The use of fish swimming curves can provide significantly conservative calculations leading to large or multiple culverts. DFO staff were very helpful and open to considering alternate design methodologies to address safe fish passage and stated that if that was the proposed methodology, a formal Request for Review would be required as part of the submission.

During the detailed design phase, it was determined that the best engineered solution to accommodate all potential fish species was the use of substrate holders. For the KM147.0 watercourse crossing, the 3Q10 discharge of 1.74 m3/s was used as the Safe Fish Passage Design Discharge (FPDD). From the hydraulic modelling, the outlet velocity of the 3.0 m culvert (embedded 20%) is 1.48 m/s (3Q10 velocity).

A fish study was completed by Stantec (Ref. *Fish Habitat Assessment for Crossing Structure Replacement: NWT Highway 8 at KM 147.0* memo report (Stantec 2019)) for the watercourse crossing at KM147.0 that concluded that although no fish were found as part of the study, there was fish habitat and that the various fish species identified in Table 4 Fish Swimming Performance data for potential fish species at KM 147.0, may be present within the watercourse.

The DFO Fish Calculator was used to determine the swimming performance of the potential species identified in the KM147.0 Fish Study. The DFO Fish Calculator uses a collection of fish swimming performance fatigue (swim speed versus endurance time) and distance (swim distance versus water velocity) curves. The results are presented in the following table.

Table 4 Fish Swimming Performance data for potential fish species at KM 147.00

Table 4 Fish Swimming Performance data for potential fish species at KM 147.0

Common Name	Scientific Name	Spawning Timing	Average Length (cm)	DFO Equivalency Name	Fish Swimming Performance Velocity Probability (able to meet design velocity) - Based on 50m Culvert	Burst Velocity Probability - Based on 2 m swimming distance
Arctic grayling	*Thymallus arcticus*	May-Jun	30-40	Salmon and Walleye Group	Length = 350mm 50% - 1.1 m/s 87.5% - 0.63 m/s	Length = 350mm 50% - 1.9 m/s 87.5% - 1.3 m/s
Arctic lamprey	*Lampetra camtschatica*	Apr-Jul	20-30	Eel Group	Length = 250mm 50% - 0.2 m/s 87.5% - 0.13 m/s	Length = 250mm 50% - 1.3 m/s 87.5% - 0.81 m/s
Broad whitefish	*Coregonus nasus*	Oct-Nov	41-50	Salmon and Walleye Group	Length = 450mm 50% - 1.3 m/s 87.5% - 0.78 m/s	Length = 450mm 50% - 3.3 m/s 87.5% - 2.5 m/s
Burbot	*Lota lota*	Feb-Mar	40-60	No Spawning		
Dolly varden	*Salvelinus malma*	Sep-Nov	38-61	Salmon and Walleye Group	Length = 500mm 50% - 1.4 m/s 87.5% - 0.85 m/s	Length = 500mm 50% - 2.4 m/s 87.5% - 1.7 m/s
Flathead chub	*Platygobio gracilis*	Jul-Aug	20-30	Salmon and Walleye Group	Length = 250mm 50% - 0.8 m/s 87.5% - 0.48 m/s	Length = 250mm 50% - 2.2 m/s 87.5% - 1.4 m/s
Lake chub	*Couesius plumbeus*	Apr-Aug	5-9	Salmon and Walleye Group	Length = 70mm 50% - 0.26 m/s 87.5% - 0.15 m/s	Length = 70mm 50% - 0.81 m/s 87.5% - 0.48 m/s
Lake trout	*Salvelinus namaycush*	Sep-Oct	45-65	Salmon and Walleye Group	Length = 508mm 50% - 1.4 m/s 87.5% - 0.86 m/s	Length = 508mm 50% - 3.5 m/s 87.5% - 2.4 m/s
Lake whitefish	*Coregonus clupeaformis*	Sep-Nov	40-55	Salmon and Walleye Group	Length = 475mm 50% - 1.4 m/s 87.5% - 0.82 m/s	Length = 475mm 50% - 3.4 m/s 87.5% - 2.3 m/s
Least cisco	*Coregonus sardinella*	Jul-Oct	10-20	Salmon and Walleye Group	Length =150mm 50% - 0.52 m/s 87.5% - 0.31 m/s	Length = 150mm 50% - 1.5 m/s 87.5% - 0.92 m/s
Ninespine stickleback	*Pungitius pungitius*	May-Jul	51			
Northern pike	*Esox lucius*	Immediately after ice out	40-50	Northern Pike (Derived)	Length = 450mm 50% - 0.6 m/s 87.5% - 0.40 m/s	Length = 450mm 50% - 2.2 m/s 87.5% - 1.7 m/s
Pond smelt	*Hypomesus olidus*	June-July	10-20			

Rainbow smelt	*Osmerus mordax*	Mar-May	10-25	No Spawning		
Round whitefish	*Prosopium cylindraceum*	Oct-Dec	20-30	Salmon and Walleye Group	Length = 250mm 50% - 0.8 m/s 87.5% - 0.48 m/s	Length = 250mm 50% - 2.2 m/s 87.5% - 1.4 m/s
Slimy sculpin	*Cottus cognatus*	May-Jun	61			
Spoonhead sculpin	*Cottus ricei*	Aug-Sep	81			
Spottail shiner	*Notropis hudsonius*	Jun-Jul[9]	6-8	Salmon and Walleye Group	Length = 70mm 50% - 0.26 m/s 87.5% - 0.15 m/s	Length = 70mm 50% - 0.81 m/s 87.5% - 0.48 m/s
Trout-perch	*Percopsis omiscomaycus*	May-Aug	7.5-10	Salmon and Walleye Group	Length = 90mm 50% - 0.34 m/s 87.5% - 0.2 m/s	Length = 90mm 50% - 1.0 m/s 87.5% - 0.96 m/s

Alberta Transportation Methodology

Several studies have been conducted that demonstrate that actual velocities in a culvert vary significantly from the “average velocity” which is the criteria used by DFO to assess culvert sizing. As indicated in Figure 4 Culvert Cross Section Velocity, velocities are significantly lower at the interface of the water with the substrate and culvert walls providing areas of low velocities promoting fish passage. Recent studies (Alberta Transportation May 2020) have concluded:

- “20% of the flow area will have point velocities less than 70% of the mean velocity
- the average of all point velocities in the region will be less than 50% of the section-averaged mean velocity.
- This suggests that application of fish swimming performance curves using the mean velocity from culvert hydraulics models can substantially underestimate the potential for fish passage.”

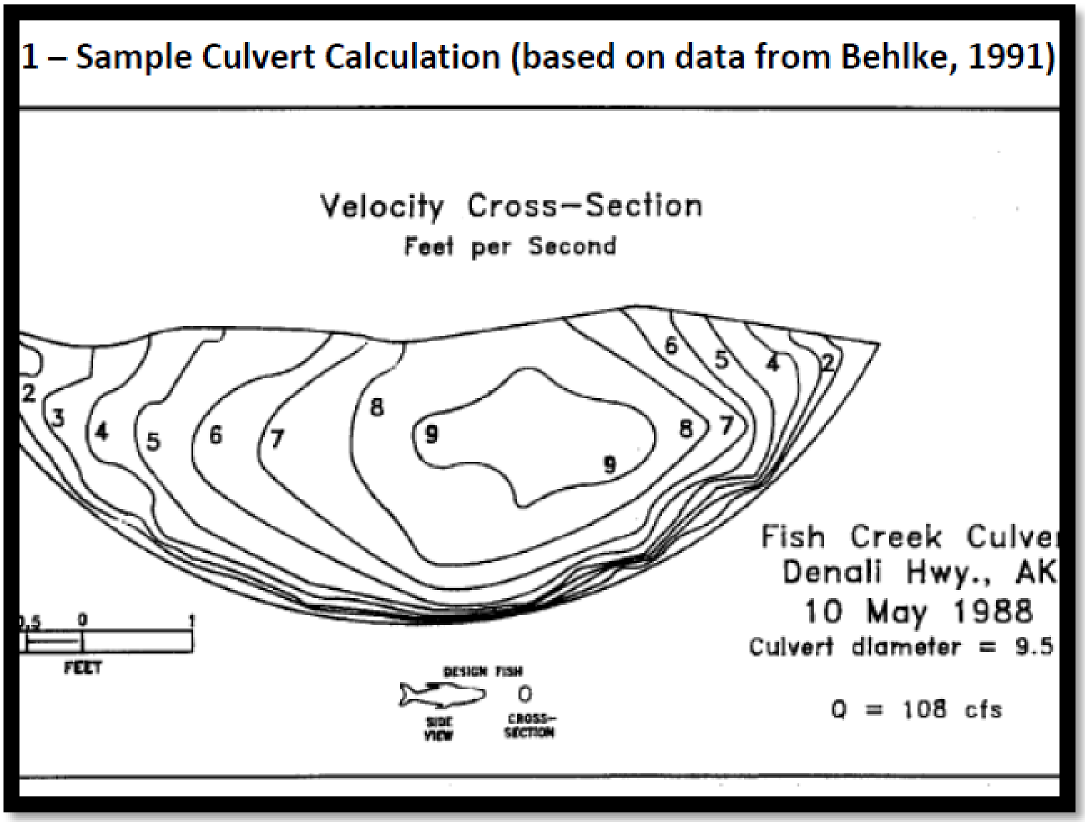


Figure 4 Culvert Cross Section Velocity

Substrate holders and pipe embedment

Substrate holders (or baffles) are intended to create allowable velocities during fish passage flows, while not exceeding fish turbulence thresholds. Substrate holders divide the culvert into a series of cells and bays, creating resting areas between the substrate holders, and points of higher velocity at the substrate holders. Fish are assumed to use their prolonged swimming speed along lower velocity areas and in between the substrate holders, use their burst speed to navigate around the substrate holders.

Some of the most comprehensive substrate holder research available comes from number of studies completed at the University of Alberta under the direction of Dr. Rajaratnam. Much of this research was funded and supported by the DFO.

Based on this research, Dr Rajaratnam, was consulted and recommended a weir substrate holder identified in Figure 3 Culvert Geometry (Outlet). The weir substrate holder will be embedded within the 3.0 m culvert to a depth of 0.6 m. The length between substrate holders will be 1.8 m. Natural bed material will fill between the substrate holders. In times of larger discharges (and velocities) the substrate holders will create turbulent flow and allow for fish resting areas between the substrate holders.

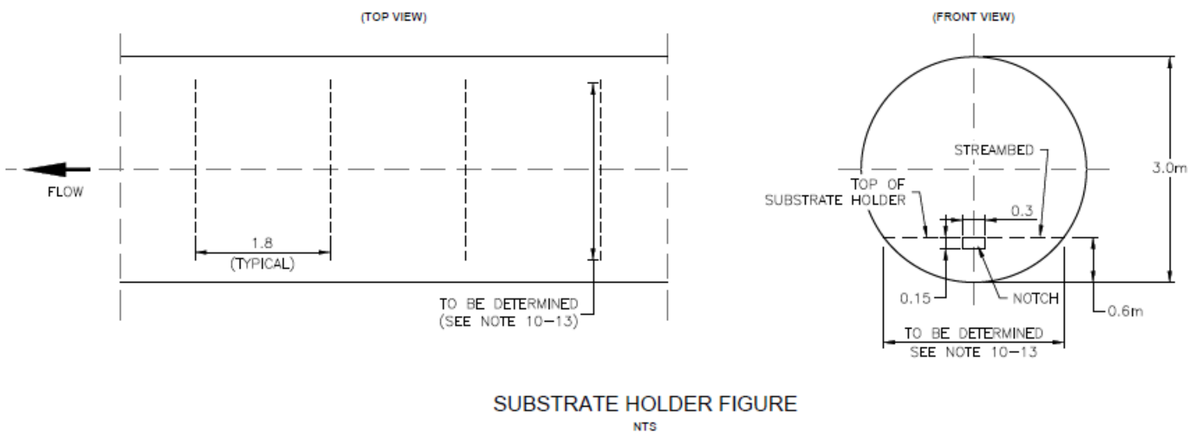


Figure 5: Substrate Holder Detail

A notch measuring 300 mm wide and 200 mm deep will be placed in the centre of the substrate holder. The notch will provide the necessary flow depth to allow fish passage during low flow conditions. In addition, the low flow channel has been extended into the outlet apron/dissipation pool to ensure a defined watercourse pathway.

Resting areas immediately upstream and downstream of the culvert – The large rock rip rip rap immediately upstream and downstream of the culvert will create areas with lower velocities for fish resting areas.

At the Culvert Inlet, two or three large Class 2 riprap rocks will be placed in the inlet apron to provide a resting area. The large Class 2 rocks will be field placed so that the top of the rocks extend to the surface for the Fish Passage Design Discharge. The rocks will be placed to minimize any potential impact to the flow characteristics of the inlet and culvert.

3.1.2.5 Inlet and outlet design

Inlet Design

To accommodate the high velocities and to streamline the flow of water into the culverts, an apron comprised of Class 1 Rock Rip underlain by a non-woven geotextile will be used as shown in Figure 6 Inlet Plan View.

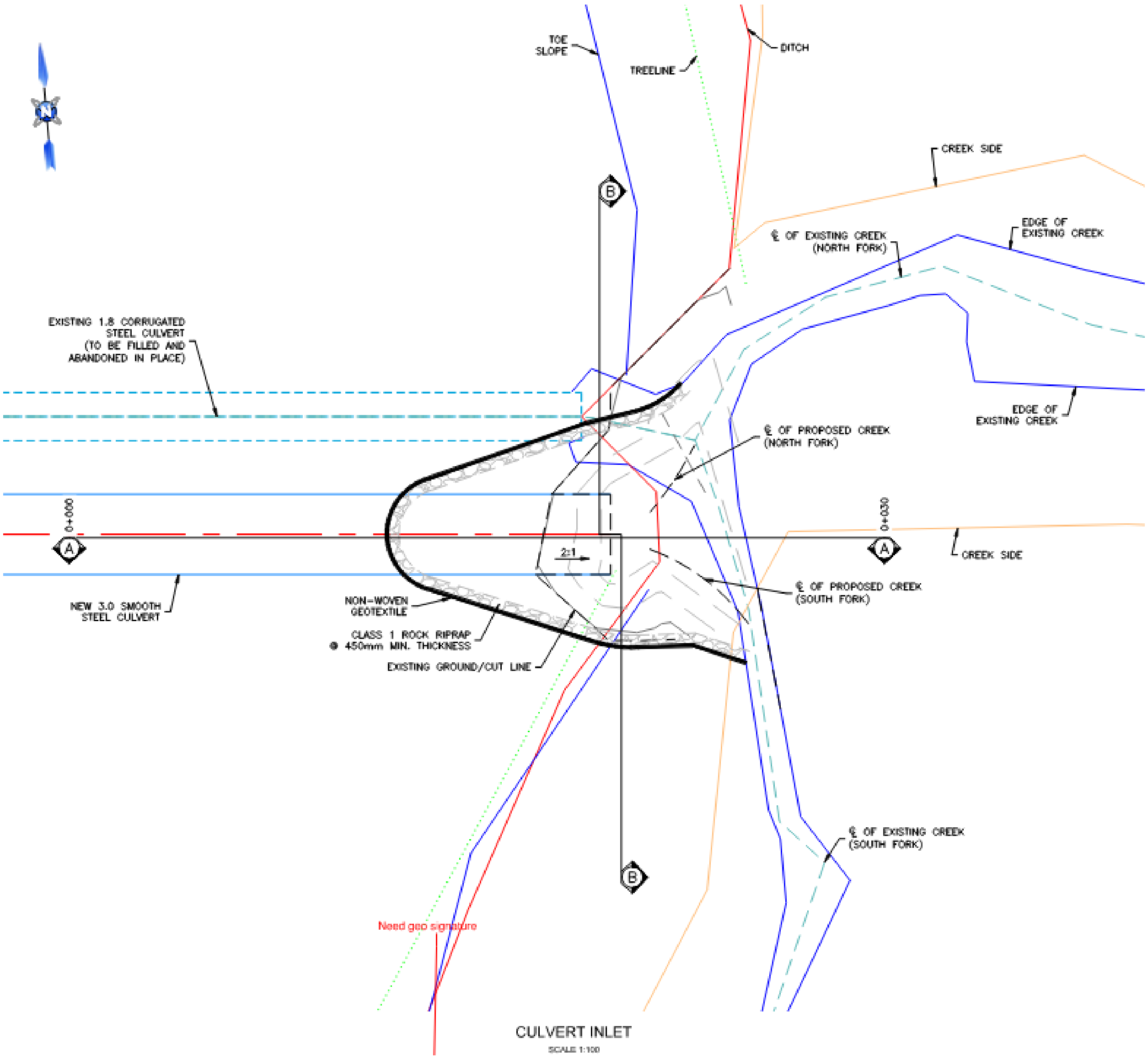


Figure 6 Inlet Plan View

From the hydraulic modelling, the culvert is inlet controlled with the headwater being just below the top of the culverts for the flood discharge. To accommodate potential ice and debris impacting the culvert hydraulics, the rock rip rap will be extended to the top of the culvert.

Compaction specifications for the new culverts have been included on the design drawings. Environmental remediation measures will be installed as part of the construction to minimize siltation and degradation of the area immediately surrounding the culvert inlet and outlet.

Outlet Design

As indicated in Figure 7 Outlet Plan View the main channel originally flows into a pool from the culvert outlet. This pool is the result of a beaver dam just downstream from the outlet. As part of the culvert outlet design, this beaver dam will be removed to streamline flow conditions and promote fish passage.

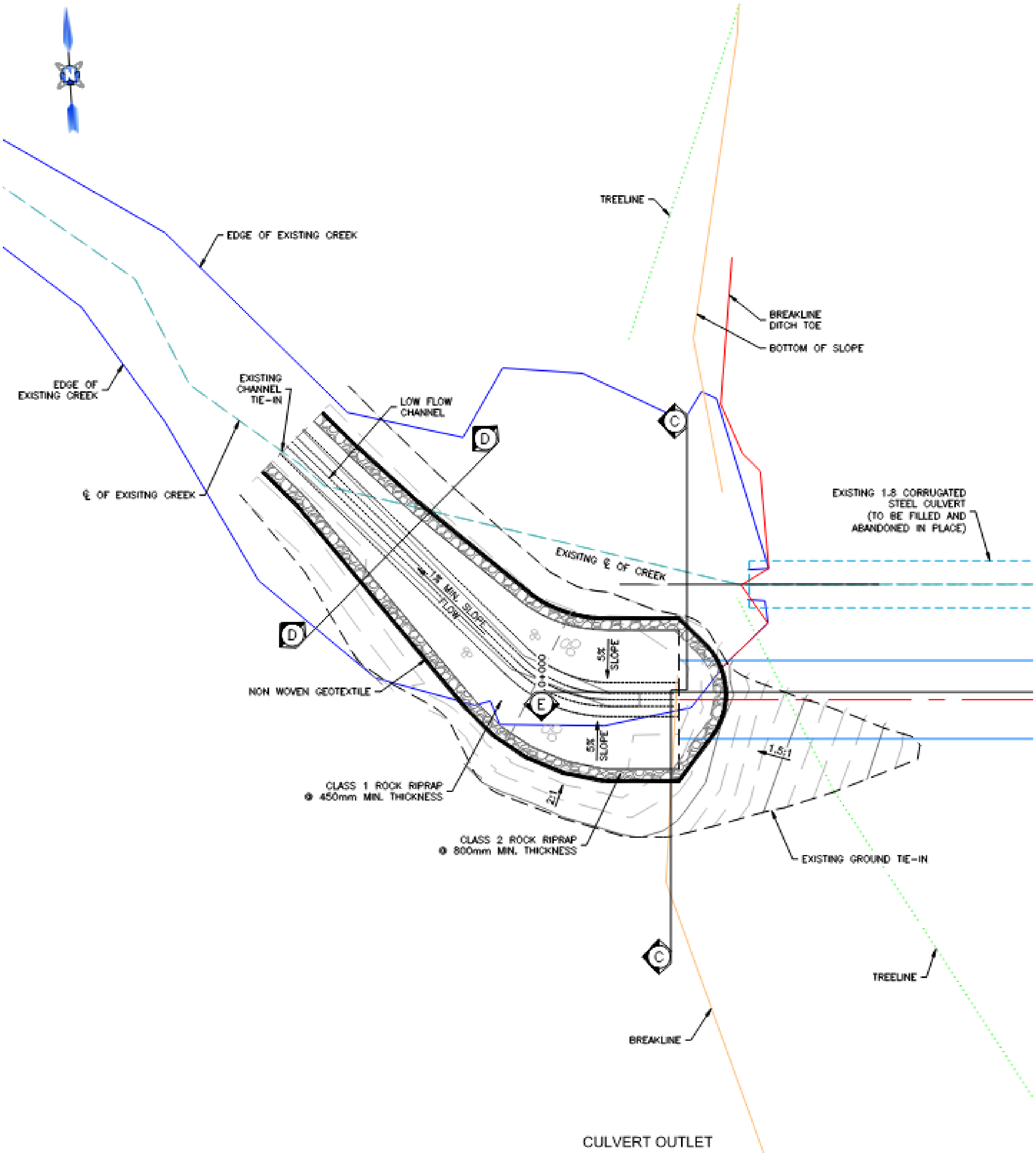


Figure 7 Outlet Plan View

The new 3.0 m culvert will be bored approximately 4.4 m center-to centre away from the existing 1.8 m culvert in an area that presently comprised of a large side slope. The 3.0 m culvert will be bored from the inlet to the outlet. As part of installation of the boring machine setup, the sidehill we be graded to a similar elevation and geometry as the outlet basin apron.

To dissipate the waterflow energy for large flood events and corresponding high velocities, a basin with Class 1 Rock Rip Rap underlain with a non-woven geotextile liner will be created. The Rock Rip Rap will encompass the basin walls at a slope of 2H:1V to the height of the 100-year flood event water level.

To accommodate fish passage in low flow conditions, the basin will be sloped to a low flow channel as indicated in Figure 7.

3.2 PIPE CONSIDERATIONS

3.2.1 Culvert Specifications

Table 5: Estimated Pipe Specifications

Diameter (m)	Grade (MPa)	Length (m)	Wall Thickness (mm)	Depth Under Highway(m)	Operating Pressure
3.0	290 (X42)	65.4..	25.4	10.6	Atmospheric

3.2.2 New Culvert Installation Stress Analysis

Table 6: Alignment Summary

Section #	From M.D. (m)	To M.D. (m)	Length (m)	Tangent Angle (°)	Curve Radius (m)	Notes
1	0	10	10	0	∞	Non-Lubricated
2	10	42	32	0	∞	Lubricated

Table 7: Friction Summary

Dynamic Case			
Section	Lubrication Friction Force Flb (kN)	Front Force Ff (kN)	Friction Between Pipe and Tunnel Wall (kN)
1	4.7	2216.4	160.1
2	21.6	2216.4	733.3
Static Case			
Section	Lubrication Friction Force Flb (kN)	Front Force Ff (kN)	Friction Between Pipe and Tunnel Wall (kN)
1	9.4	2216.4	320.2
2	43.2	2216.4	1466.7

Table 8: Jacking Force Summary

<table>
<tr><th colspan="5">Without Safety Factor</th><th rowspan="2">Equipment Specification Check</th></tr>
<tr><th>Section</th><th>Dynamic (kN)</th><th>Dynamic (lbf)</th><th>Static (kN)</th><th>Static (lbf)</th></tr>
<tr><td>1</td><td>2381</td><td>535148</td><td>2546</td><td>572191</td><td rowspan="3">Overall Maximum Expected Thrust Force (Tonne) = 517</td></tr>
<tr><td>2</td><td>3136</td><td>704805</td><td>4056</td><td>911505</td></tr>
<tr><td colspan="5"></td></tr>
<tr><th colspan="5">With Safety Factor</th><td>Recommended Min. Jacking Capabilities =</td></tr>
<tr><td></td><td>Dynamic SF= 1.5</td><td></td><td>Static SF = 1.25</td><td></td><td rowspan="4">700 Tons</td></tr>
<tr><th>Section</th><th>Dynamic (kN)</th><th>Dynamic (lbf)</th><th>Static (kN)</th><th>Static (lbf)</th></tr>
<tr><td>1</td><td>3572</td><td>539711</td><td>2207</td><td>496063</td></tr>
<tr><td>2</td><td>4704</td><td>1057208</td><td>5070</td><td>1139381</td></tr>
</table>

4 ENVIRONMENT AND REGULATORY

The detailed design and construction planning for the installation of the 3 m culvert and the decommissioning of the 2 m culvert considered potential environmental effects and regulatory requirements at the federal level through Fisheries and Oceans Canada, and the territorial level.

Over the past year there has been ongoing discussion amongst and between CCI, the GNWT and Fisheries and Oceans Canada (DFO) with regard to meeting the environmental requirements for a crossing pursuant to federal legislation, regulations and policy. CCI was retained by the GNWT to provide support for submitting additional information to complete a DFO Request for Review application for the project.

In support of the detailed design and construction planning, desktop assessments were completed to describe the fish community and fish habitat within the vicinity of the proposed project. An initial field assessment was undertaken to update available desktop information and to characterize fish habitat at the proposed project site. This work was carried out for the GNWT-INF by Stantec Consulting Ltd. (Stantec) and is documented in their *Fish Habitat Assessment for Crossing Structure Replacement: NWT Highway 8 (Dempster Highway) at KM 147.0* memo report (Stantec 2019).

These assessments formed the baseline for the environmental setting and fish and fish habitat for consideration and inclusion in the detailed design. Additional information was considered through the design process and site-specific characteristics of the project site were considered through the development of construction planning. This effort has culminated in the development of the Watercourse Crossing Environmental Protection Plan (WCEPP) (CCI 2022). The WCEPP provides the regulatory framework, baseline environmental and fish and fish habitat assessment information, the construction sequencing and the environmental mitigation to avoid and/or minimize potential environmental effects through the construction process. Supplemental drawings were developed to spatially present the construction sequencing from construction commencement through reclamation; please refer to drawing 2567-EG-0207-A.

5 CONSTRUCTION

5.1 NEW CULVERT INSTALLTION – OVERVIEW OF TRENCHLESS METHODOLOGY

Construction using a Tunnel Boring Machine (TBM), or an equivalent Excavator Boring Shield Machine (EBS) is a trenchless installation technique to install pipe(s) beneath the ground surface under road, existing utilities, rail and watercourses.

The launch and reception of the TBM is typically done from/to a shaft or pit constructed down lower than the alignment, this additional depth depends on the contractor’s equipment requirements.

Jacking or casing pipe for TBM style of installation can consist of reinforced concrete pipe (RCP), Steel where each joint must be welded to form a watertight seal, HOBAS reinforced fibreglass resin structure and Permalok steel with press fit joints. Vitrified clay jacking pipe can also be utilized but is not typically preferred within the industry for these diameters, lengths, and formations.

Jacking pipe is then placed behind the TBM in segments and is advanced along the proposed alignment, the press is moved back to allow for the next section of jacking pipe to be lowered on to the rails. As the machine is advanced the contractor will pump lubrication fluid through the pre-installed ports in the jacking pipe, this helps manage jacking forces and supports the soils around the tunnel wall.

The tooling at the face excavates the material and cuttings transported along a conveyor belt back to where the muck bucket and haul unit (figure 4) are situated. Once full, the haul unit is electrically driven along a pre-installed rail system to the launch pit / shaft. A piece of lifting equipment then removes the muck bucket form the pit and unloads to the cuttings on surface before the bucket is lowered back onto the rail system and shuttled back to the conveyor belt.

Once the machine punched out into the receiving pit / shaft is can be removed using an appropriately rated equipment, leaving the casing / carrier pipe in situ. The lubrication and grout ports are then used to pump a flowable grout in the annular space to restrain the casing / carrier pipe within the formation. Any ports added into the casing pipe for pumping of grout or lubrication can be welded closed to prevent migration of ground water into the pipe.

5.1.1 Tunnel Boring Machine

5.1.1.1 Diameters and Sizing

The TBM comes in a range of sizes between 1219.1mm (48”) to 4267mm (168”), customs sizes are available from the manufacture upon request. The overcut for these machines typically is 0.75” radially.

Figure 8. Tunnel Boring Machine

5.1.1.2 Excavator Boring Shield (EBS) Face Support & Excavation

The native material at the face that is being excavated can be supported using the hydraulically operated sand shields, these sand shields prevent excessive material from sluffing in causing over excavation. This style of TBM works best in sand, medium to stiff clay, dry or dewatered soil and weather rock in regions without groundwater present. The excavator backhoe claw has a full range of motion connected to the EX-50 boom and can reach beyond the face of the bore to remove or breakup material before they are carried by the conveyor system.

Figure 9. Tunnel Boring Machine Showing Shields and Excavator "Claw"

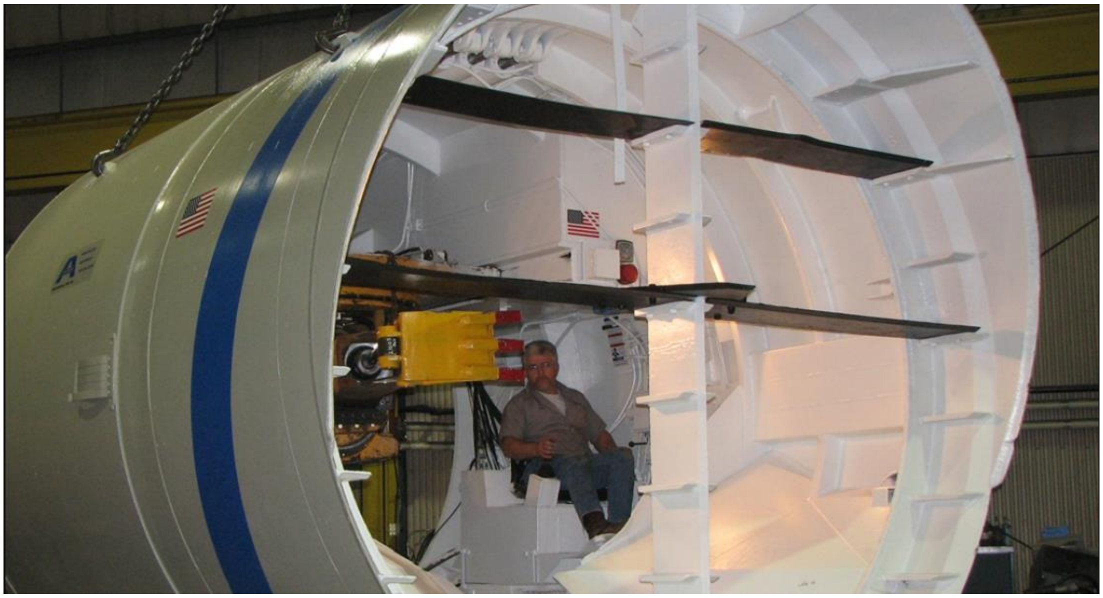


Figure 10. Tunnel Boring Machine Showing Internal View

5.1.1.3 TBM – Face Support and Excavation

5.1.2 The Press or Keyhole Jacking Frame

The equipment that provides the jacking forces through the extension of hydraulic cylinders, once fully extended they retract to allow the next section of pipe to be lowered into place. The keyhole jacking frame is typically used for pipe installation diameters above 96” and have the jacking capacity of between 400 to 1200 tonnes for force.

The jacking fame is welded to a surveyed and leveled rig mat, fine tuning can me managed with the threaded puck feet.

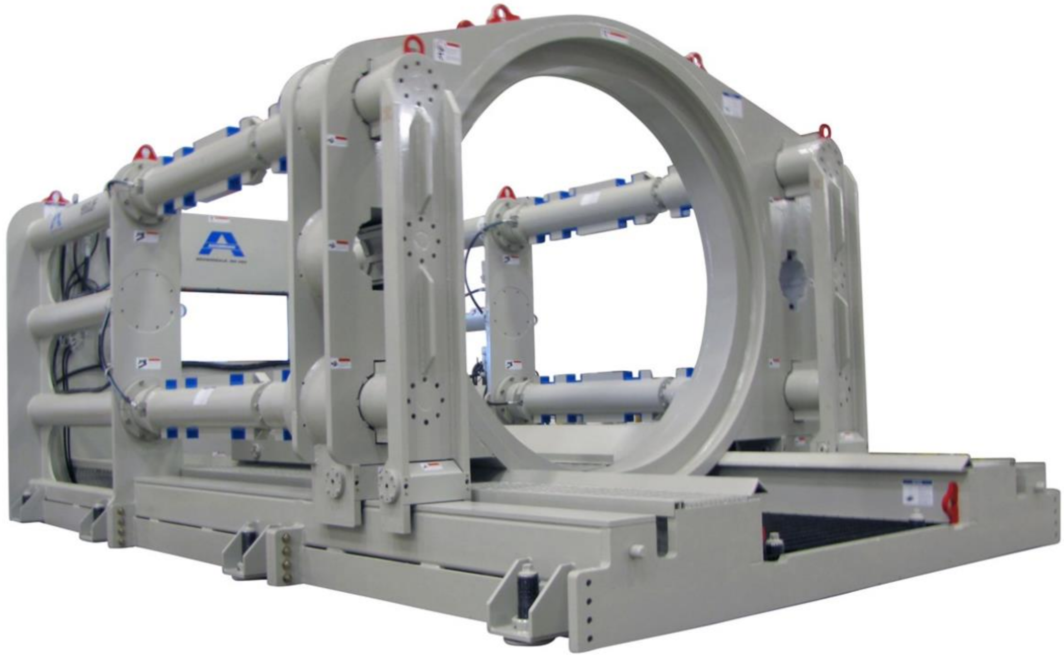


Figure 11. Keyhole Jacking Frame

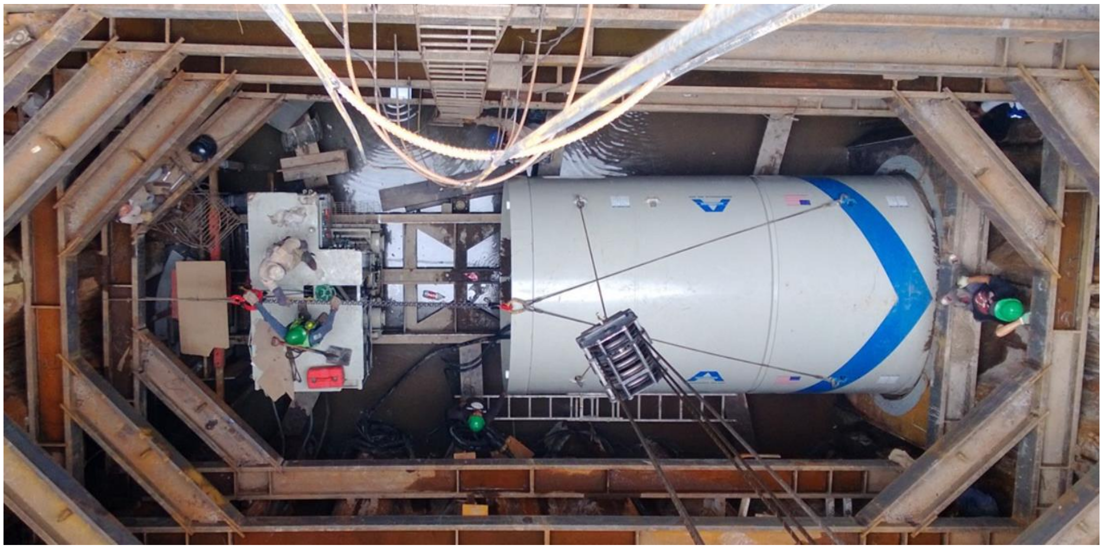


Figure 12. 5200 Press Unit Setup on Rails

5.1.3 Guidance Control

The EBS is steered by the operator situated close to the face of the machine, the operator is referencing a laser that is shot along the alignment from the launch pit to a target at the face. The laser is housed in a protective box which has its own standalone footings, this is surveyed in and confirmed with a laser level. A stringline will be surveyed in and run across the top of the launch pit this is a manual check the laser alignment before and periodic throughout the drive.

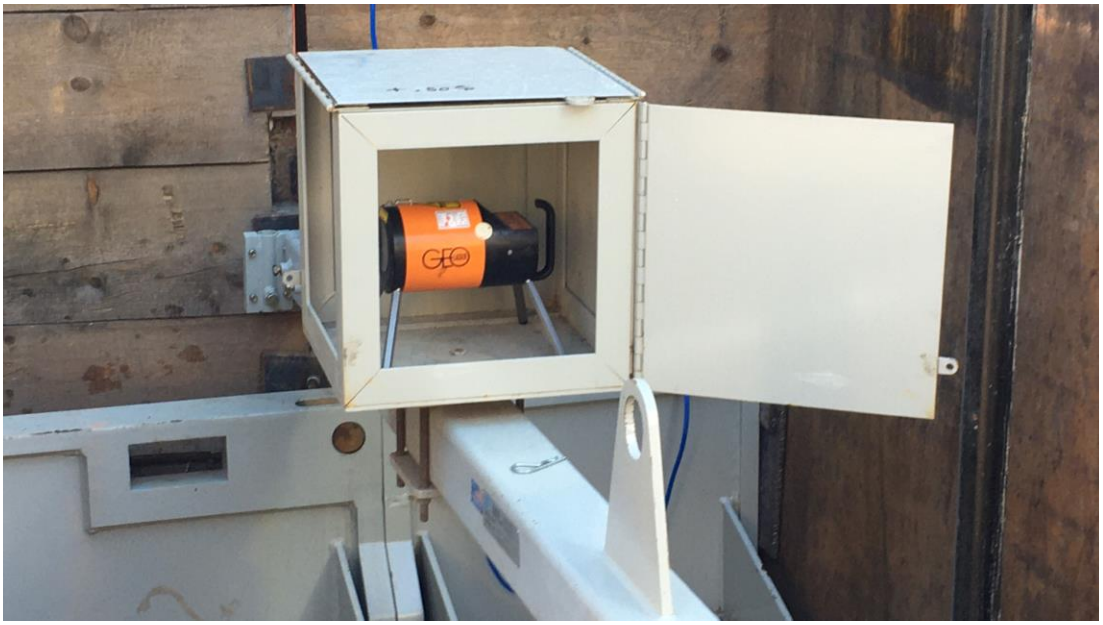


Figure 13. Geo Laser KL-91L

5.1.4 Haul Unit & Muck Bucket

Cuttings are transported from the face to the muck bucket using a conveyor belt suspended from the roof of the EBS. Once the muck bucket is full the haul unit is electrically operated and travels along the installed rail system to bring the cuttings into the launch pit. A crane of piece of lifting equipment the lifts the muck bucket to surface where is it emptied out. The empty muck bucket is then lowered back down onto the haul unit and returns to the EBS so tunnelling can resume.

Figure 14. Muck Bucket and 1548 Haul Unit

CCI has prepared drawings to show each phase of construction.

- Phase I, II and III(Drawing 2567-EG-0206)
  - Phase I Dam Removal
  - Phase II Culvert Installation Site Preparation
- Phase IV, V & Notes (Drawing 2567-EG-107)
  - Phase III New Culvert Installation
  - Phase IV Grouting
  - Phase V Final Reclamation

6 NEW CULVERT INSTALLATION EXECUTION

6.1 DAM REMOVAL – PHASE I

Prior to culvert installation, the beaver dam on the outlet sideof the culvert must be removed to facilitate apron construction as well as reclamation efforts.

The dam shall be removed implementing the procedure and mitigation presented in Department of Fisheries and Oceans Canada (DFO) interim code of practice: Beaver Dam Removal

Detailed steps for beaver dam removal can be found in CCI IFP drawing 2567-EG-0207.

6.2 SITE PREPARATION – PHASE II

Access to tunneling area on both downstream and upstream sides of the culvert installation will be constructed as per the construction drawing package.

- Culvert Installation (Drawing 2567-EG-0201)
- Culvert Installation Notes (Drawing 2567-EG-0202)

With reference to the site layout requirements and detailed drawings, the area will be graded level and flat to allow for equipment to be spotted safely into place before the contractor mobilizes the equipment to site.

Construction is targeted to be completed during the fall/winter months for an anticipated reduced flow in the watercourse which will save time, cost, environmental and safety associated to this water control.

The contractor should utilize the existing culvert to isolate the water flow during the new installation.

A traffic management plan should be developed to allow the contractor to safely mobilize their equipment to prepare the site prior to the trenchless installation. The highway must remain open during all phases of construction.

6.2.1 Mobilization

The contractor will mobilize all necessary from their yard to the provided laydown yard close to the construction site. Equipment will be cleaned and inspected before being transported to site.

6.3 INSTALLATION – PHASE III

The installation will be completed using machine able to excavate along the alignment within the specification that will be outlined within the Issues for Construction (IFC) engineering drawing.

The contractor will provide a jacking unit that provides sufficient jacking force to successfully install the steel pipe. The jacking frame will be secured via an engineered anchoring plan that is able withstand the forces that the jacking unit will apply (including a safety factor) during the installation.

6.4 GROUTING – PHASE IV

The annular space between the tunnel wall and the new culvert pipe will need to be grouted to mitigate short term settlement and ensure the culvert is restrained in place for its lifecycle.

Before the grouting contractor is mobilized to site, the ends of the overcut will be sealed off with a quick set grout using formwork, this will then be capped with clay to provide additional support. The contractor will then use the pre-installed grout ports to pump a flowable grout mixture from the inside of the tunnel into the overcut, the contractor will follow their preapproved execution plan which will outline sequencing and pressures.

Grout samples should be collected so they can be tested after the full cure cycle has been completed to verify the strength.

6.4.1 Demobilization

The contractor will clean the site and remove all equipment back to the laydown yard before demobilizing full to their company base.

6.5 FINAL RECLAMATION – PHASE V

Site reclamation will commence once the trenchless installations and grouting activities are complete.

Final grade and contouring shall be completed as per the design drawing to ensure the inlet area channels water directly into the culverts. Clean riprap is placed to mitigate scour, stabilize the bank and promote aquatic habitat.

The outlet area design incorporates a large armoured pool, downstream of the culverts that provides scour mitigation and an opportunity for fish to rest prior to swimming upstream through the culverts.

Willow staking on the watercourse banks will be placed to stabilize the disturbed areas and provide shade cover for aquatic species. Silt fencing will be installed to avoid the potential soil movement and runoff into the water. The disturbed areas will be seeded to promote vegetation regrowth and root-mat.

7 SUMMARY

A new culvert is required to provide increased flow potential at Km 147.0 and is planned to be completed by trenchless methodologies to reduce the construction disturbance to the highway traffic and community. Construction will commence late summer with civil works, pad preparation and stream isolation. The installation of the new 3m culvert will be completed by a tunneling machine, advancing from launch to receiving point with welded segments of smooth steel pipe. The steel culvert will be grouted in place.

The existing culvert will be decommissioned and grouted in place.

Inlet and outlet pools will be sized and armoured to dissipate flow energy, reclaim the past flooded area and provide an improved aquatic habitat.

8 REFERENCE DOCUMENTS

1. This report is based on the following HDD design drawings.

Type	Drawing Number
Culvert Installation	2567-EG-0201
Construction Notes	2567-EG-0202
Inlet Details	2567-EG-0203
Outlet	2567-EG-0204
Hydrotechnical Notes and Liner	2567-EG-0205
Phase I & II	2567-EG-0206
Phase III & Notes	2567-EG-0207
Phase Profiles	2567-EG-0208

2. White Bear Geomatics Ltd: "*Survey of Creek Crossing at 67 29'01"N, 133 46'01"W, Near Tsiigehchic, NT.*

3. Geotechnical Report: Tetra Tech Project No.: ENG.YARC03234-01 "*Geotechnical Investigation of Existing Culverts" Boreholes BH-08 and BH-09*

4. Stantec Consulting Ltd. Hydrotechnical Assessment: *"Dempster Highway KM 147 Creek Hydrotechnical Assessment"* Document No.: 144930112

APPENDIX A – LOCATION SURVEY

SURVEY OF CREEK CROSSING AT 67°29'01"N, 133°46'01"W, NEAR TSIIGEHCHIC, NT.

DATA COLLECTED ON JULY 4, 2018

COORDINATES ARE NAD83 CSRS (2010.0), UTM ZONE 8
HEIGHTS ARE CGG 2013
LOCAL SCALE FACTOR: 0.99963027
UNITS ARE METRES

CONTROL MONUMENT - REBAR ●

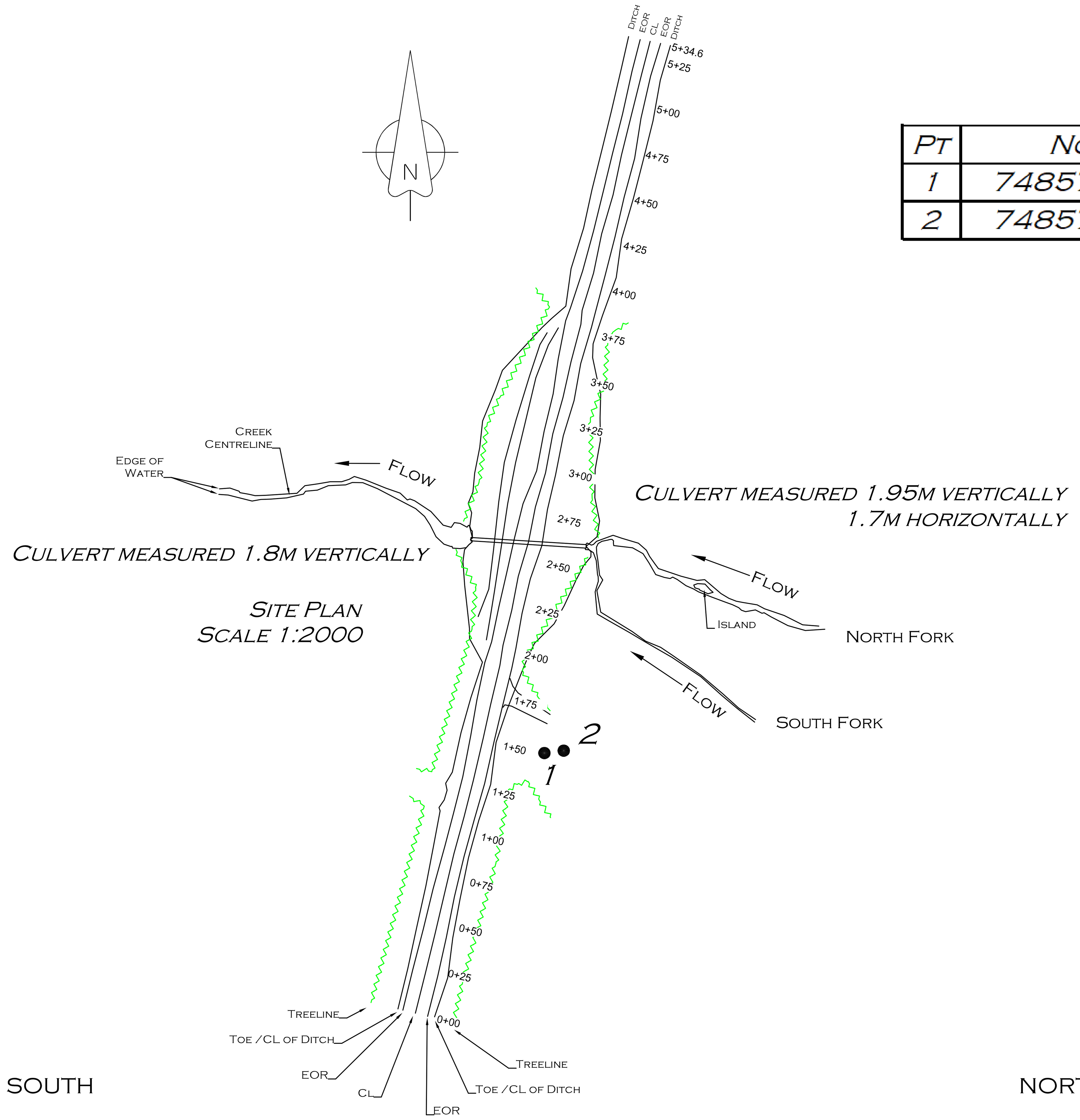
NOTES:

WATER LEVEL AT TOP OF BANK DURING TIME OF SURVEY

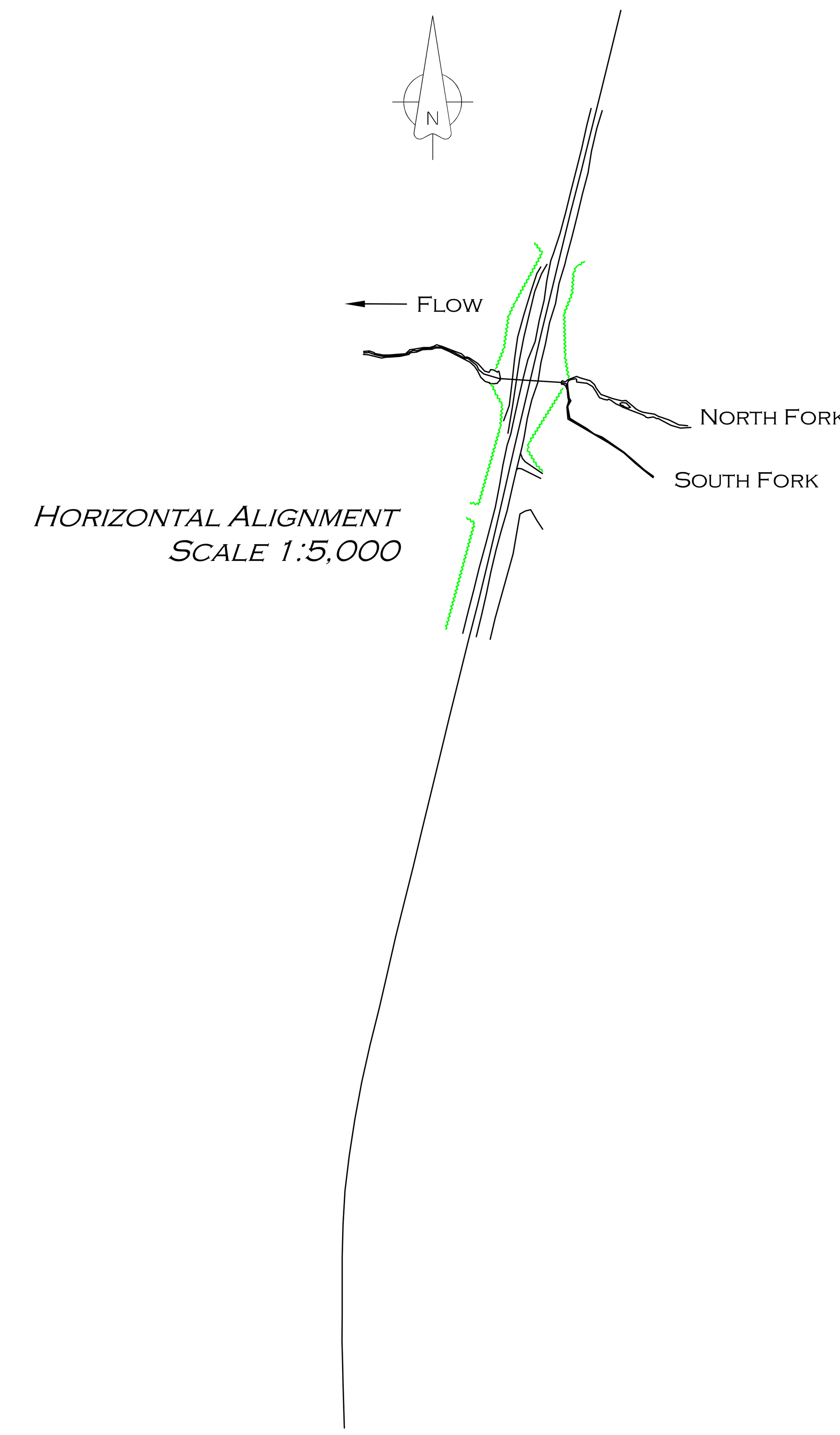
EOR - EDGE OF ROAD - DETERMINED BY EXTENT OF DRIVABLE SURFACE
CL - ROAD CENTRELINE
DITCH - TOE OF DITCH OR LOWEST POINT

SURVEY CONTROL STATIONS:

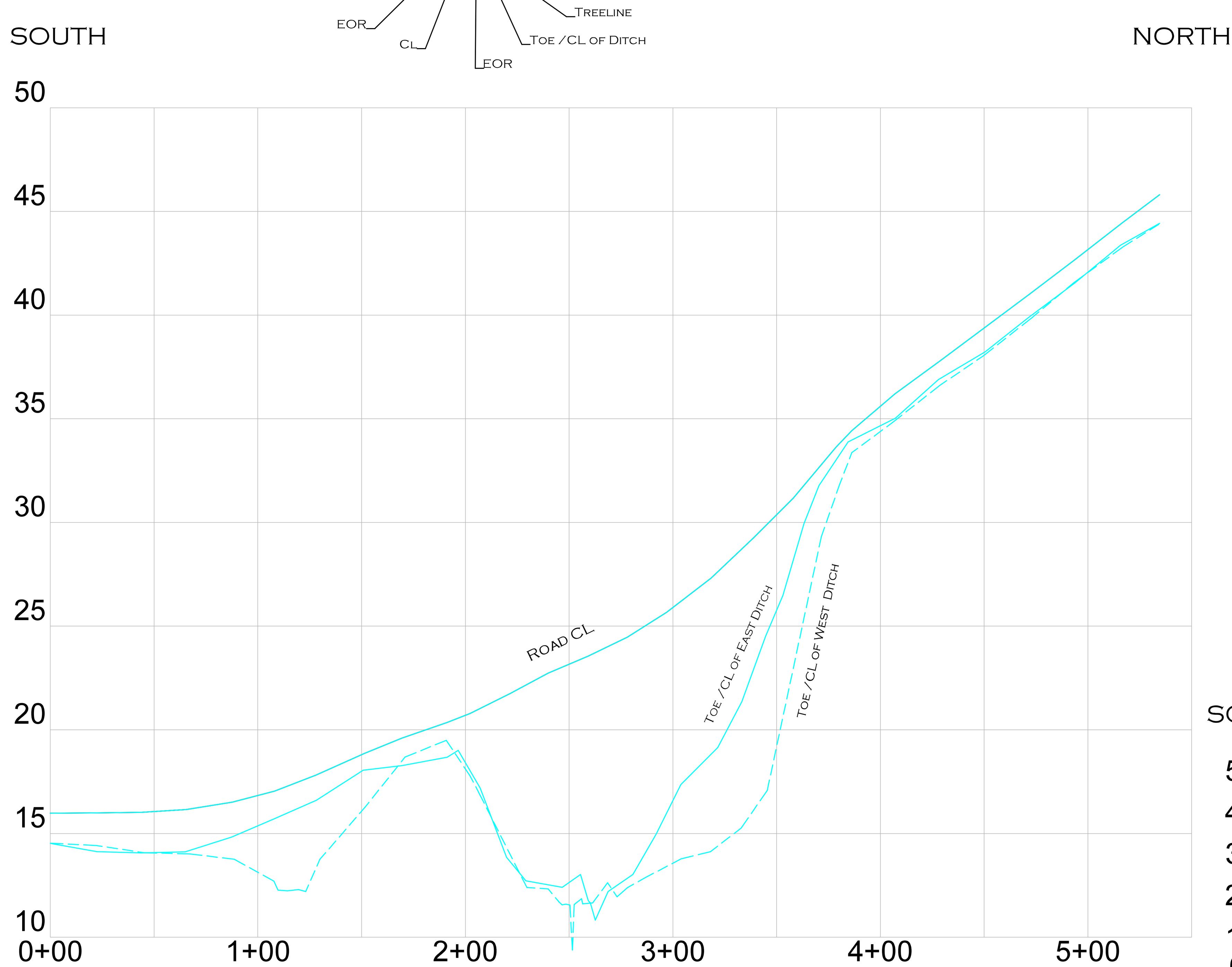
PT	NORTH	EAST	HEIGHT
1	7485720.026	552699.324	25.342
2	7485721.301	552709.504	25.639



SITE PLAN
SCALE 1:2000



HORIZONTAL ALIGNMENT
SCALE 1:5,000



ROAD PROFILE
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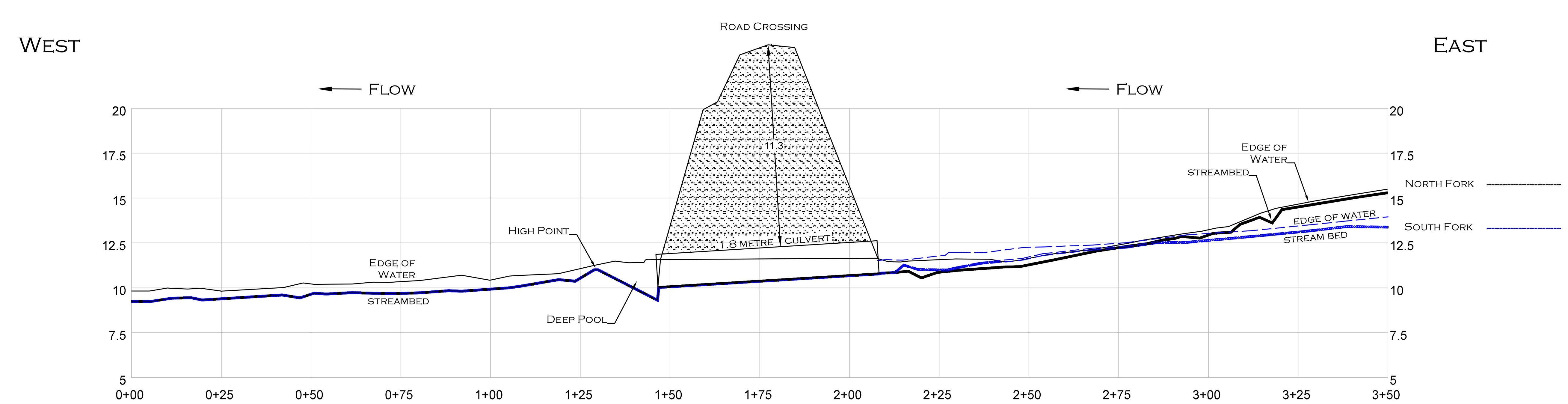
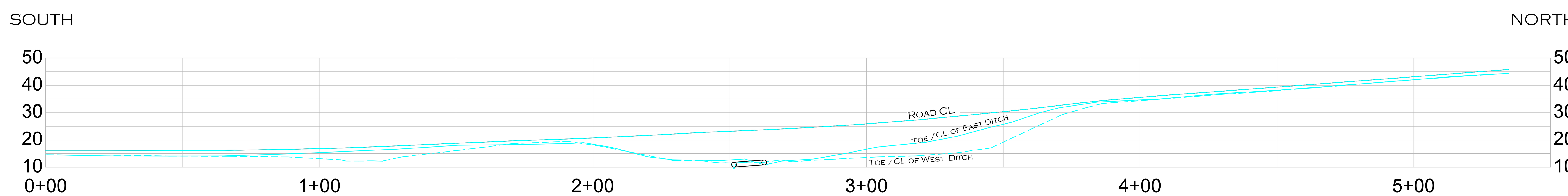
VERTICAL SCALE: 1:200



STREAM PROFILE
HORIZONTAL SCALE: 1:1000
VERTICAL SCALE: 1:200



NATURAL SCALE PROFILE
HORIZONTAL SCALE: 1:1000
VERTICAL SCALE: 1:1000

WHITE BEAR GEOMATICS LTD.
WWW.WHITEBEARGEO.COM
867-688-4442 (OFFICE)
403-580-9398 (CELL)

REV: 0
FILE: 18-209.DWG
DATE: 2018 JULY 12

APPENDIX B – GEOTECHNICAL REPORT

Water

Department of Transportation – Structures Section
Highway and Marine Services Division
Government of Northwest Territories

Hydrotechnical Analysis-Culverts Assessment

Prepared by:

AECOM Canada Ltd.
17007 – 107th Avenue, Edmonton, AB, Canada T5S 1G3
T 780.486.7000 F 780.486.7070 www.aecom.com

Project Number:
60143840

Date:
January, 2010

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("Consultant") for the benefit of the client ("Client") in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the "Agreement").

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- are subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations")
- represent Consultant's professional judgement in light of the Limitations and industry standards for the preparation of similar reports
- may be based on information provided to Consultant which has not been independently verified
- have not been updated since the date of issuance of the Report and their accuracy is limited to the time period and circumstances in which they were collected, processed, made or issued
- must be read as a whole and sections thereof should not be read out of such context
- were prepared for the specific purposes described in the Report and the Agreement
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- in the case of subsurface, environmental or geotechnical conditions, is not responsible for variability in such conditions geographically or over time

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- for use by governmental reviewing agencies

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This Statement of Qualifications and Limitations is attached to and forms part of the Report.

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780 486 7000 tel
780 486 7070 fax

January 19, 2009

Sean Smiley, Project Officer
Department of Transportation - Structures Section
Highways & Marine Services Division
Government of the Northwest Territories
P.O. Box 1320
Yellowknife NT X1A 2L9

Dear Sean:

Project No: **060143840**

Regarding: Hydrotechnical Analysis Culverts Assessment

We are please to submit the final report of the hydrotechnical analysis and culverts assessment for culverts in Northwest Territories.

If you have any questions or require any further information, please call.

Sincerely,
AECOM Canada Ltd.

Marcel Chichak, P.Eng.
Senior Water Resources Engineer
Marcel.Chichal@aecom.com
FN:sw
Encl.

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
0	Farzad Nader	December 16, 2009	Draft
1	Farzad Nader	January 18, 2010	Final

AECOM Signatures

Report Prepared By:

Farzad Nader, P.Eng.

Report Reviewed By:

Michel Lanteigne, P.Eng.

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1. Introduction

The Department of Transportation of Northwest Territories requested that AECOM carry out a hydrotechnical assessment to recommend appropriate sizes and the number of culverts for the following existing culvert crossings as presented in Table 1.1:

Table 1.1: Existing Culverts Crossing

Culvert Size and type	Culvert Length (m)	Location-highway	Km	Latitude and Longitude
2-2560×1850 mm arch culverts	23.51	Highway 5	25.6	N 60° 44.005′ W115° 24.0672′
2-3600×2400 mm arch culverts	28.16	Highway 5	31.0	N 60° 43.781′ W115° 18.354′
2100×1500 mm arch culvert	24.22	Highway 5	52.7	N 60° 10.403′ W113° 42.286′
2100×1500 mm arch culvert	23.28	Hay River Reserve Road	12.4	N 60° 50.679′ W115° 43.807′
1830 mm CSP culvert	60.0	Highway 8	146.8	N 60° 29.028′ W115° 46.011′
1500 mm CSP culvert	24.82	Highway 8	209.4	N 60° 59.202′ W115° 27.783′

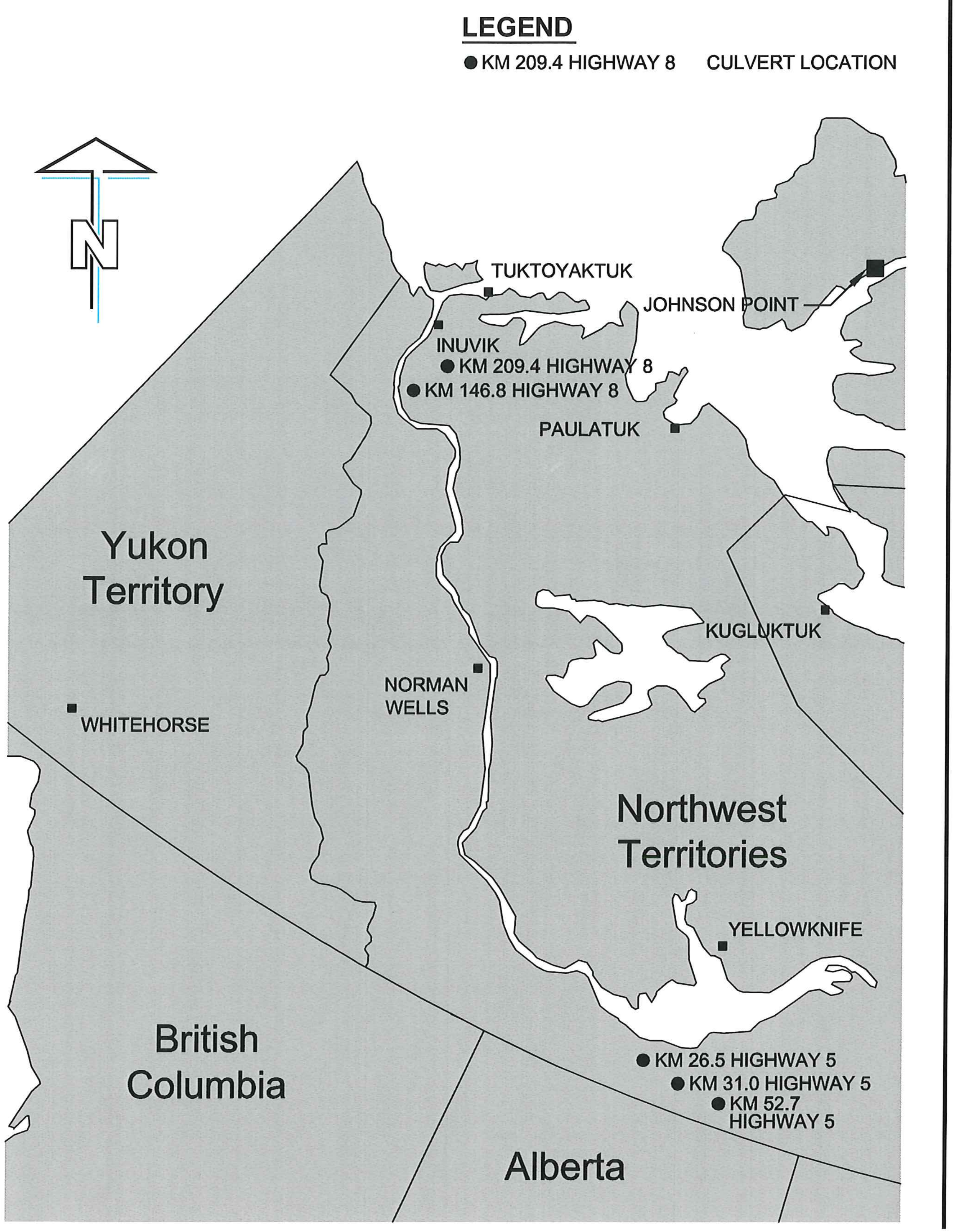
Culverts locations are shown in Figure 1.1.

A hydrologic and hydraulic analysis was completed for culvert crossings to determine the size and the number of culverts that should be installed to be able to convey the required peak flow, without exceeding fish passage velocity design criteria.

The information and recommendations provided herein are based on site information provided by the Department of Transportation, which included:

1. Description and size of existing structures;
2. Photographs;
3. Survey of the road and sideslopes;

Survey information of the creek bed upstream and downstream of the structures has not been provided for any of the sites. We understand that this information is not available at this time.



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Department of Transportation Government of NWT
Hydrotechnical Analysis-Culverts Assessment

AECOM

Culvert Location
Figure 1.1

2. Hydrological Analysis

Topographic maps (1:50,000 scale NTS maps) were used to determine the drainage area for the culvert crossings. The drainage area for each culvert crossing was delineated and presented in Table 2.1.

Table 2.1: Drainage Area for Existing Culvert Crossings

Culvert Location	Drainage Area (km^2)
Km 25.6 of Highway No.5 (2-2560×1850 mm arch culverts)	204.6
Km 31.0 of Highway No.5 (2-3600×2400 mm arch culverts)	112.7
Km 52.7 of Highway No.5 (2100×1500 mm arch culvert)	363.1
Km 12.4 of Hay River Reserve Access Road (2100×1500 mm arch culvert)	14.2
Km 146.8 of Highway No.8 (1830 mm CSP culvert)	20.0
Km 209.4 of Highway No.8 (1500 mm CSP culvert)	7.0

Culvert Locations and delineated drainage area for each culvert crossing is shown in Figures 2.1 to 2.5.

2.1 WSC stream gauges:

There are several WSC (Water Survey Canada) stream gauges in the region. Six stations of the existing WSC stations in the region, with drainage areas between 3,330 km^2 and 51,700 km^2 were originally selected, based on the proximity to the culvert crossings on Highway No. 5 and the culvert crossing the Hay River reserve access road.

Likewise, for culvert crossings on Highway No. 8, three WSC stations with drainage areas of 28.2 km^2 and 1,300 km^2 were selected.

The details of the stations considered for this study are listed in Table 2.2.

Table 2.2: WSC Stations Selected for Hydrological Analysis

Region	WSC ID	WSC Name	Latitude and Longitude	Drainage Area (km^2)	Period of Record	Years of Data (Maximum Instantaneous/ Maximum Daily Discharge)
Highway No. 5 and hay River Region	07OB001	HAY RIVER NEAR HAY RIVER	N 60°44'41" W 115°51'35"	51,700	1963-2008	11/42
	07OB002	GREAT SLAVE LAKE AT HAY RIVER	N 60°51'0" W 115°47'59"	15,900	1959-2008	17/27
	07PA001	BUFFALO RIVER AT HIGHWAY NO. 5	N 60°42'44" W 114°54'11"	18,500	1969-1990	18/22
	07PA002	WHITESAND RIVER NEAR ALTA/NWT BOUNDARY	N 60°0'17" W 115°34'44	3,410	1986-1994	4/8
	07PC001	BUFFALO RIVER NEAR ALTA/NWT BOUNDARY	N 60°0'49" W 114°31'32"	4,350	1987-1994	6/7
	07PB002	LITTLE BUFFALO RIVER BELOW HIGHWAY NO. 5	N 60°3'1" W 112°41'52"	3,330	1965-1994	10/27
Highway No. 8 Region	10LC007	CARIBOU CREEK ABOVE HIGHWAY NO. 8 (DEMPSTER HIGHWAY)	N 68°5'22" W 133°29'24"	590	1975 - 2008	9/33
	10LC003	RENGLENG RIVER BELOW HIGHWAY NO. 8 (DEMPSTER HIGHWAY)	N 67°45'21" W 133°50'39"	1,300	1973 - 2008	17/32
	10LC017	BOOT CREEK NEAR INUVIK	N 68°21'40" W133°38'38"	28.2	1981-1990	10/17

2.2 Computing Missing Hydrological Data

The WSC discharge data for the selected stations were extracted from EC's (Environment Canada's) website. After reviewing the maximum instantaneous and maximum daily discharge data for each station, station with WSC ID 07OB002 was eliminated because the maximum instantaneous discharge was constant (157 m^3/s) in all available years of data, therefore the information from this station is considered un-reliable. Stations with WSC ID 07PA002 and 07PC001 were also eliminated due to the lack of compatibility with other stations.

To estimate the data gaps, two methods were used for obtaining values for maximum instantaneous discharge and maximum daily data. In the first method, a best fit linear relationship between the reported maximum daily and maximum instantaneous discharge was developed. The maximum instantaneous discharges were then calculated from the relationship and added to the discharge data table for that station.

In the second method, using HEC REGFQ (Regional Frequency Analysis), the USARMY corps of engineering software, the statistics of annual maximum hydrologic events that are necessary for a regional frequency study were computed. Missing events were regenerated so that complete sets of events are obtained for all years at all stations while preserving all intercorrelations. Considering all stations together (stations in the same region), missing maximum instantaneous or maximum daily flows were estimated by correlation with corresponding flows at other stations and the flow at the same station for the adjacent duration. When all flows have been reconstituted, the mean and standard deviation for each station and duration were recomputed by the software. Regenerating the data for all stations equivalent to the station with longest set of data is considered to constitute some advantages over basic linear regression.

2.3 Flood Frequency Analysis

After calculating and regenerating missing data the maximum instantaneous discharges was analyzed using EC's CFA 3.1 (Consolidated Frequency Analysis Package Version 3.1).

Using CFA, the maximum instantaneous discharges were analyzed using Generalized Extreme Value (GEV), Three-Parameter Log-Normal Distribution (3PLN), Log-Pearson Type III (LP3) and Wakeby distributions. The fit to each distribution was visually assessed and the distribution that was deemed to fit the data best was selected. The results of the flood frequency analysis for WSC stations in Highway No.5 region are summarized in Table 2.3. For WSC stations in Highway No.8 region, the flood frequency analyses are summarized in Table 2.4.

Table 2.3: Frequency Flood Analysis for WSC Stations in Highway No.5 Region

WCS ID	Selected Distribution	Drainage Area km²	Discharge (m^3/s) for Return Period (years)					
			5	10	20	50	100	200
07OB001	Wakeby	51,700	952	1,120	1,270	1,450	1,570	1,670
07PA001	Wakeby	18,500	232	253	282	340	405	499
07PB002	LP3	3,330	25	35	49	73	98	130

Table 2.4: Frequency Flood Analysis for WSC Stations in Highway No.8 Region

WCS ID	Selected Distribution	Area km²	Discharge (m^3/s) for Return Period (years)					
			5	10	20	50	100	200
10LC003	GEV	1,300	70	93	119	161	200	246
10LC007	3PLN	590	46	62	78	102	123	145
10LC007	GEV	28.2	3	4	5	6	8	10

To assess the consistency in runoff rate between the different drainage basins, the unit discharge was calculated for each frequency and station. The calculated unit discharges for stations in the Highway No.5 region and stations in highway No. 8 region are summarized in Table 2.5 and 2.6 respectively.

Table 2.5: Frequency Unit Discharge for WSC Stations in Highway No. 5 Region

WCS ID	*Unit Runoff [m^3/s per km²] for Return Period (Years)*					
	5	10	20	50	100	200
07OB001	0.02	0.02	0.02	0.03	0.03	0.03
07PA001	0.01	0.01	0.02	0.02	0.02	0.03
07PB002	0.01	0.01	0.01	0.02	0.03	0.04

Table 2.6: Frequency Unit Discharge for WSC Stations in Highway No. 8 Region

WCS ID	Unit Runoff [m^3/s per km²] for Return Period (Years)					
	5	10	20	50	100	200
10LC003	0.05	0.07	0.09	0.12	0.15	0.19
10LC007	0.08	0.10	0.13	0.17	0.21	0.25
10LC017	0.10	0.13	0.16	0.22	0.28	0.34

The results show very good consistency in runoff rate between different stations for both regions. Unit runoff for stations in the Highway No.8 region is up to 10 times greater than unit runoff generated in the Highway No.5 region.

2.4 Regional Analysis

The regional analysis usually consists of a regression analysis of flood frequency and drainage area for the different stations in the region, from which the flood frequency for another drainage area can be estimated.

For estimating the design discharge for culverts crossing Highway No. 5 and the culvert crossing the Hay River reserve access road, the power equations for the different frequency floods Q_N (m^3/s) versus drainage area A (km^2) were determined from the flood frequency analysis for stations located in the Highway No. 5 Region. The resulting regional flood frequency equations and their coefficient of determination (R^2) are as follows:

$Q_{5\text{-Year}} = 0.0005 \times A^{1.329}$ $R^2 = 0.99$
$Q_{10\text{-Year}} = 0.0013 \times A^{1.2513}$ $R^2 = 0.99$
$Q_{20\text{-Year}} = 0.0033 \times A^{1.173}$ $R^2 = 0.99$
$Q_{50\text{-Year}} = 0.0114 \times A^{1.0707}$ $R^2 = 0.98$
$Q_{100\text{-Year}} = 0.0288 \times A^{0.993}$ $R^2 = 0.98$

Likewise, for estimating the design discharge for culverts crossing Highway No. 8, the power equations for the different flood frequency Q_N (m^3/s) versus drainage area A (km^2) were determined from the flood frequency analysis for stations located in the Highway No. 8 Region. The resulting regional flood frequency equations are as follows:

$Q_{5\text{-Year}} = 0.1488 \times A^{0.8751}$ $R^2 = 0.99$
$Q_{10\text{-Year}} = 0.1978 \times A^{0.8751}$ $R^2 = 0.99$
$Q_{20\text{-Year}} = 0.2579 \times A^{0.8721}$ $R^2 = 0.99$
$Q_{50\text{-Year}} = 0.3562 \times A^{0.8668}$ $R^2 = 0.99$
$Q_{100\text{-Year}} = 0.4504 \times A^{0.8622}$ $R^2 = 0.99$

2.5 Design Discharges

The following design criteria for determining the discharge flow for culvert crossings, as established by DOT and the Department of Fisheries and Oceans (DFO), were adopted for this study:

- Convey the 50 year return period flow with no road overtopping; and
- Use the 10 year return period flow to assess acceptable velocities for fish passage through the proposed culverts.

Table 2.7 presents the calculated peak flows for different return periods for the existing culvert crossing based on the frequency flood and regional analysis:

Table 2.7: Calculated Peak Flow for the Existing Culverts

Culvert Location	Drainage Area (km^2)	Instantaneous Peak Flow (m^3/s)				
		5 Year	10 Year	20 Year	50 Year	100 Year
Km 25.6 of Highway No.5 (2-2560×1850 mm arch culverts)	204.6	0.60	**1.1**	1.7	**3.4**	5.7
Km 31.0 of Highway No.5 (2-3600×2400 mm arch culverts)	112.7	0.30	**0.5**	0.9	**1.8**	3.2
Km 52.7 of Highway No.5 (2100×1500 mm arch culvert)	363.1	1.30	**2.1**	3.4	**6.3**	10.1
Km 12.4 of Hay River Reserve Access Road (2100×1500 mm arch culvert	14.2	0.02	**0.04**	0.10	**0.2**	0.5
Km 146.8 of Highway No.8 (1830 mm CSP culvert)	20.0	2.0	**2.7**	3.5	**4.8**	6.0
Km 209.4 of Highway No.8 (1500 mm CSP culvert)	7.0	0.8	**1.1**	1.4	**1.9**	2.4

2.6 Hydraulics

To determine the design criteria for fish passage, a fisheries assessment of the crossings is required to determine a target species. For the purpose of this study it is assumed that Northern Pike (Esox Lucius) are present. Northern Pikes, sometimes called jackfish, are found in most lakes and rivers in mainland Northwest Territories. Northern Pike ranges from 120 mm to 620 mm fork length for this study it was assumed that 500 mm fork length Northern Pike are present.

Based on the assumption that 500 mm Northern Pike are present the culvert crossing must be able to convey 10 year return period flow with a maximum velocity (Katopodis, 1992). The maximum velocity is different based on the length of the culverts. Figure 2.6 presents swimming distance curves for different fish lengths.

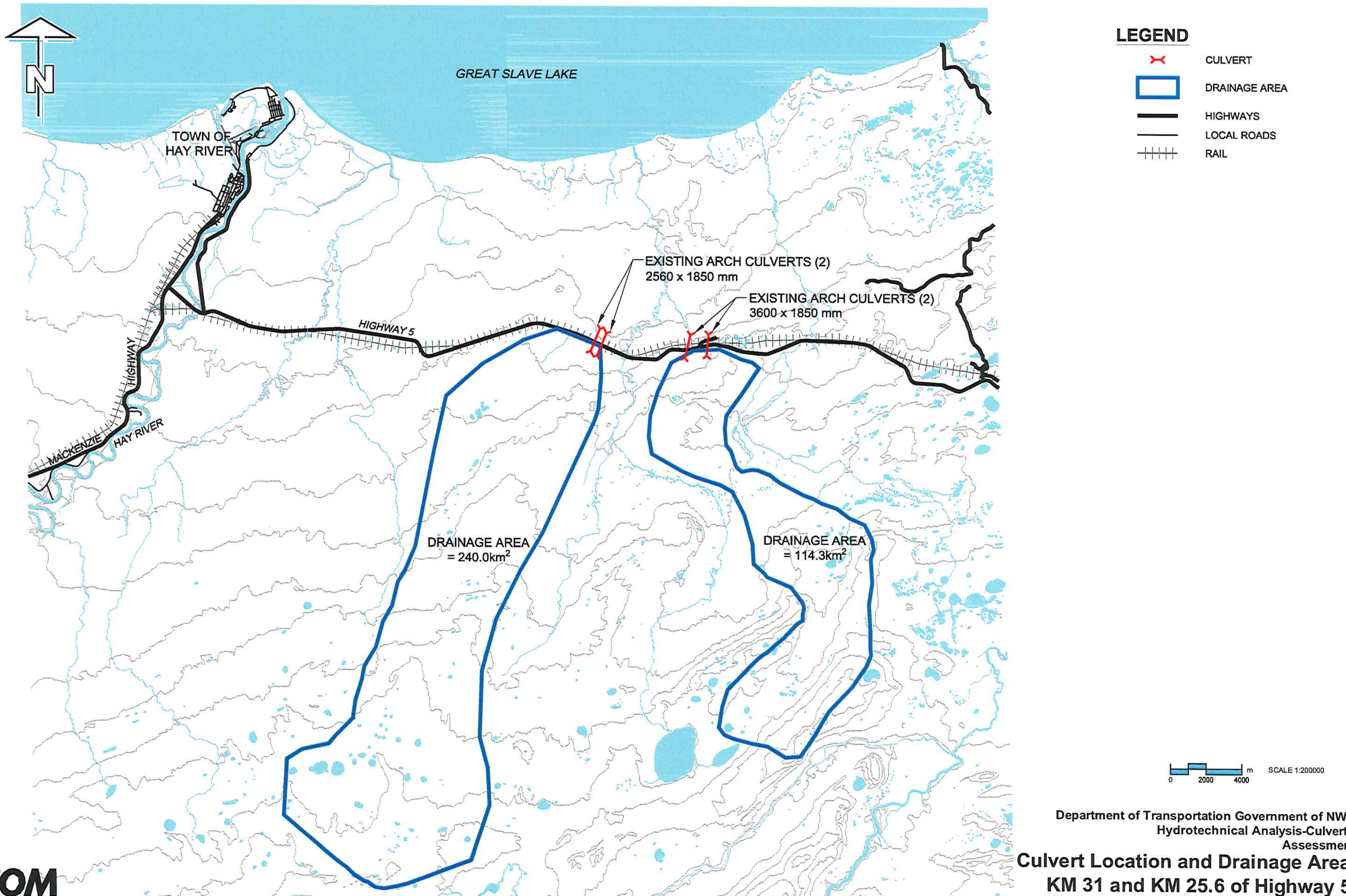
Preliminary culvert hydraulic analysis was performed using CulvertMaster. Drawings, including survey information for the existing crossing were obtained from DOT and used in hydraulic calculation. Based on the preliminary culvert design, the following options are recommended for size of the culverts as presented in Table 2.8.

In the absence of survey information of the creek profile, the grade across the road at culvert sites were estimated based on photographs and the survey of the road of the existing culverts. Actual site conditions may differ, particularly if the culverts have settled differentially over the years.

Table 2.8: Recommended Culvert Size

Culvert Location	Existing Culvert Size and Type	Maximum Velocity for Fish Passage (m/s)	Proposed Culvert Assuming Fish Are Present-Option A	Proposed Culvert Assuming Fish Are Present -Option B	Proposed Culvert Assuming Fish Are Not Present
Km 25.6 of Highway No.5	2-2560×1850 mm arch culverts	0.6	6.0 m Single Span Bridge	3890×2690 mm arch culvert	1800 mm CSP Culvert
Km 31.0 of Highway No.5	2-3600×2400 mm arch culverts	0.6	6.0 m Single Span Bridge	2130×1400 mm arch culvert	1500 mm CSP Culvert
Km 52.7 of Highway No.5	2100×1500 mm arch culvert	0.6	6.0 m Single Span Bridge	2-3650×2280 mm arch culvert	2-1800 mm CSP Culvert
Km 12.4 of Hay River Reserve Access Road	2100×1500 mm arch culvert	0.6	1350 mm CSP Culvert	1150×820 mm arch culvert	900 mm CSP Culvert
Km 146.8 of Highway No.8	1830 mm CSP culvert	0.4	*3-1500 mm CSP Culvert	2-3890×2690 mm arch culvert	1950 mm CSP Culvert
Km 209.4 of Highway No.8	1500 mm CSP culvert	0.6	2-2100 mm CSP Culvert	3890×2690 mm arch culvert	1500 mm CSP Culvert

*See Section 3



Department of Transportation Government of NWT
Hydrotechnical Analysis-Culverts
Assessment

Culvert Location and Drainage Area KM 31 and KM 25.6 of Highway 5

Figure 2.1

AECOM

ISS/REV: A
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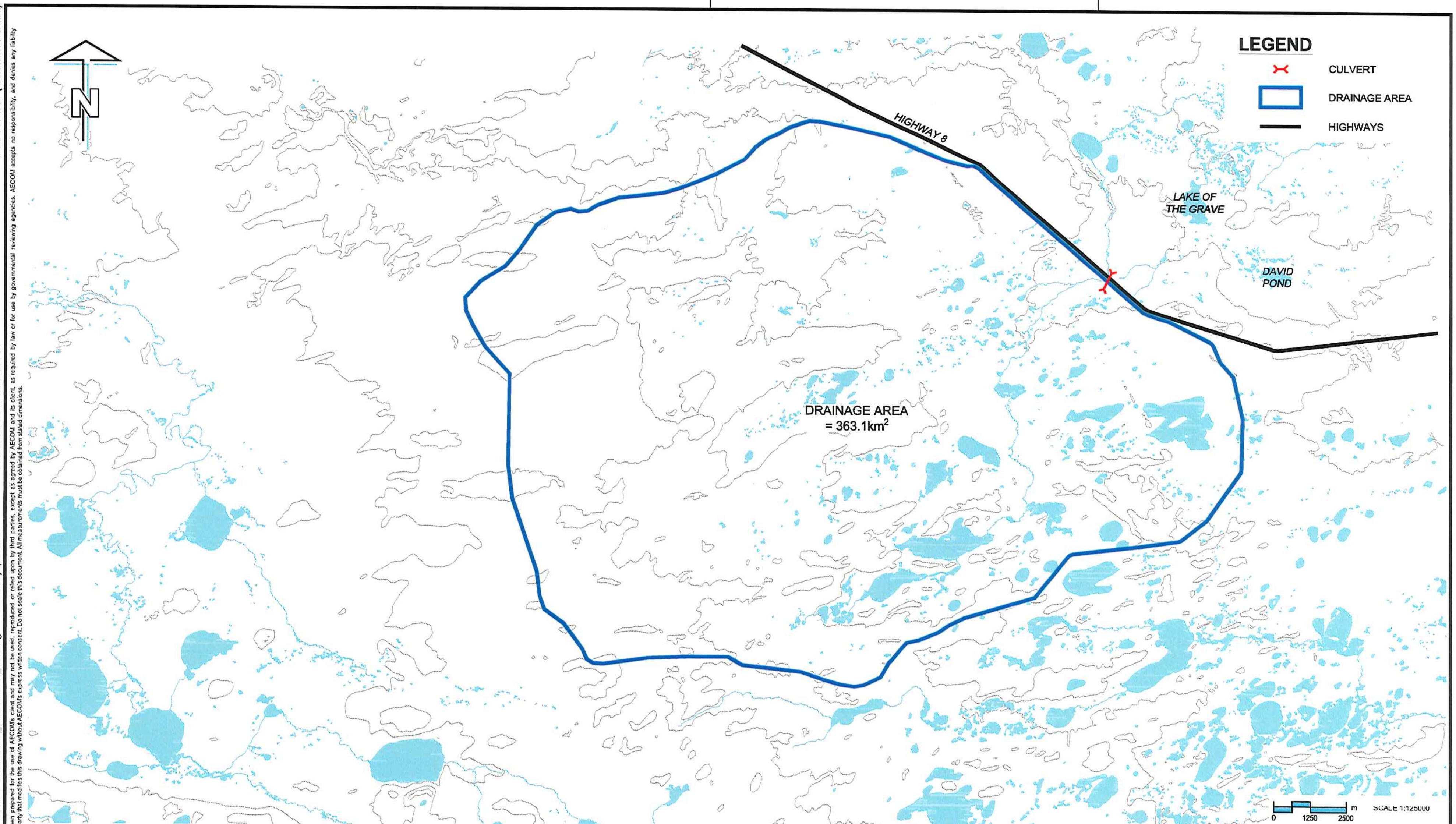

Department of Transportation Government of NWT
Hydrotechnical Analysis-Culverts Assessment

Culvert Location and Drainage Area
KM 52.7 Highway 5
Figure 2.2

AECOM

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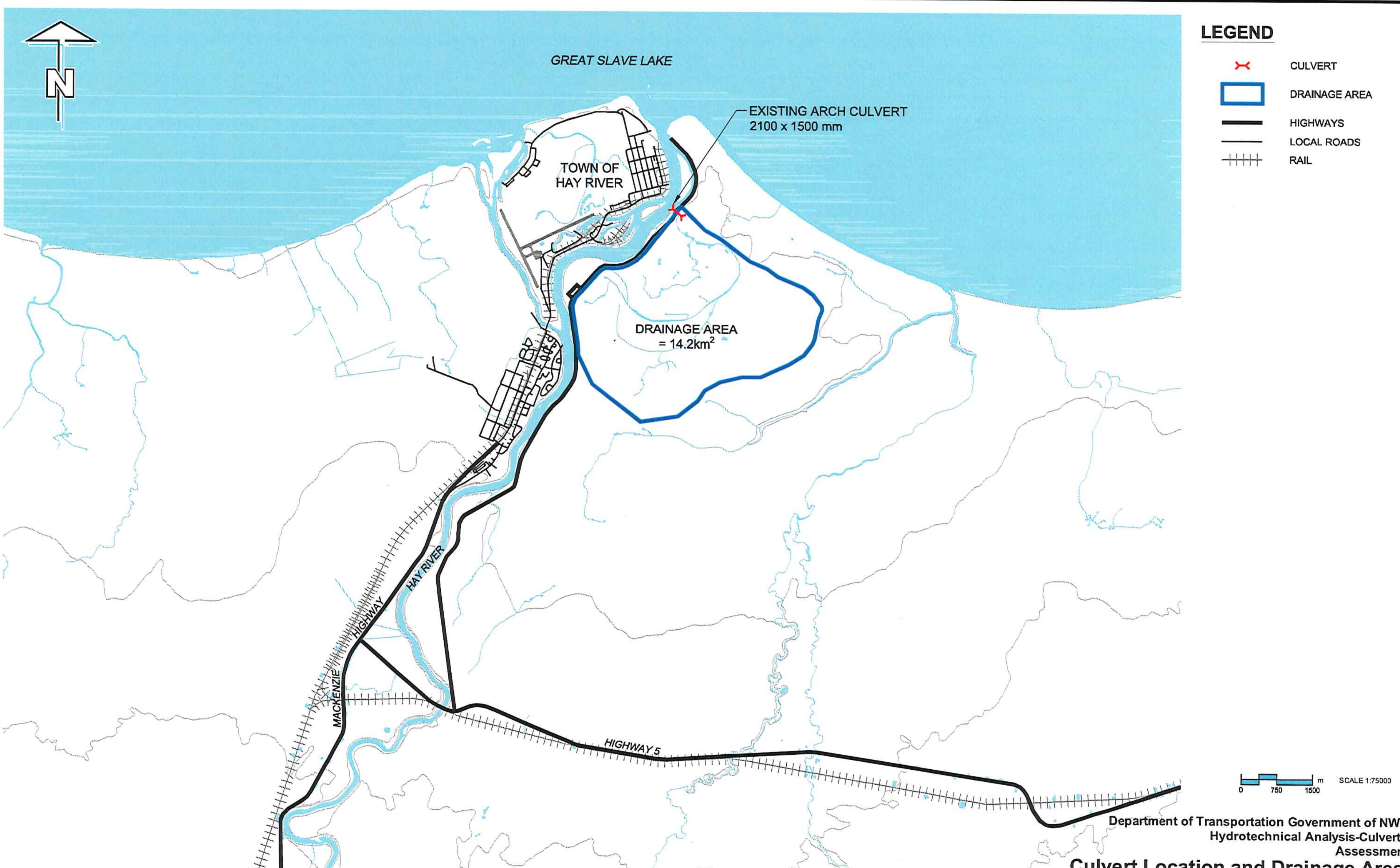
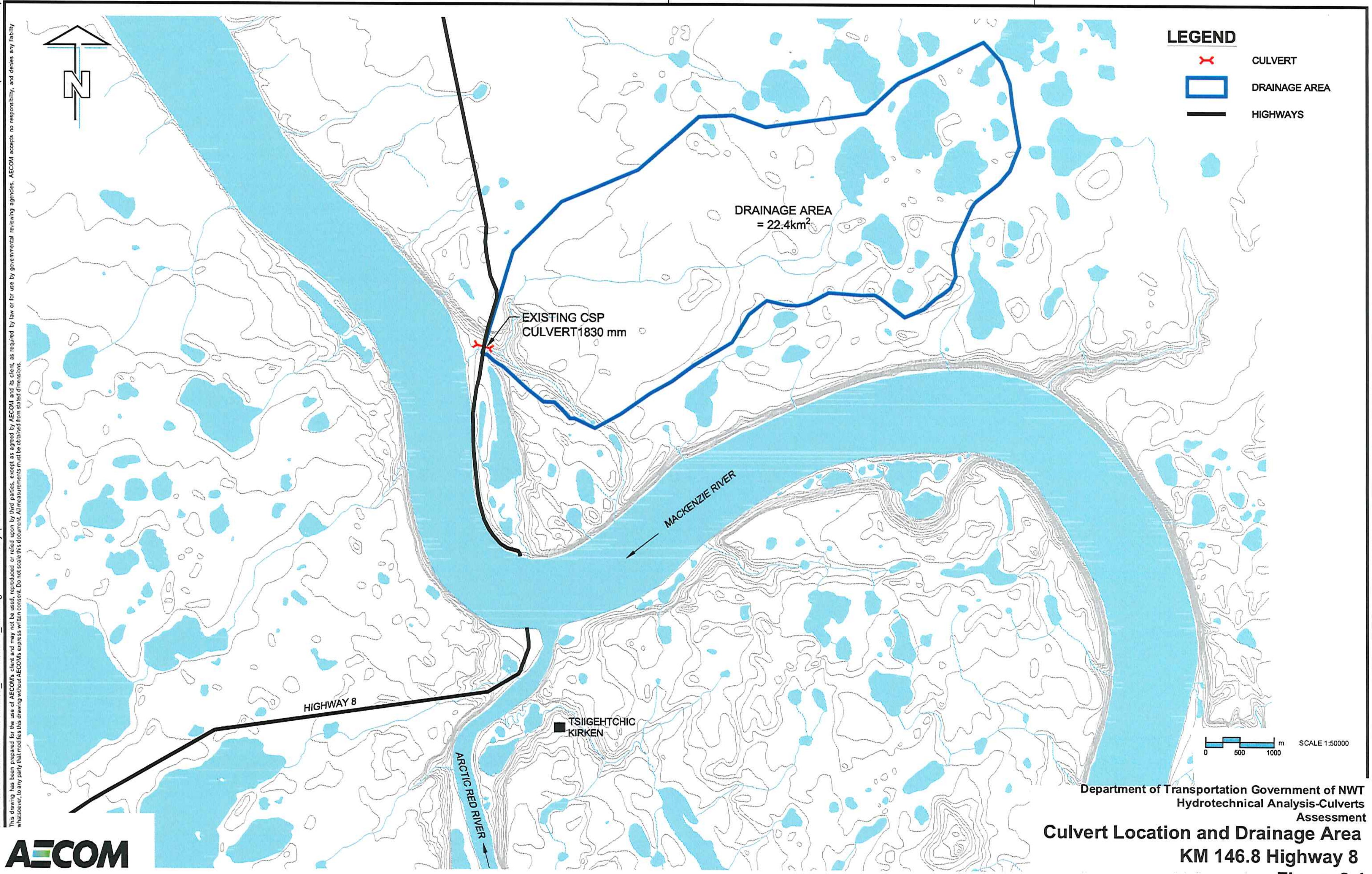


Department of Transportation Government of NWT
Hydrotechnical Analysis-Culverts Assessment

Culvert Location and Drainage Area
KM 12.4 Acess Road Hay River Reserve
Figure 2.3

AECOM



Department of Transportation Government of NWT
Hydrotechnical Analysis-Culverts
Assessment

Culvert Location and Drainage Area
KM 146.8 Highway 8
Figure 2.4

AECOM

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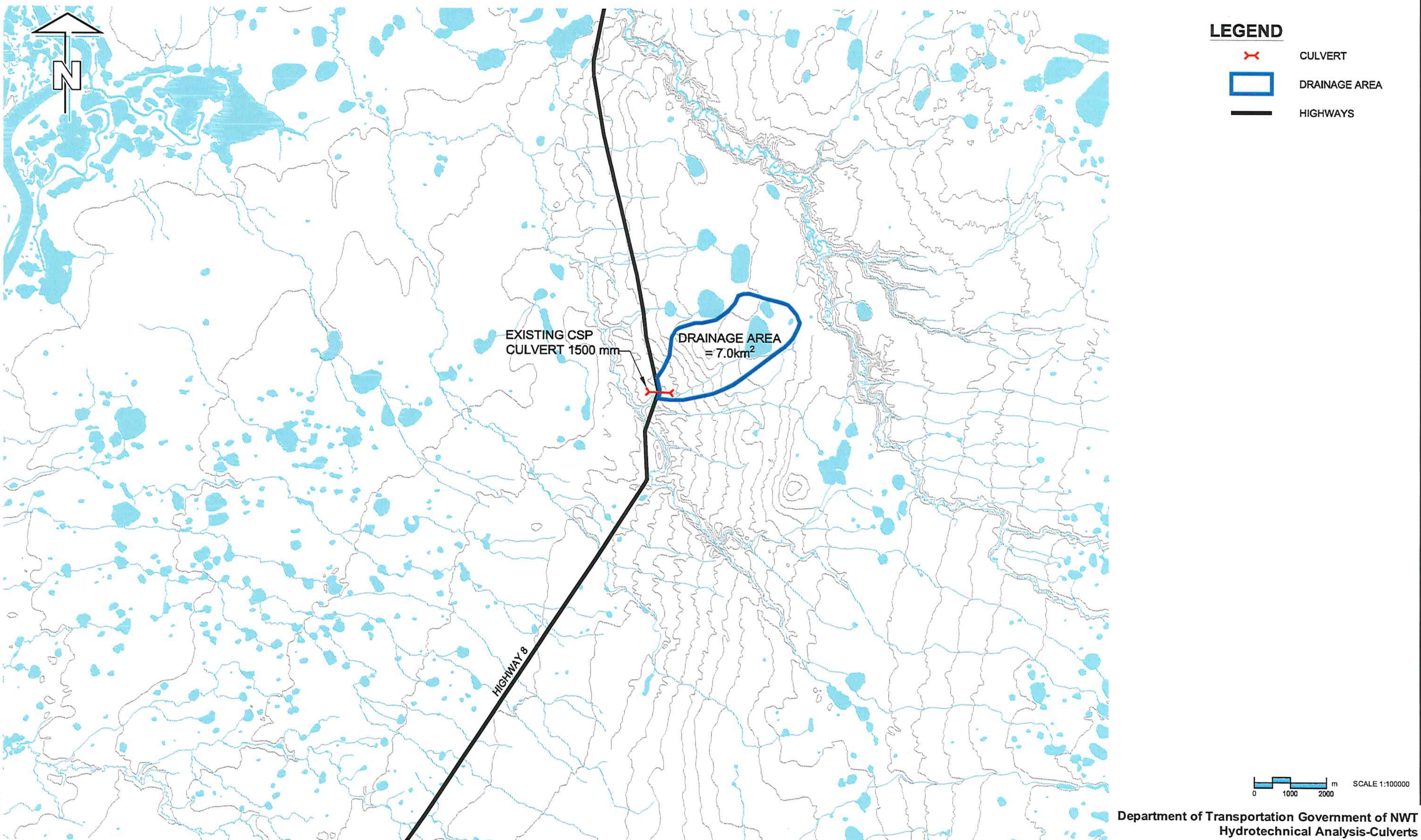

Department of Transportation Government of NWT
Hydrotechnical Analysis-Culverts Assessment

Culvert Location and Drainage Area
KM 209.4 Highway 8
Figure 2.5

AECOM

ISS/REV: A
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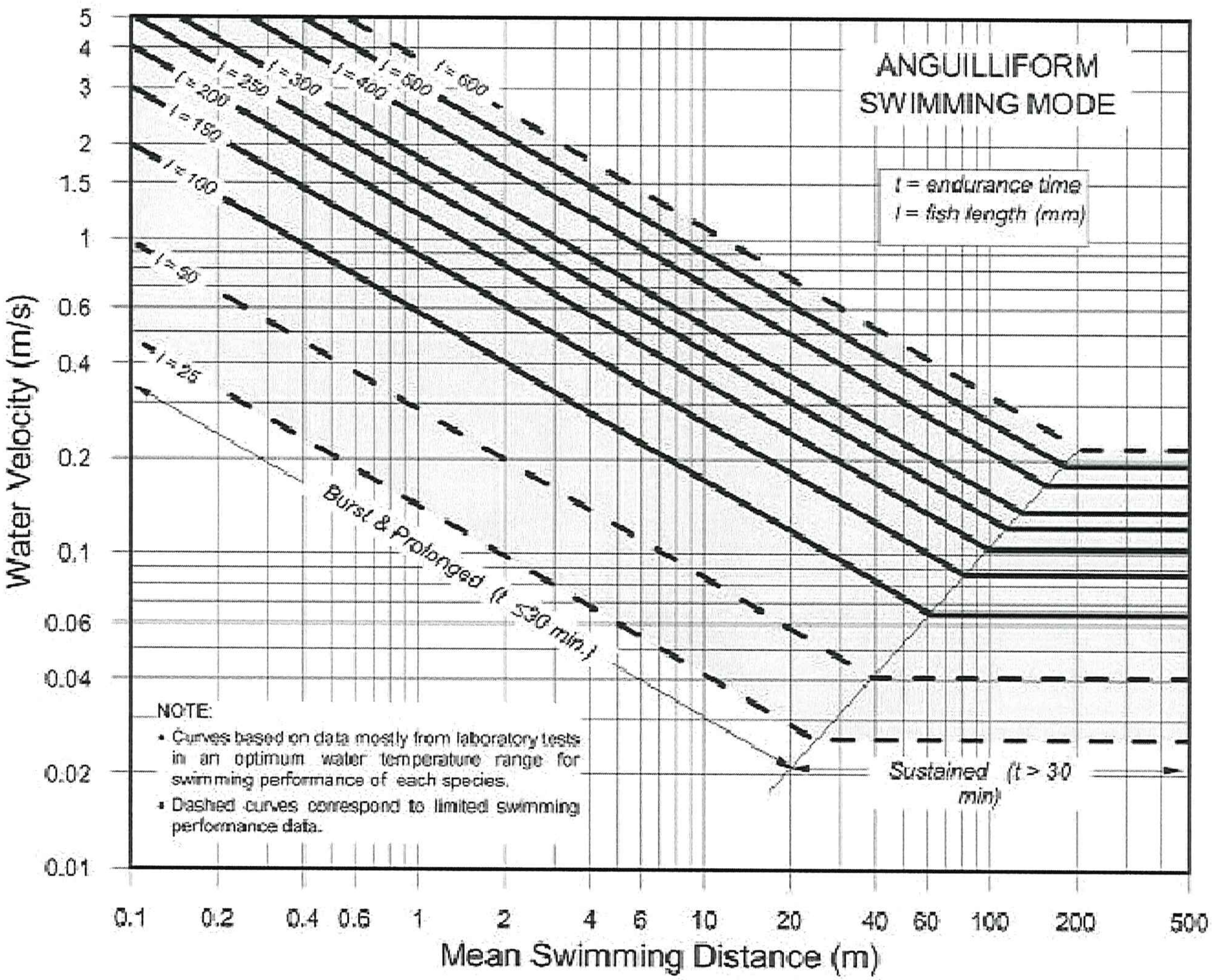

NOTES

1. GRAPH TAKEN FROM "ANALYSIS OF ICHTHYOMECHANICAL DATA FOR FISH PASSAGE OR EXCLUSION SYSTEM DESIGN" BY CHRIS KATOPODIS FRESHWATER INSTITUTE

AECOM

Department of Transportation Government of NWT
Hydrotechnical Analysis-Culverts Assessment

Swimming Distance Curves For Different Fish Lengths

Figure 2.6

3. Conclusions and Recommendations

- A fisheries assessment of the streams should be completed in order to determine if fish are present and the species.
- The recommendations for replacement culvert sizes and number of culverts are based on the limited site information provided. A survey of the stream for a distance of 200 meters upstream and downstream is required to confirm the suitability of the recommended structures.

APPENDIX C – HYDROTECHNICAL ASSESSMENT

Dempster Highway KM 147 Creek Hydrotechnical Assessment

February 11, 2019

144930112

Prepared for:

Transportation Division Infrastructure
Government of the Northwest Territories

Prepared by:

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Hillary Flesher, P.Eng.

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Marcel Chichak, P.Eng.

Table of Contents

1.0 INTRODUCTION

The Government of Northwest Territories (GNWT) Department of Infrastructure (INF) plans to construct a new watercourse crossing at KM 147 along the Dempster Highway (HWY 8). In June 2018, Stantec was retained by GNWT to complete hydrotechnical assessments to inform the design of a new structure. The scope of work for this assignment includes: data and document review; watershed delineation; hydrological analysis; and hydraulics analysis. Stantec travelled to site on August 31, 2018 to complete a field reconnaissance inclusive of hydrotechnical, fisheries and survey personnel.

2.0 HYDROLOGY

KM 147 along the Dempster Highway passes an unnamed creek located in the Mackenzie River Delta, approximately 124 km south of Inuvik, NWT as shown in **Figure 1**.

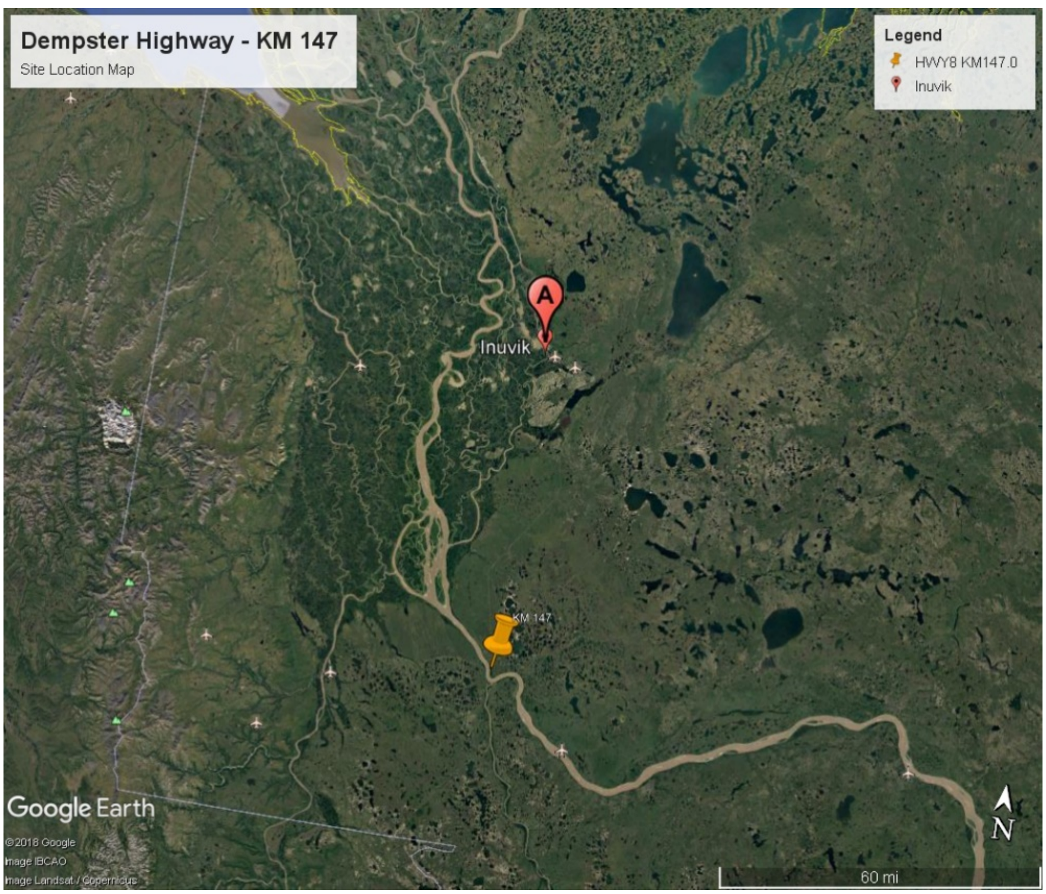

Figure 1 Site Location (source: Google Earth Imagery)

Dempster Highway crosses the Creek in a 2.0 m diameter corrugated steel pipe (CSP) culvert. Upstream of the culvert, the creek is divided into two channels with approximately 35 m of land between them. The north upstream channel streambed is rocky with rapids throughout and larger shrubs and trees at the top of bank while the south streambed is smooth and muddy with long grasses and shrubs at the top of bank. Positioned 20 degree right hand forward (RHF) skew to the road, the culvert extends 62 m beneath the highway. A blockage, likely from beaver activity in the area, exists downstream of the culvert causing stagnant water throughout the existing culvert. A collection of photographs showing the site are included in in **Appendix A.** With a lack of high resolution digital terrain data, stream slope has been calculated with the approximate 380 m reach of collected survey data. The length of creek measured is 383 m with a drop of 6.45 m, but the slope is not linear equaling a slope of 0.0129 m/m (or 1.3%). Stream profile can be found in **Appendix B.**

The basin, delineated in **Figure 2**, has limited lakes and wetlands in its contributing drainage area. The gross drainage area is approximately 14.7 km², with the lakes accounting for approximately 0.81 km², or approximately 5.5%. With the low percentage of lakes in the drainage area, peak level discharge will not be dampened, and the full extent of discharge is expected.

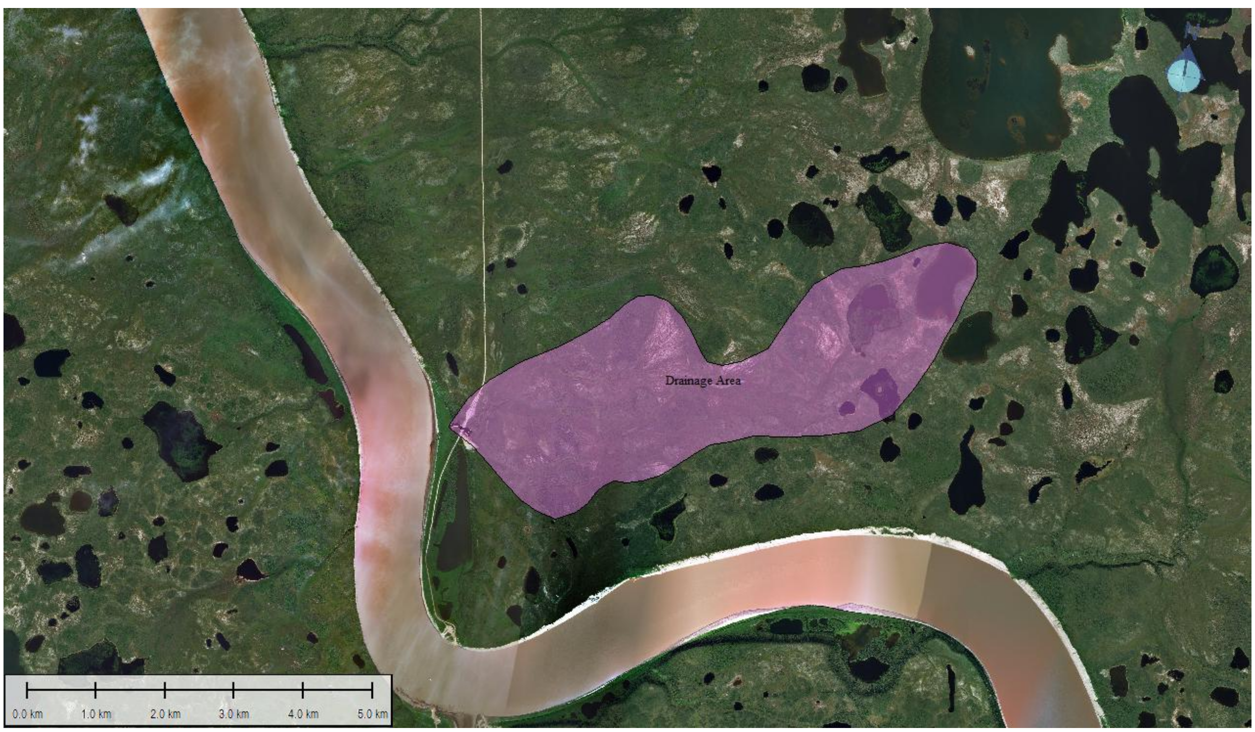

Figure 2 KM 147 Creek Drainage Area (source: Digital terrain mapping using GIS software)

Creek cross section dimensions measured in the field, provide average measurements upstream and downstream as shown in **Table 1.** The floodplain that extends beyond the top of bank consists of grasses, shrubs, and trees and extends into the distance.

Table 1 Average Channel Characteristics

Top Width (m)	Height of Bank (m)	Streambed Width (m)
4.0	0.35	0.8

The 1% annual exceedance probability (AEP), or Q100 discharge, was estimated from the reginal flood frequency curve developed by Kavik-Stantec (Kavik-Stantec, 2012) as shown in **Appendix C** at 5.0 m^3/s. As per GNWT's verbal recommendation, a 30% increase to account for climate change is required. This increase raises the design discharge to 6.5 m^3/s. To confirm, we ground truthed using a channel capacity calculator, based on Manning's equation, to ensure theoretical discharge matched the channel morphology. Fish passage discharge was calculated using 50% of the bankful height as Q_{FPD} = 0.3 m^3/s.

Alberta Transportation has provided guidance on determination of fish passage design discharge for ungauged streams (Watt, 2014). Using their methodology, a fish passage flow depth of 0.44 m results, corresponding to a discharge of approximately 1.5 m^3/s. Note that their guidance is based on statistical analysis of data from Alberta rivers, performed only on flows during the spawning period for certain Alberta fish species: March 1 through May 15. While this guidance document provides some context for fish passage flows, it cannot be considered valid in an environment where streams typically do not begin flowing until early May.

3.0 HYDRAULICS

Using a HEC RAS (U.S. Army Corps of Engineers, 2018) 1-D flow model in an open channel condition with provided design discharge, stream slope, and creek cross sections, output values for velocity and water elevations were calculated. Water elevation levels provided are referenced to sea level or geodetic datum. The open channel model output can be found in **Appendix D** with summarized hydrology design parameters in **Table 2.**

Table 2 Hydrology Design Parameters

Gross Drainage Area (km^2)	14.7
Stream Slope (m/m)	0.013
Q_{DESIGN} (m^3/s)	6.5
Open Channel Design Velocity (m/s)	1.65
Design Water Surface Elevation	12.3
Streambed Elevation (m)	10.94
Q_{FPD} (m^3/s)	0.3
Fish Passage Velocity (m/s)	0.57
Fish Passage Water Surface Elevation (m)	11.62

Creek cross-section points were collected from 120 m upstream to 210 m downstream of the existing culvert. Rather than relying upon fixed interval sections, data was collected at convenient locations due to on-site access issues. Using public domain digital terrain data combined with site survey, a surface elevation grid was generated for intermediate area. Cross-sections were then cut, perpendicular to the creek centerline, at 25.0 m spacings starting 120 m upstream of the existing culvert. These cross-sections were input into HEC RAS 1-D flow model, to conduct hydraulic analysis for different culvert options. Three separate culvert options were analyzed including the existing 2.0 m round CSP culvert, a 3.0 m round CSP culvert, and a 3.67 m SPCSP culvert. The HEC RAS outputs for each option can be found in **Appendix E** with summarized hydraulic design parameters in **Table 3**.

Option 1: 2.0 m Round CSP Culvert

An existing 2.0 m round CSP culvert passes the creek beneath Dempster Highway with 10.6 m cover to the top of the road surface. Downstream beaver dam blockage is causing water to pond at both the inlet and outlet of the culvert. The culvert structure is deforming and collapsing on both sides and the crown. The culvert was installed with zero embedment, which can restrict fish passage. The 2.0 m culvert is smaller than the invert bank cross-sections, resulting in high velocities throughout the length of the culvert. At full design discharge levels, the existing culvert flows at 80% full allowing for limited freeboard. Hydraulic design parameters can be found in **Table 3**.

Option 2: 3.0 m Round CSP Culvert

To allow for fish passage, culverts should be embedded approximately 25% of their diameter (Alberta Transportation Technical Standards Branch, 2004), and to provide adequate cover over the culvert barrel to develop a structural envelope. As the creek valley is approximately 12.6 m from the road surface to the bottom of the creek, adequate structural capacity will be required by the culvert to withstand the amount of fill depth. The maximum height of cover for a 3.0 m CSP is 13.0 m for a specified wall thickness of at least 2.8 mm. Larger CSP structures would be undesirable due to the flexibility limit of the steel.

With these guidelines, a 3.0 m diameter round culvert is the largest structure than can fit at the crossing without going to a structural plate culvert. Hydraulic analysis, summarized in **Table 3**, indicates that this structure is sufficient for the design discharge to flow through the culvert. However, freeboard of 1.22 m does not provide the requested freeboard of 1.5 m requiring a larger culvert diameter.

Option 3: 3.67 m Round SPCSP Culvert

While the 3.0 m round CSP was sufficient to pass the design discharge, it does not allow for the 1.5 m freeboard. A 3.67 m round SPCSP was modelled to determine if the design velocity and freeboard would change enough to warrant the extra diameter. Structural plate corrugated steel pipes are desirable for remote sites as they are easily transportable; however, they take longer to install as each plate section must be correctly bolted together.

Hydraulic analysis, summarized in **Table 3**, indicates improved design parameters for freeboard and velocity. The freeboard value increased by 0.49 m and velocity decreased by 0.19 m/s, improving each value. Freeboard of 1.74 provides sufficient space to account for ice thickness recommended at 0.8 m (Alberta Transportation Technical Standards Branch , 2014). The inlet velocity of 2.06 m/s, at design discharge, is calculated requiring Alberta Transportation Class 1 riprap at both the inlet and outlet inverts. Due to the freeboard requirement, increasing the culvert size to 3.67 m round SPCSP provides a wider area to pass the flow.

Table 3 Hydraulic Analysis Results

	Option 1: Existing 2.0 m CSP		**Option 2: New 3.0 m CSP**		**Option 3: New 3.67 m SPCSP**	
Design Discharge (m^3/s)	6.5		6.5		6.5	
Inlet or Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Streambed Elevation (m)	10.87	9.87	10.74	10.43	10.74	10.42
Design Water Surface Elevation (m)	12.1	11.43	11.77	11.43	11.63	11.43
Freeboard (m)	0.77	0.44	1.22	1.25	1.86	1.74
Invert Embedment (m)	0.0	0.0	0.75	0.75	0.92	0.92
Velocity (m/s)	3.2	2.48	2.18	2.25	2.06	1.82

4.0 DESIGN CONSIDERATIONS

Culverts that have the potential for fish passage need to be embedded during installation to provide the least amount of change from the channel to the culvert. At the downstream end of the culvert, a small scour pool exists. To avoid increasing the scour hole depth, the downstream invert should be embedded below the streambed. The existing culvert is skewed to the roadway. Re-aligning the creek downstream of the culvert could help to reduce the overall length of the culvert while avoiding the scour hole at the end of the existing culvert.

Existing site conditions have a beaver dam approximately 20 m downstream of the outlet causing back flooding through the culvert. Blockage and ponding, that could cause damage and undermine the slopes, should be reduced to allow the creek to flow unrestricted downstream of the culvert.

With a design velocity up to 2.06 m/s, Alberta Transportation Class 1 riprap (100% smaller than 300 mm) will be required at the culvert inlet and outlet and streambed slopes. Although graded filters have largely been supplanted by geotextile fabrics, experience in NWT suggests that they not be used to underlay heavy rock riprap. In the final design, sufficient thickness should be provided between subgrade and riprap to accommodate a graded filter layer. To address flexibility of large diameter culverts, a concrete end treatment will be required at the inlet of the proposed structure.

5.0 SENSITIVITY ANALYSIS

Varying the mannings's n roughness within a reasonable range for the channel from 0.033 to 0.045 (Corvallis Forestry Research Community, 2018) increases velocity and discharge, but does not affect culvert design recommendations including design high water level and protection works. Varying roughness provided a corresponding velocity value of 2.75 m/s, increased by 0.69 m/s, and now requires Alberta Transportation Class 2 riprap (100% smaller than 500 mm). Climate change was previously accounted for through the design discharge increase of 30% used for the culvert options and was not further increased through the sensitivity analysis.

6.0 CONSTRUCTABILITY

The existing culvert was installed with the invert at streambed elevation. This installation does not allow for easy passage of fish as any presence of a natural creek bed material has been removed. The culvert invert is smoother than a natural bed and doesn't provide any sheltered rest spots for fish travelling against the flow. Any replacement structure should be adequately embedded to allow for fish passage.

The existing culvert has both settled under the roadway centerline and has failed vertically from roadway loading. The surrounding structural granular envelope will need to be designed and constructed adequately to support the structure to ensure the culvert does not fail again. Factors that will need to be considered are compaction and material grade. Compaction of the culvert backfill will need to be specified, tested on site and proceed in balanced lifts on each side of the culvert. The material grade will need to be specified, compacted with a plate tamper near to the culvert and placed at both a prescribed material and ambient temperature. A structural engineer should provide a detailed construction work plan for the contractor to follow.

A geotechnical investigation is required to provide the designer with information on presence of permafrost, potential settlement, and positive camber requirements. Camber requirements will account for settlement under initial load and over time to guide culvert placement. A geotechnical investigation will guide the foundation design for the engineer.

7.0 CONCLUSION AND RECOMMENDATIONS

Based on our survey, hydrological and hydraulic analysis, we recommend:

- A 3.67 m round SPCSP culvert is required to sufficiently pass the design discharge and provide for fish passage; and
- A geotechnical investigation is required to provide information to a structural designer for the foundation.

A summary of the proposed structure's hydraulic parameters is listed in **Table 4.**

Table 4 Hydrotechnical Design Parameters

3.0 m Round CSP Culvert	
Drainage Area (km^2)	14.7
Stream Slope (m/m)	0.013
Design Discharge (m^3/s)	6.5
Design Velocity (m/s)	2.06
Fish Passage Discharge (m^3/s)	0.3
Fish Passage Velocity (m/s)	0.33

8.0 REFERENCES

Alberta Transportation Technical Standards Branch . (2014). *Bridge Conceptual Design Guidelines.* Alberta Transportation Technical Standards Branch.

Alberta Transportation Technical Standards Branch. (2004). *Design Guidelines for Bridge Size Culverts.* Alberta Transportation Technical Standards Branch.

Corvallis Forestry Research Community. (2018, 11 16). *Manning's n Values*. Retrieved from http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

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U.S. Army Corps of Engineers. (2018, June). Hydrologic Engineering Center - River Analysis System (HEC-RAS) 5.0.5. Davis, CA, United States of America.

Watt, C. (2014). *Discussion on the Selection of the Recommended Fish Passage Design Discharge (DRAFT).* Edmonton, Alberta: Government of Alberta, Department of Transportation.

Appendix A
SITE PHOTOS

Figure 1

2018-08-31

Upstream View

Figure 2

2018-08-31

Downstream View

Figure 3

2018-08-31

At Centerline
Looking North

Figure 4

2018-08-31

At Centerline Looking South

Figure 5

2018-08-31

Upstream Inlet

alk

Figure 6

2018-08-31

Downstream Outlet

Figure 7

2018-08-31

Upstream of Inlet,
South Channel

Figure 8

2018-08-31

Upstream North Channel

Figure 9

2018-08-31

Upstream View of Existing Culvert. Note: uneven and compressed top of culvert

Figure 10

2018-08-31
Scour pool and back up of water downstream of culvert outlet.

Figure 11

2018-08-31

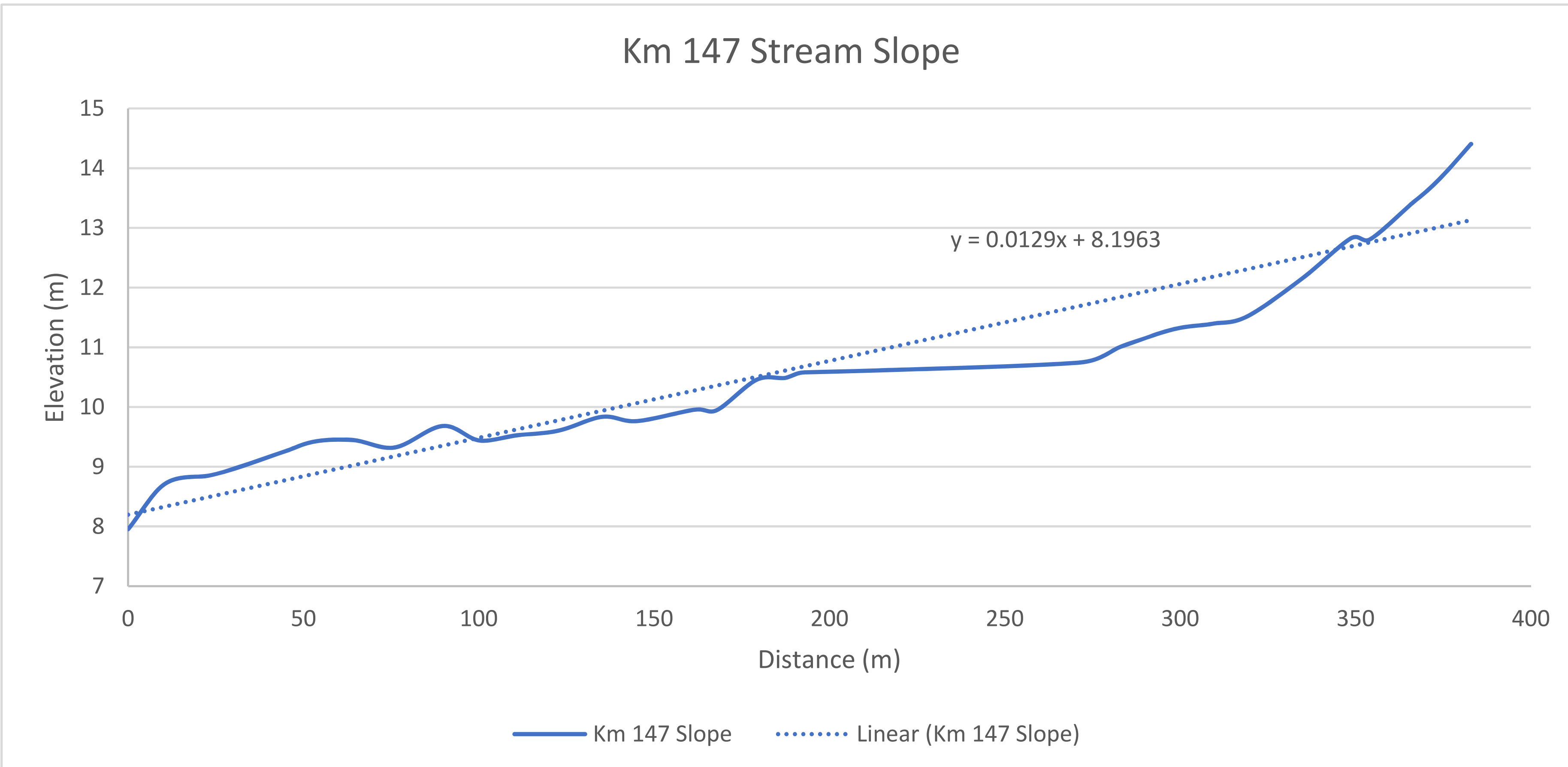
Downstream beaver dam causing back up at outlet.

Figure 12

2018-08-31

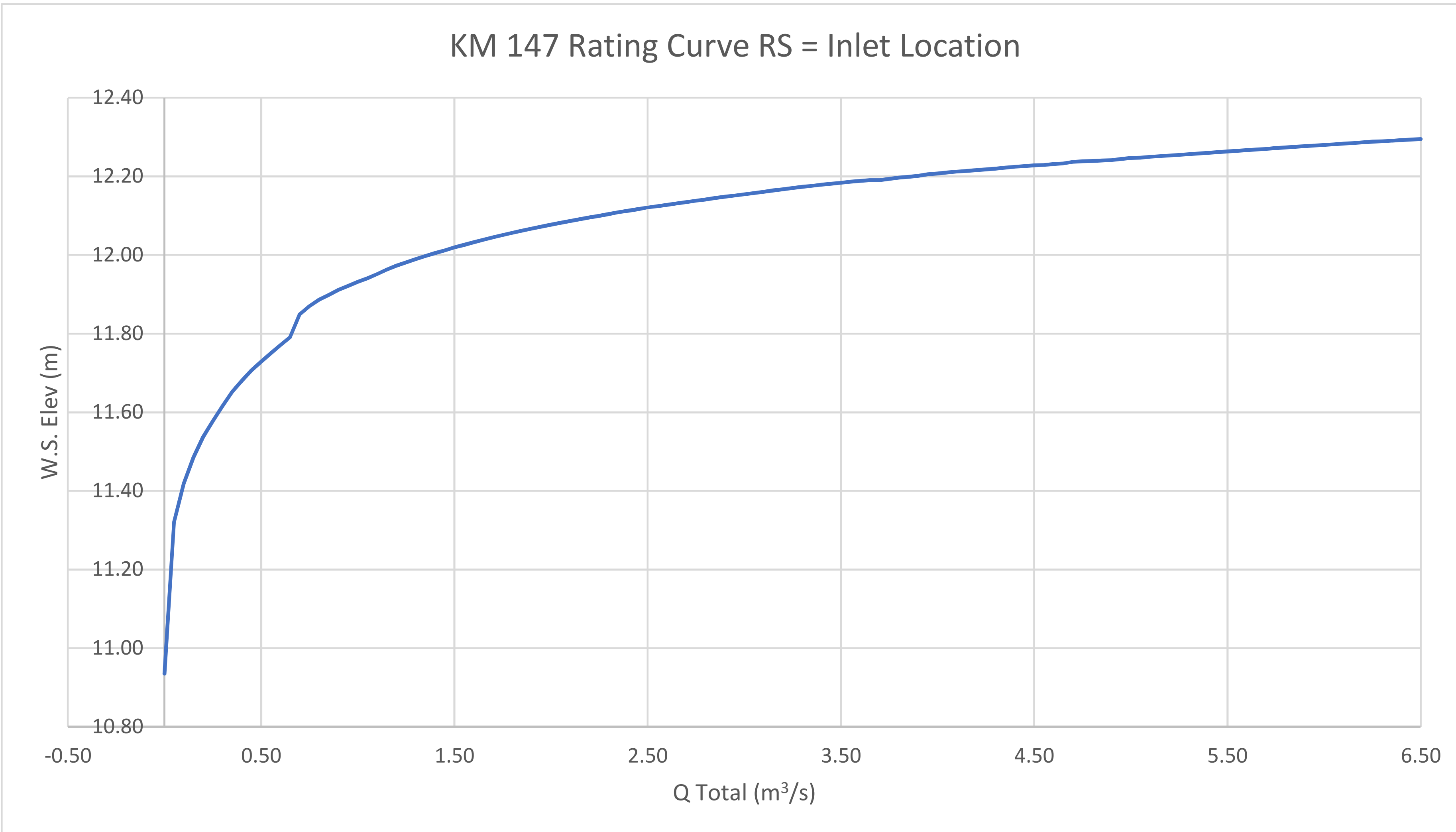
Typical downstream channel.

Appendix B
STREAM SLOPE



Km 147 Stream Slope
Elevation (m)
15
14
13
12
11
10
9
8
7
0
50
100
150
200
250
300
350
400
Distance (m)
y = 0.0129x + 8.1963
Km 147 Slope
Linear (Km 147 Slope)

Appendix C
FLOOD FREQUENCY RATING CURVE


KM 147 Rating Curve RS = Inlet Location
W.S. Elev (m)
12.40
12.20
12.00
11.80
11.60
11.40
11.20
11.00
10.80
-0.50
0.50
1.50
2.50
3.50
4.50
5.50
6.50
Q Total (m³/s)

Appendix D
CHANNEL HEC RAS OUTPUT


N
Centreline
0 m
50 m
100 m
150 m
200 m

Site With No Crossing													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Total	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m/s)	(m2)	(m)	
upstream_north	322	6.5 Flow	4.23	13.79	14.28	14.33	14.49	0.035606	1.41	2.27	3	12.29	1.14
upstream_north	322	1%AEPflow	3.25	13.79	14.23	14.27	14.41	0.035606	1.35	2.08	2.41	11.34	1.12
upstream_north	322	Fish	0.2	13.79	13.93	13.93	13.97	0.045969	0.9	0.9	0.22	2.6	1
upstream_north	297	6.5 Flow	4.23	12.78	13.05	13.11	13.27	0.07052	1.64	2.34	2.57	12.27	1.49
upstream_north	297	1%AEPflow	3.25	12.78	13.02	13.06	13.2	0.069862	1.5	2.11	2.16	12.03	1.45
upstream_north	297	Fish	0.2	12.78	12.86	12.85	12.87	0.028063	0.5	0.56	0.39	8.39	0.74
upstream_north	272	6.5 Flow	4.23	11.78	12.5	12.28	12.55	0.004881	0.93	1	4.55	10.07	0.44
upstream_north	272	1%AEPflow	3.25	11.78	12.41	12.23	12.45	0.005477	0.89	0.94	3.66	9.53	0.45
upstream_north	272	Fish	0.2	11.78	11.92	11.92	11.96	0.049201	0.87	0.87	0.23	3.01	1.01
upstream_north	247	6.5 Flow	4.23	11.12	12.49		12.5	0.000562	0.41	0.48	10.3	21.19	0.16
upstream_north	247	1%AEPflow	3.25	11.12	12.4		12.41	0.000482	0.39	0.41	8.4	20.94	0.14
upstream_north	247	Fish	0.2	11.12	11.65	11.35	11.65	0.000165	0.12	0.12	1.68	6.03	0.07
upstream south	322	6.5 Flow	2.28	13.32	13.66	13.66	13.76	0.030252	1.21	1.4	1.88	11.57	0.95
upstream south	322	1%AEPflow	1.75	13.32	13.63	13.63	13.71	0.034056	1.19	1.31	1.47	10.34	0.98
upstream south	322	Fish	0.11	13.32	13.42	13.42	13.44	0.055991	0.71	0.71	0.15	2.92	1.01
upstream south	297	6.5 Flow	2.28	12.55	12.98	12.86	13.02	0.007128	0.84	0.88	2.72	9.54	0.49
upstream south	297	1%AEPflow	1.75	12.55	12.94	12.83	12.97	0.006485	0.74	0.77	2.36	9.22	0.46
upstream south	297	Fish	0.11	12.55	12.69	12.64	12.69	0.005341	0.28	0.28	0.37	4.99	0.33
upstream south	272	6.5 Flow	2.28	12.32	12.61	12.61	12.69	0.032308	1.15	1.26	1.97	14.75	0.95
upstream south	272	1%AEPflow	1.75	12.32	12.58	12.58	12.65	0.036317	1.12	1.18	1.56	12.75	0.98
upstream south	272	Fish	0.11	12.32	12.46		12.46	0.019534	0.37	0.37	0.28	6.94	0.58
upstream south	247	6.5 Flow	2.28	11.64	12.5	11.98	12.51	0.000299	0.23	0.3	9.99	21.48	0.11
upstream south	247	1%AEPflow	1.75	11.64	12.42	11.95	12.42	0.000293	0.21	0.27	8.16	20.4	0.11
upstream south	247	Fish	0.11	11.64	11.76		11.78	0.040171	0.6	0.6	0.17	3.43	0.86
downstream	222	6.5 Flow	6.5	10.94	12.3	12.23	12.43	0.020456	1.65	1.65	3.95	9.91	0.82
downstream	222	1%AEPflow	5	10.94	12.25	12.16	12.35	0.017479	1.44	1.44	3.48	9.3	0.75
downstream	222	Fish	0.3	10.94	11.62		11.63	0.004034	0.57	0.57	0.53	1.59	0.31
downstream	150	6.5 Flow	6.5	10.79	11.38		11.44	0.009509	1.09	1.1	5.96	17.2	0.58
downstream	150	1%AEPflow	5	10.79	11.31		11.37	0.010664	1.03	1.04	4.83	16.12	0.6
downstream	150	Fish	0.3	10.79	10.97		11	0.032269	0.71	0.71	0.42	5.52	0.83
downstream	125	6.5 Flow	6.5	10.45	11.12		11.2	0.009414	1.27	1.31	5.11	12.5	0.6
downstream	125	1%AEPflow	5	10.45	11.05		11.12	0.008934	1.15	1.16	4.35	11.68	0.57
downstream	125	Fish	0.3	10.45	10.69	10.61	10.7	0.006115	0.37	0.37	0.82	8.37	0.37
downstream	100	6.5 Flow	6.5	10.18	10.76		10.89	0.017147	1.59	1.61	4.09	10.76	0.79
downstream	100	1%AEPflow	5	10.18	10.68		10.8	0.019609	1.51	1.51	3.32	9.9	0.82
downstream	100	Fish	0.3	10.18	10.32	10.32	10.36	0.048336	0.84	0.84	0.36	5.02	1
downstream	75	6.5 Flow	6.5	9.76	10.59		10.65	0.005377	1.07	1.07	6.06	11.68	0.46
downstream	75	1%AEPflow	5	9.76	10.5		10.55	0.005268	0.98	0.98	5.1	10.58	0.45
downstream	75	Fish	0.3	9.76	10	9.86	10	0.001498	0.28	0.28	1.08	5.87	0.21
downstream	50	6.5 Flow	6.5	9.74	10.39		10.47	0.009009	1.28	1.28	5.08	10.56	0.59
downstream	50	1%AEPflow	5	9.74	10.3		10.37	0.009704	1.2	1.2	4.16	10.05	0.6
downstream	50	Fish	0.3	9.74	9.86	9.86	9.89	0.051689	0.77	0.77	0.39	6.43	1
downstream	25	6.5 Flow	6.5	9.49	10.24		10.3	0.004955	1.06	1.06	6.14	10.75	0.45
downstream	25	1%AEPflow	5	9.49	10.16		10.21	0.004489	0.95	0.95	5.26	10.08	0.42
downstream	25	Fish	0.3	9.49	9.69	9.57	9.69	0.001358	0.25	0.25	1.21	7.2	0.19
downstream	0	6.5 Flow	6.5	9.43	10.06	9.91	10.14	0.009063	1.24	1.24	5.23	11.46	0.59
downstream	0	1%AEPflow	5	9.43	9.98	9.85	10.05	0.009069	1.13	1.13	4.41	11.08	0.57
downstream	0	Fish	0.3	9.43	9.61	9.57	9.62	0.009065	0.42	0.42	0.71	8.06	0.45

No Crossing

0.907% streambed slope used for downstream boundary condition
3.56% streambed slope used for upstream north branch boundary condition
2.24% streambed slope used for upstream south branch boundary condition
Manning's n 0.045 used for the channel based on site photo's, Clean, winding, some pools, shoals, weeds and stones.
Manning's n 0.100 used for the overbanks based on site photo's, Medium to dense brush in summer.

Site With Existing 2.0m CSP													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Total	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m/s)	(m2)	(m)	
upstream_north	322	6.5 Flow	4.23	13.79	14.28	14.33	14.49	0.035606	1.41	2.27	3	12.29	1.14
upstream_north	322	1%AEPflow	3.25	13.79	14.23	14.27	14.41	0.035606	1.35	2.08	2.41	11.34	1.12
upstream_north	322	Fish	0.2	13.79	13.94	13.93	13.97	0.035825	0.79	0.8	0.25	3.19	0.88
upstream_north	297	6.5 Flow	4.23	12.78	13.05	13.11	13.27	0.07052	1.64	2.34	2.57	12.27	1.49
upstream_north	297	1%AEPflow	3.25	12.78	13.02	13.06	13.2	0.069862	1.5	2.11	2.16	12.03	1.45
upstream_north	297	Fish	0.2	12.78	12.85	12.85	12.87	0.054711	0.63	0.69	0.31	7.23	1
upstream_north	272	6.5 Flow	4.23	11.78	13.1	12.28	13.11	0.000352	0.36	0.45	11.61	13.71	0.13
upstream_north	272	1%AEPflow	3.25	11.78	12.77	12.23	12.78	0.000689	0.43	0.5	7.5	11.56	0.18
upstream_north	272	Fish	0.2	11.78	11.94	11.92	11.97	0.024529	0.66	0.66	0.3	3.55	0.73
upstream_north	247	6.5 Flow	4.23	11.12	13.1		13.1	0.000081	0.17	0.25	24.53	29.6	0.06
upstream_north	247	1%AEPflow	3.25	11.12	12.77		12.77	0.000123	0.2	0.26	16.28	22.1	0.08
upstream_north	247	Fish	0.2	11.12	11.38	11.35	11.39	0.02109	0.6	0.6	0.32	3.87	0.67
upstream south	322	6.5 Flow	2.28	13.32	13.66	13.66	13.76	0.030252	1.21	1.4	1.88	11.57	0.95
upstream south	322	1%AEPflow	1.75	13.32	13.63	13.63	13.71	0.034056	1.19	1.31	1.47	10.34	0.98
upstream south	322	Fish	0.11	13.32	13.42	13.42	13.44	0.055991	0.71	0.71	0.15	2.92	1.01
upstream south	297	6.5 Flow	2.28	12.55	13.1	12.86	13.12	0.002488	0.58	0.64	3.9	10.49	0.31
upstream south	297	1%AEPflow	1.75	12.55	12.84	12.83	12.92	0.029459	1.21	1.22	1.45	8.36	0.91
upstream south	297	Fish	0.11	12.55	12.69	12.64	12.69	0.005511	0.29	0.29	0.36	4.97	0.34
upstream south	272	6.5 Flow	2.28	12.32	13.1		13.1	0.00022	0.16	0.25	14.35	33.97	0.1
upstream south	272	1%AEPflow	1.75	12.32	12.77		12.78	0.001847	0.33	0.46	5.24	25.42	0.25
upstream south	272	Fish	0.11	12.32	12.46		12.46	0.018282	0.36	0.36	0.29	7.17	0.56
upstream south	247	6.5 Flow	2.28	11.64	13.1		13.1	0.000029	0.09	0.14	25.69	31.2	0.04
upstream south	247	1%AEPflow	1.75	11.64	12.77		12.77	0.000053	0.11	0.16	16.16	25.35	0.05
upstream south	247	Fish	0.11	11.64	11.76	11.76	11.78	0.044635	0.63	0.63	0.17	3.36	0.9
downstream	222	6.5 Flow	6.5	10.87	13.03	12.11	13.09	0.001771	1.03	1.03	6.28	23.74	0.26
downstream	222	1%AEPflow	5	10.87	12.71	11.84	12.76	0.002291	1.01	1.01	4.97	16.6	0.29
downstream	222	Fish	0.3	10.87	11.27	11.03	11.28	0.002366	0.46	0.46	0.65	1.79	0.25
Culvert Inlet		6.5 Flow	6.5	10.87	12.1		12.62		3.2	3.2	2.03		
		1%AEPflow	5	10.87	11.94		12.37		2.91	2.91	1.72		
		Fish	0.3	10.87	11.12		11.21		1.3	1.3	0.23		
Culvert Outlet		6.5 Flow	6.5	9.87	11.43		11.74		2.48	2.48	2.63		
		1%AEPflow	5	9.87	11.36		11.56		1.99	1.99	2.51		
		Fish	0.3	9.87	11		11		0.16	0.16	1.83		
downstream	156	6.5 Flow	6.5	9.87	11.43	10.53	11.46	0.000922	0.72	0.77	9.05	11.49	0.21
downstream	156	1%AEPflow	5	9.87	11.36	10.44	11.38	0.000649	0.59	0.63	8.52	11.02	0.18
downstream	156	Fish	0.3	9.87	11	9.97	11	0.000007	0.05	0.05	5.78	8.33	0.02
downstream	150	6.5 Flow	6.5	10.79	11.38	11.26	11.44	0.009426	1.1	1.11	5.91	17.15	0.58
downstream	150	1%AEPflow	5	10.79	11.31	11.22	11.37	0.010659	1.03	1.04	4.83	16.12	0.6
downstream	150	Fish	0.3	10.79	10.97	10.95	11	0.032269	0.71	0.71	0.42	5.52	0.83
downstream	125	6.5 Flow	6.5	10.45	11.12		11.2	0.009414	1.27	1.31	5.11	12.5	0.6
downstream	125	1%AEPflow	5	10.45	11.05		11.12	0.008934	1.15	1.16	4.35	11.68	0.57
downstream	125	Fish	0.3	10.45	10.69	10.61	10.7	0.006115	0.37	0.37	0.82	8.37	0.37
downstream	100	6.5 Flow	6.5	10.18	10.76		10.89	0.017147	1.59	1.61	4.09	10.76	0.79
downstream	100	1%AEPflow	5	10.18	10.68		10.8	0.019609	1.51	1.51	3.32	9.9	0.82
downstream	100	Fish	0.3	10.18	10.32	10.32	10.36	0.048336	0.84	0.84	0.36	5.02	1
downstream	75	6.5 Flow	6.5	9.76	10.59		10.65	0.005377	1.07	1.07	6.06	11.68	0.46
downstream	75	1%AEPflow	5	9.76	10.5		10.55	0.005268	0.98	0.98	5.1	10.58	0.45
downstream	75	Fish	0.3	9.76	10	9.86	10	0.001502	0.28	0.28	1.08	5.87	0.21
downstream	50	6.5 Flow	6.5	9.74	10.39		10.47	0.009009	1.28	1.28	5.08	10.56	0.59
downstream	50	1%AEPflow	5	9.74	10.3		10.37	0.00971	1.2	1.2	4.16	10.05	0.6
downstream	50	Fish	0.3	9.74	9.86	9.86	9.89	0.051689	0.77	0.77	0.39	6.43	1
downstream	25	6.5 Flow	6.5	9.49	10.24		10.3	0.004955	1.06	1.06	6.14	10.75	0.45
downstream	25	1%AEPflow	5	9.49	10.16		10.21	0.004496	0.95	0.95	5.26	10.08	0.42
downstream	25	Fish	0.3	9.49	9.69	9.57	9.69	0.001383	0.25	0.25	1.2	7.19	0.19
downstream	0	6.5 Flow	6.5	9.43	10.06	9.91	10.14	0.009063	1.24	1.24	5.23	11.46	0.59
downstream	0	1%AEPflow	5	9.43	9.98	9.85	10.05	0.009069	1.13	1.13	4.41	11.08	0.57
downstream	0	Fish	0.3	9.43	9.61	9.57	9.62	0.009065	0.42	0.42	0.71	8.06	0.45

Assumed 2.0 CSP

0.907% streambed slope used for downstream boundary condition
3.56% streambed slope used for upstream north branch boundary condition
2.24% streambed slope used for upstream south branch boundary condition
Manning's n 0.045 used for the channel based on site photo's, Clean, winding, some pools, shoals, weeds and stones.
Manning's n 0.100 used for the overbanks based on site photo's, Medium to dense brush in summer.

62.0 m Long Culvert

Pipe projecting from slope
Not embedded

Road Elevation 18.79m

Appendix E
PROPOSED STRUCTURE HEC RAS OUTPUTS AND CROSS-SECTIONS

Site With 3.0m CSP

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Total	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m/s)	(m2)	(m)	
upstream_north	322	6.5 Flow	4.23	13.79	14.28	14.33	14.49	0.035606	1.41	2.27	3	12.29	1.14
upstream_north	322	1%AEPflow	3.25	13.79	14.23	14.27	14.41	0.035606	1.35	2.08	2.41	11.34	1.12
upstream_north	322	Fish	0.2	13.79	13.94	13.93	13.97	0.035825	0.79	0.8	0.25	3.19	0.88
upstream_north	297	6.5 Flow	4.23	12.78	13.05	13.11	13.27	0.07052	1.64	2.34	2.57	12.27	1.49
upstream_north	297	1%AEPflow	3.25	12.78	13.02	13.06	13.2	0.069862	1.5	2.11	2.16	12.03	1.45
upstream_north	297	Fish	0.2	12.78	12.85	12.85	12.87	0.054711	0.63	0.69	0.31	7.23	1
upstream_north	272	6.5 Flow	4.23	11.78	12.28	12.28	12.43	0.030343	1.71	1.75	2.47	8.69	1
upstream_north	272	1%AEPflow	3.25	11.78	12.23	12.23	12.36	0.032607	1.59	1.61	2.04	8.34	1.01
upstream_north	272	Fish	0.2	11.78	11.97	11.92	11.98	0.012664	0.5	0.5	0.39	4.2	0.53
upstream_north	247	6.5 Flow	4.23	11.12	12.28	11.74	12.3	0.001398	0.62	0.63	6.87	10.86	0.24
upstream_north	247	1%AEPflow	3.25	11.12	12.05	11.68	12.08	0.002472	0.69	0.69	4.69	8.84	0.3
upstream_north	247	Fish	0.2	11.12	11.35	11.35	11.39	0.058919	0.84	0.84	0.23	3.66	1.07
upstream south	322	6.5 Flow	2.28	13.32	13.66	13.66	13.76	0.030252	1.21	1.4	1.88	11.57	0.95
upstream south	322	1%AEPflow	1.75	13.32	13.63	13.63	13.71	0.034056	1.19	1.31	1.47	10.34	0.98
upstream south	322	Fish	0.11	13.32	13.42	13.42	13.44	0.055991	0.71	0.71	0.15	2.92	1.01
upstream south	297	6.5 Flow	2.28	12.55	12.98	12.86	13.02	0.007128	0.84	0.88	2.72	9.54	0.49
upstream south	297	1%AEPflow	1.75	12.55	12.94	12.83	12.97	0.006466	0.74	0.77	2.36	9.22	0.46
upstream south	297	Fish	0.11	12.55	12.69	12.64	12.69	0.005511	0.29	0.29	0.36	4.97	0.34
upstream south	272	6.5 Flow	2.28	12.32	12.61	12.61	12.69	0.032308	1.15	1.26	1.97	14.75	0.95
upstream south	272	1%AEPflow	1.75	12.32	12.58	12.58	12.65	0.036317	1.12	1.18	1.56	12.75	0.98
upstream south	272	Fish	0.11	12.32	12.46		12.46	0.018282	0.36	0.36	0.29	7.17	0.56
upstream south	247	6.5 Flow	2.28	11.64	12.29	11.98	12.3	0.001151	0.4	0.46	5.75	17.87	0.21
upstream south	247	1%AEPflow	1.75	11.64	12.08	11.95	12.1	0.004984	0.63	0.65	2.76	11.99	0.4
upstream south	247	Fish	0.11	11.64	11.76	11.76	11.78	0.044635	0.63	0.63	0.17	3.36	0.9
downstream	222	6.5 Flow	6.5	10.74	12.15	11.47	12.23	0.004034	1.25	1.25	5.22	7.97	0.36
downstream	222	1%AEPflow	5	10.74	11.92	11.36	11.99	0.004067	1.17	1.17	4.27	5.86	0.36
downstream	222	Fish	0.3	10.74	11.02	10.84	11.02	0.001431	0.33	0.33	0.92	3.39	0.2
Culvert Inlet		6.5 Flow	6.5	10.74	11.77		12.01		2.18	2.18	2.98		
		1%AEPflow	5	10.74	11.61		11.81		1.98	1.98	2.52		
		Fish	0.3	10.74	11.01		11.02		0.41	0.41	0.73		
Culvert Outlet		6.5 Flow	6.5	10.43	11.43		11.69		2.25	2.25	2.89		
		1%AEPflow	5	10.43	11.36		11.54		1.86	1.86	2.7		
		Fish	0.3	10.43	11		11		0.19	0.19	1.62		
downstream	156	6.5 Flow	6.5	9.87	11.43	10.53	11.46	0.000902	0.69	0.77	9.41	11.5	0.21
downstream	156	1%AEPflow	5	9.87	11.36	10.44	11.38	0.000636	0.57	0.62	8.82	11.02	0.17
downstream	156	Fish	0.3	9.87	11	9.97	11	0.000007	0.05	0.05	5.9	8.33	0.02
downstream	150	6.5 Flow	6.5	10.79	11.38	11.26	11.44	0.009403	1.11	1.12	5.84	17.09	0.58
downstream	150	1%AEPflow	5	10.79	11.31	11.22	11.37	0.010459	1.04	1.04	4.81	16.11	0.6
downstream	150	Fish	0.3	10.79	10.97	10.95	11	0.032269	0.71	0.71	0.42	5.52	0.83
downstream	125	6.5 Flow	6.5	10.45	11.12		11.2	0.009414	1.27	1.31	5.11	12.5	0.6
downstream	125	1%AEPflow	5	10.45	11.05		11.12	0.008934	1.15	1.16	4.35	11.68	0.57
downstream	125	Fish	0.3	10.45	10.69	10.61	10.7	0.006115	0.37	0.37	0.82	8.37	0.37
downstream	100	6.5 Flow	6.5	10.18	10.76		10.89	0.017147	1.59	1.61	4.09	10.76	0.79
downstream	100	1%AEPflow	5	10.18	10.68		10.8	0.019609	1.51	1.51	3.32	9.9	0.82
downstream	100	Fish	0.3	10.18	10.32	10.32	10.36	0.048336	0.84	0.84	0.36	5.02	1
downstream	75	6.5 Flow	6.5	9.76	10.59		10.65	0.005377	1.07	1.07	6.06	11.68	0.46
downstream	75	1%AEPflow	5	9.76	10.5		10.55	0.005268	0.98	0.98	5.1	10.58	0.45
downstream	75	Fish	0.3	9.76	10	9.86	10	0.001498	0.28	0.28	1.08	5.87	0.21
downstream	50	6.5 Flow	6.5	9.74	10.39		10.47	0.009009	1.28	1.28	5.08	10.56	0.59
downstream	50	1%AEPflow	5	9.74	10.3		10.37	0.009704	1.2	1.2	4.16	10.05	0.6
downstream	50	Fish	0.3	9.74	9.86	9.86	9.89	0.051689	0.77	0.77	0.39	6.43	1
downstream	25	6.5 Flow	6.5	9.49	10.24		10.3	0.004955	1.06	1.06	6.14	10.75	0.45
downstream	25	1%AEPflow	5	9.49	10.16		10.21	0.004489	0.95	0.95	5.26	10.08	0.42
downstream	25	Fish	0.3	9.49	9.69	9.57	9.69	0.001358	0.25	0.25	1.21	7.2	0.19
downstream	0	6.5 Flow	6.5	9.43	10.06	9.91	10.14	0.009063	1.24	1.24	5.23	11.46	0.59
downstream	0	1%AEPflow	5	9.43	9.98	9.85	10.05	0.009069	1.13	1.13	4.41	11.08	0.57
downstream	0	Fish	0.3	9.43	9.61	9.57	9.62	0.009065	0.42	0.42	0.71	8.06	0.45

Assumed 3.0 CSP, embedded 25% (0.75m)

0.907% streambed slope used for downstream boundary condition
3.56% streambed slope used for upstream north branch boundary condition
2.24% streambed slope used for upstream south branch boundary condition
Manning's n 0.045 used for the channel based on site photo's, Clean, winding, some pools, shoals, weeds and stones.
Manning's n 0.100 used for the overbanks based on site photo's, Medium to dense brush in summer.

62.0 m Long Culvert

Pipe projecting from slope

Road Elevation 18.79m

Culvert Slope 0.5%

US Inv	9.99
DS	9.68

Site With 3.67m SPCSP													
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Total	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m/s)	(m2)	(m)	
upstream_north	322	6.5 Flow	4.23	13.79	14.28	14.33	14.49	0.035606	1.41	2.27	3	12.29	1.14
upstream_north	322	1%AEPflow	3.25	13.79	14.23	14.27	14.41	0.035606	1.35	2.08	2.41	11.34	1.12
upstream_north	322	Fish	0.2	13.79	13.94	13.93	13.97	0.035825	0.79	0.8	0.25	3.19	0.88
upstream_north	297	6.5 Flow	4.23	12.78	13.05	13.11	13.27	0.07052	1.64	2.34	2.57	12.27	1.49
upstream_north	297	1%AEPflow	3.25	12.78	13.02	13.06	13.2	0.069862	1.5	2.11	2.16	12.03	1.45
upstream_north	297	Fish	0.2	12.78	12.85	12.85	12.87	0.054711	0.63	0.69	0.31	7.23	1
upstream_north	272	6.5 Flow	4.23	11.78	12.28	12.28	12.43	0.030343	1.71	1.75	2.47	8.69	1
upstream_north	272	1%AEPflow	3.25	11.78	12.23	12.23	12.36	0.032607	1.59	1.61	2.04	8.34	1.01
upstream_north	272	Fish	0.2	11.78	11.97	11.92	11.98	0.012664	0.5	0.5	0.39	4.2	0.53
upstream_north	247	6.5 Flow	4.23	11.12	12.13	11.74	12.16	0.002791	0.78	0.79	5.38	9.42	0.32
upstream_north	247	1%AEPflow	3.25	11.12	11.95	11.68	11.99	0.004512	0.85	0.85	3.82	8.13	0.4
upstream_north	247	Fish	0.2	11.12	11.35	11.35	11.39	0.058919	0.84	0.84	0.23	3.66	1.07
upstream south	322	6.5 Flow	2.28	13.32	13.66	13.66	13.76	0.030252	1.21	1.4	1.88	11.57	0.95
upstream south	322	1%AEPflow	1.75	13.32	13.63	13.63	13.71	0.034056	1.19	1.31	1.47	10.34	0.98
upstream south	322	Fish	0.11	13.32	13.42	13.42	13.44	0.055991	0.71	0.71	0.15	2.92	1.01
upstream south	297	6.5 Flow	2.28	12.55	12.98	12.86	13.02	0.007128	0.84	0.88	2.72	9.54	0.49
upstream south	297	1%AEPflow	1.75	12.55	12.94	12.83	12.97	0.006477	0.74	0.77	2.36	9.22	0.46
upstream south	297	Fish	0.11	12.55	12.69	12.64	12.69	0.005511	0.29	0.29	0.36	4.97	0.34
upstream south	272	6.5 Flow	2.28	12.32	12.61	12.61	12.69	0.032308	1.15	1.26	1.97	14.75	0.95
upstream south	272	1%AEPflow	1.75	12.32	12.58	12.58	12.65	0.036317	1.12	1.18	1.56	12.75	0.98
upstream south	272	Fish	0.11	12.32	12.46		12.46	0.018282	0.36	0.36	0.29	7.17	0.56
upstream south	247	6.5 Flow	2.28	11.64	12.17	11.98	12.19	0.003311	0.59	0.64	3.85	13.78	0.34
upstream south	247	1%AEPflow	1.75	11.64	12.01	11.95	12.05	0.014361	0.9	0.9	1.94	9.75	0.64
upstream south	247	Fish	0.11	11.64	11.76	11.76	11.78	0.044635	0.63	0.63	0.17	3.36	0.9
downstream	222	6.5 Flow	6.5	10.74	11.92	11.47	12.04	0.006903	1.52	1.52	4.27	5.85	0.47
downstream	222	1%AEPflow	5	10.74	11.73	11.36	11.84	0.007032	1.42	1.42	3.52	3.92	0.48
downstream	222	Fish	0.3	10.74	11.01	10.84	11.02	0.001604	0.34	0.34	0.88	3.38	0.21
Culvert Inlet		6.5 Flow	6.5	10.74	11.63		11.84		2.06	2.06	3.16		
		1%AEPflow	5	10.74	11.51		11.68		1.84	1.84	2.72		
		Fish	0.3	10.74	11.01		11.01		0.33	0.33	0.92		
Culvert Outlet		6.5 Flow	6.5	10.42	11.43		11.6		1.82	1.82	3.56		
		1%AEPflow	5	10.42	11.36		11.48		1.51	1.51	3.32		
		Fish	0.3	10.42	11		11		0.15	0.15	2		
downstream	156	6.5 Flow	6.5	9.87	11.43	10.53	11.46	0.000891	0.68	0.76	9.6	11.5	0.21
downstream	156	1%AEPflow	5	9.87	11.36	10.44	11.38	0.000629	0.56	0.62	9	11.02	0.17
downstream	156	Fish	0.3	9.87	11	9.97	11	0.000007	0.05	0.05	5.95	8.33	0.02
downstream	150	6.5 Flow	6.5	10.79	11.38	11.26	11.44	0.00941	1.1	1.11	5.89	17.13	0.58
downstream	150	1%AEPflow	5	10.79	11.31	11.22	11.37	0.010651	1.04	1.04	4.83	16.12	0.6
downstream	150	Fish	0.3	10.79	10.97	10.95	11	0.032269	0.71	0.71	0.42	5.52	0.83
downstream	125	6.5 Flow	6.5	10.45	11.12		11.2	0.009414	1.27	1.31	5.11	12.5	0.6
downstream	125	1%AEPflow	5	10.45	11.05		11.12	0.008934	1.15	1.16	4.35	11.68	0.57
downstream	125	Fish	0.3	10.45	10.69	10.61	10.7	0.006115	0.37	0.37	0.82	8.37	0.37
downstream	100	6.5 Flow	6.5	10.18	10.76		10.89	0.017147	1.59	1.61	4.09	10.76	0.79
downstream	100	1%AEPflow	5	10.18	10.68		10.8	0.019609	1.51	1.51	3.32	9.9	0.82
downstream	100	Fish	0.3	10.18	10.32	10.32	10.36	0.048336	0.84	0.84	0.36	5.02	1
downstream	75	6.5 Flow	6.5	9.76	10.59		10.65	0.005377	1.07	1.07	6.06	11.68	0.46
downstream	75	1%AEPflow	5	9.76	10.5		10.55	0.005268	0.98	0.98	5.1	10.58	0.45
downstream	75	Fish	0.3	9.76	10	9.86	10	0.001498	0.28	0.28	1.08	5.87	0.21
downstream	50	6.5 Flow	6.5	9.74	10.39		10.47	0.009009	1.28	1.28	5.08	10.56	0.59
downstream	50	1%AEPflow	5	9.74	10.3		10.37	0.009704	1.2	1.2	4.16	10.05	0.6
downstream	50	Fish	0.3	9.74	9.86	9.86	9.89	0.051689	0.77	0.77	0.39	6.43	1
downstream	25	6.5 Flow	6.5	9.49	10.24		10.3	0.004955	1.06	1.06	6.14	10.75	0.45
downstream	25	1%AEPflow	5	9.49	10.16		10.21	0.004489	0.95	0.95	5.26	10.08	0.42
downstream	25	Fish	0.3	9.49	9.69	9.57	9.69	0.001358	0.25	0.25	1.21	7.2	0.19
downstream	0	6.5 Flow	6.5	9.43	10.06	9.91	10.14	0.009063	1.24	1.24	5.23	11.46	0.59
downstream	0	1%AEPflow	5	9.43	9.98	9.85	10.05	0.009069	1.13	1.13	4.41	11.08	0.57
downstream	0	Fish	0.3	9.43	9.61	9.57	9.62	0.009065	0.42	0.42	0.71	8.06	0.45

Assumed 3.67 SPCSP, embedded 25% (0.92m)

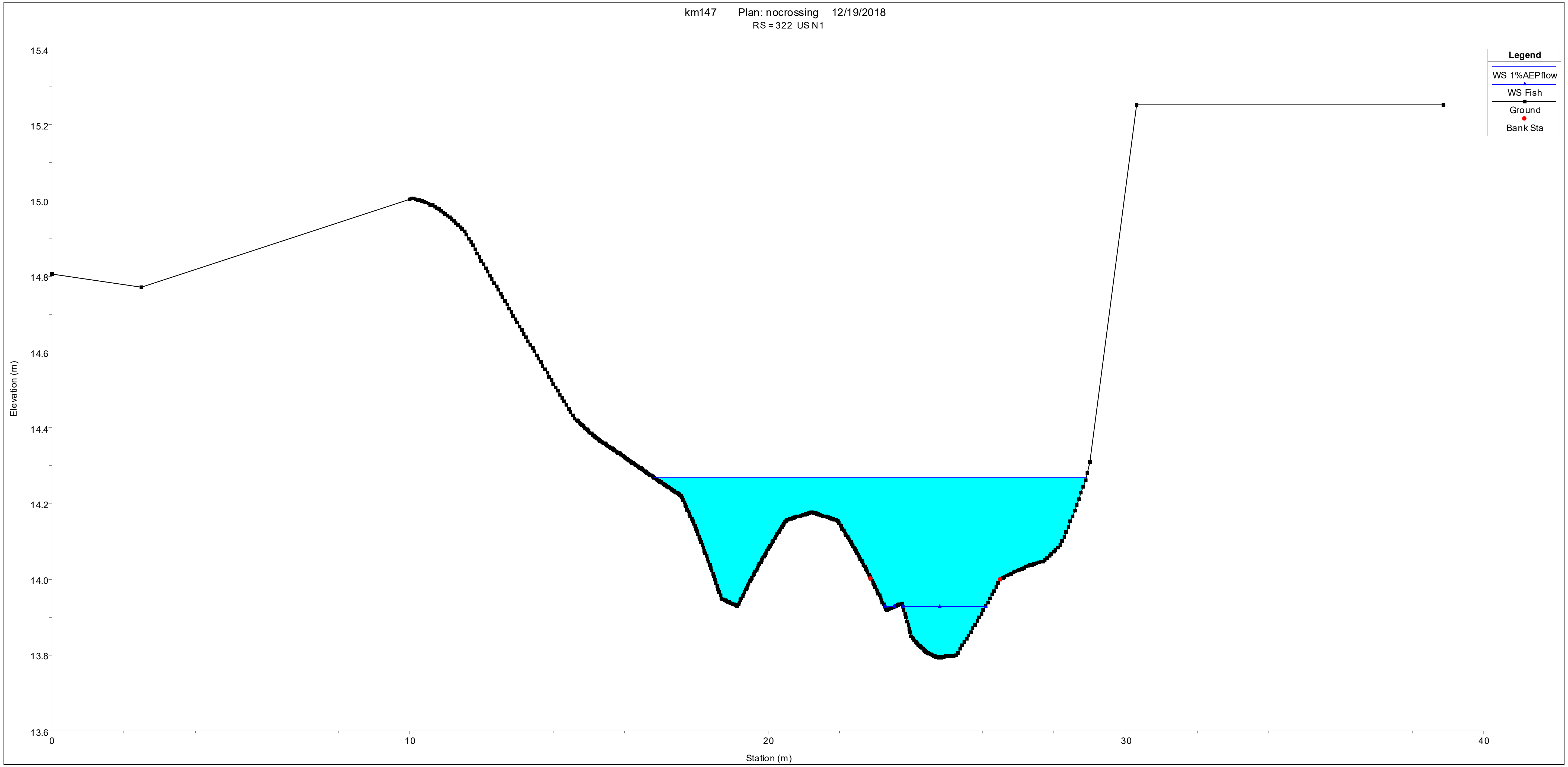
0.907% streambed slope used for downstream boundary condition
3.56% streambed slope used for upstream north branch boundary condition
2.24% streambed slope used for upstream south branch boundary condition
Manning's n 0.045 used for the channel based on site photo's, Clean, winding, some pools, shoals, weeds and stones.
Manning's n 0.100 used for the overbanks based on site photo's, Medium to dense brush in summer.

62.0 m Long Culvert

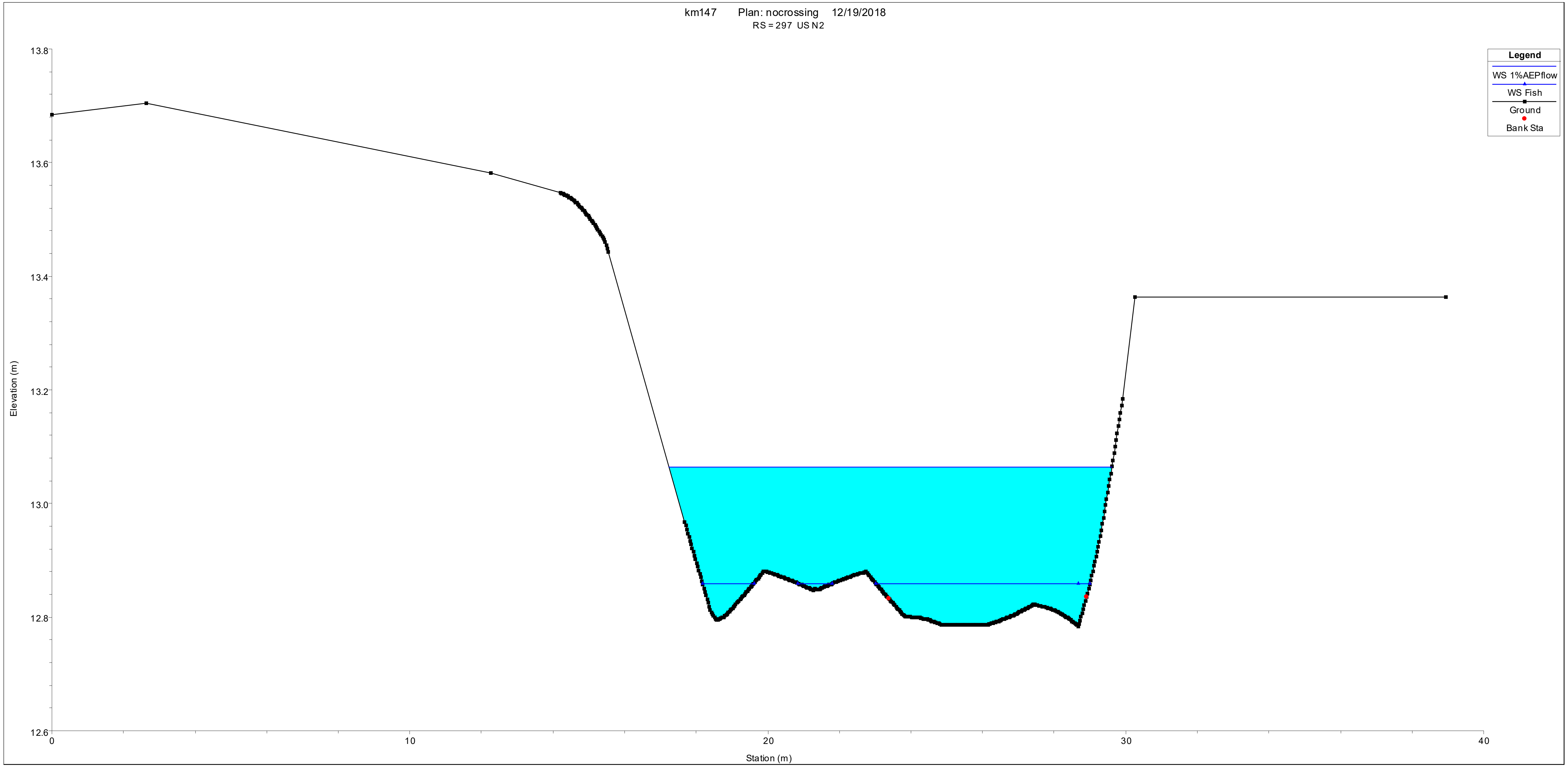
Pipe projecting from slope

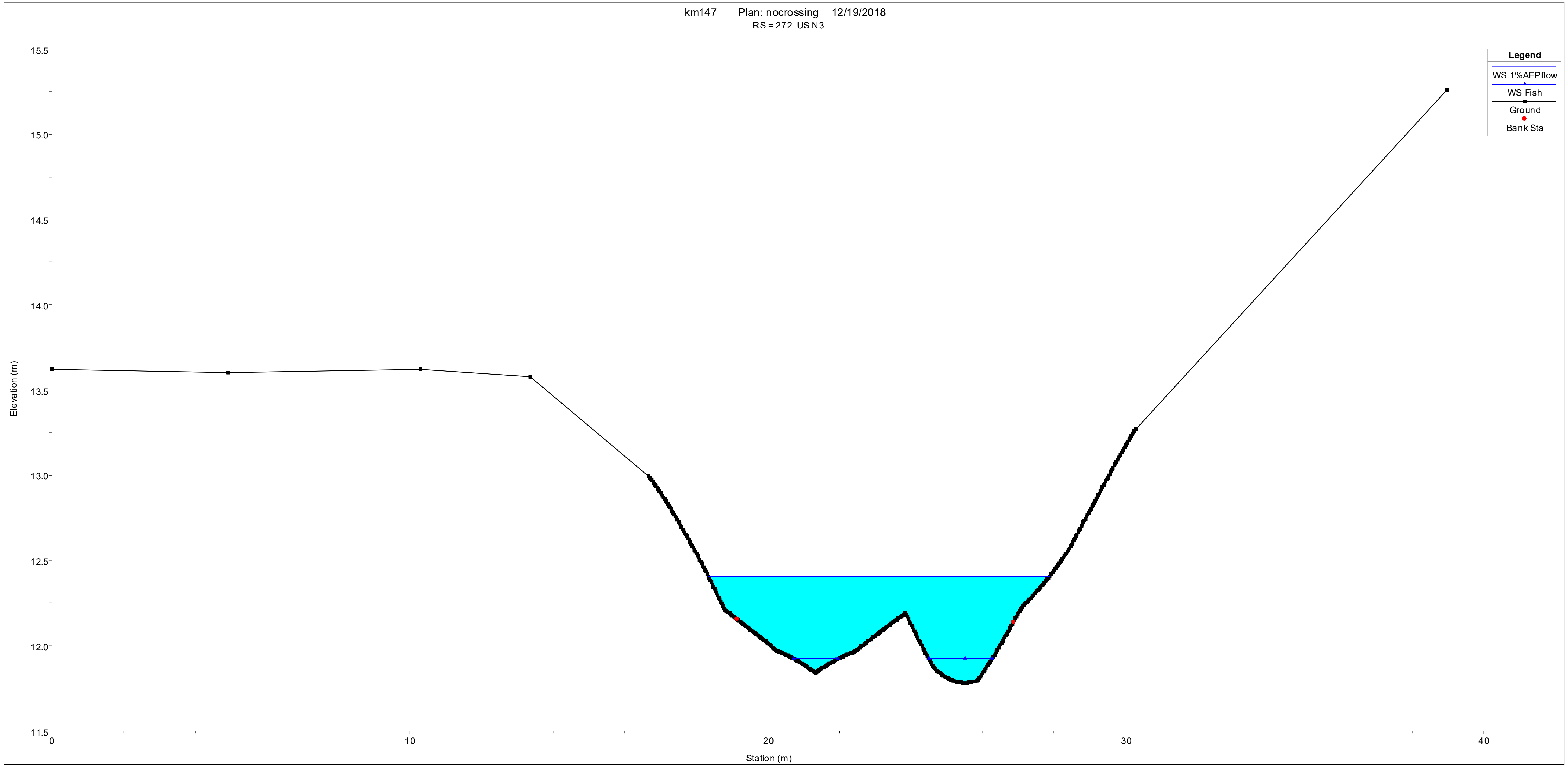
Road Elevation 18.79m

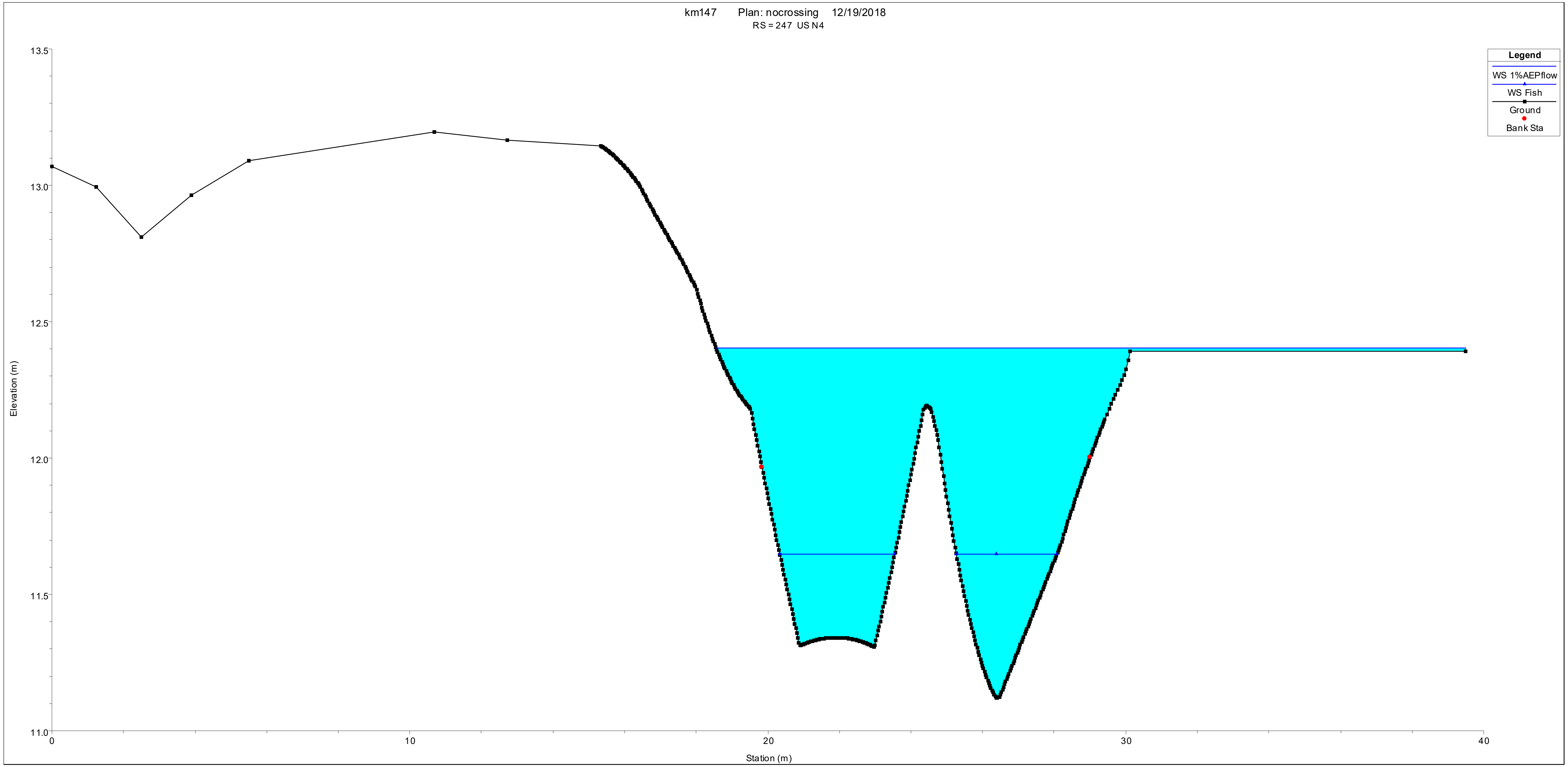
Culvert Slope 0.5%
US Inv 9.81
DS 9.5

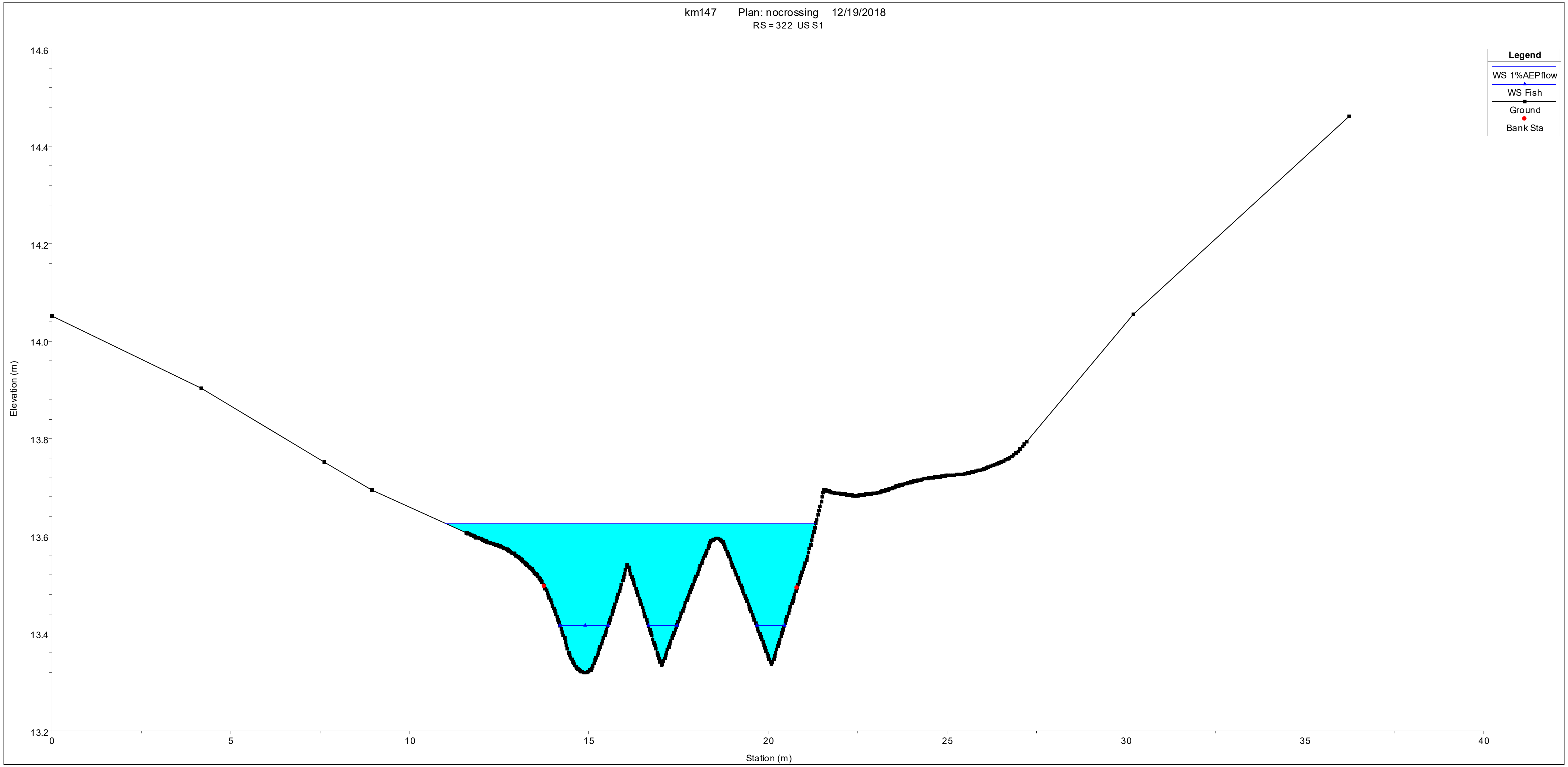


km147 Plan: nocrossing 12/19/2018
RS = 322 US N1
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
15.4
15.2
15.0
14.8
14.6
14.4
14.2
14.0
13.8
13.6
0
10
20
30
40

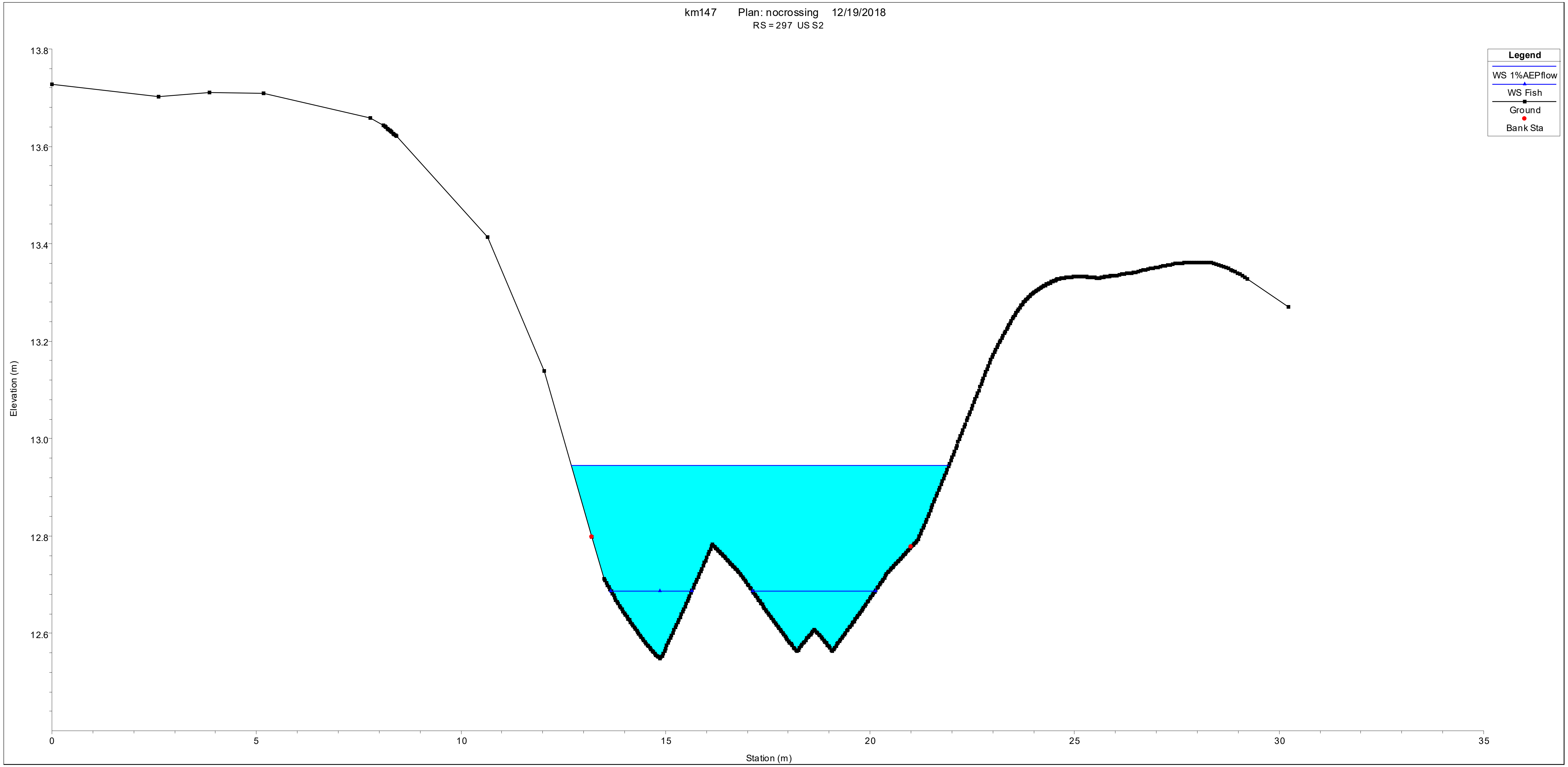

km147 Plan: nocrossing 12/19/2018
RS = 297 US N2
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
13.8
13.6
13.4
13.2
13.0
12.8
12.6
0
10
20
30
40

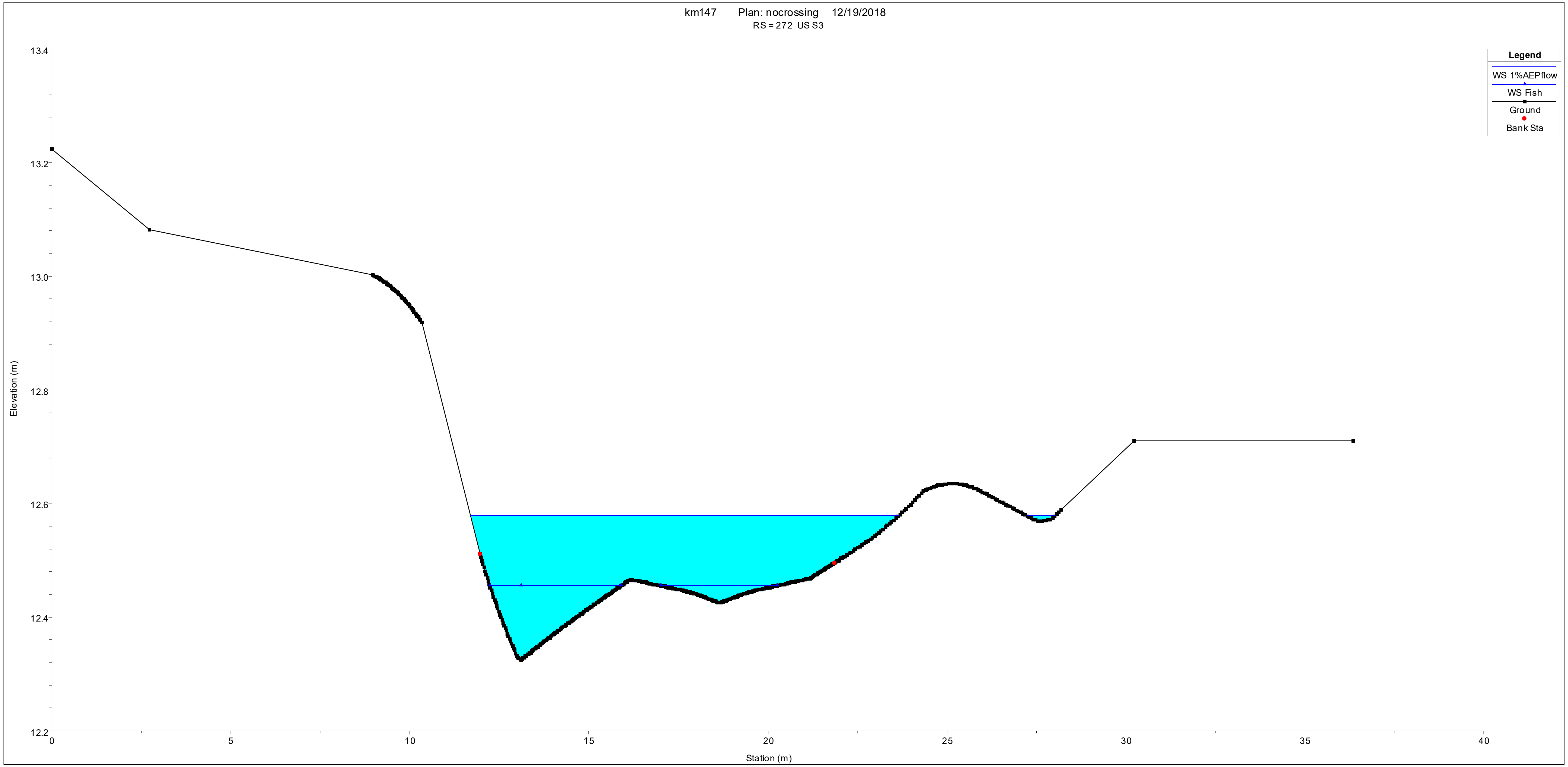

km147 Plan: nocrossing 12/19/2018
RS = 272 US N3
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
0
10
20
30
40


km147 Plan: nocrossing 12/19/2018
RS = 247 US N4
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
13.5
13.0
12.5
12.0
11.5
11.0
0
10
20
30
40
Station (m)

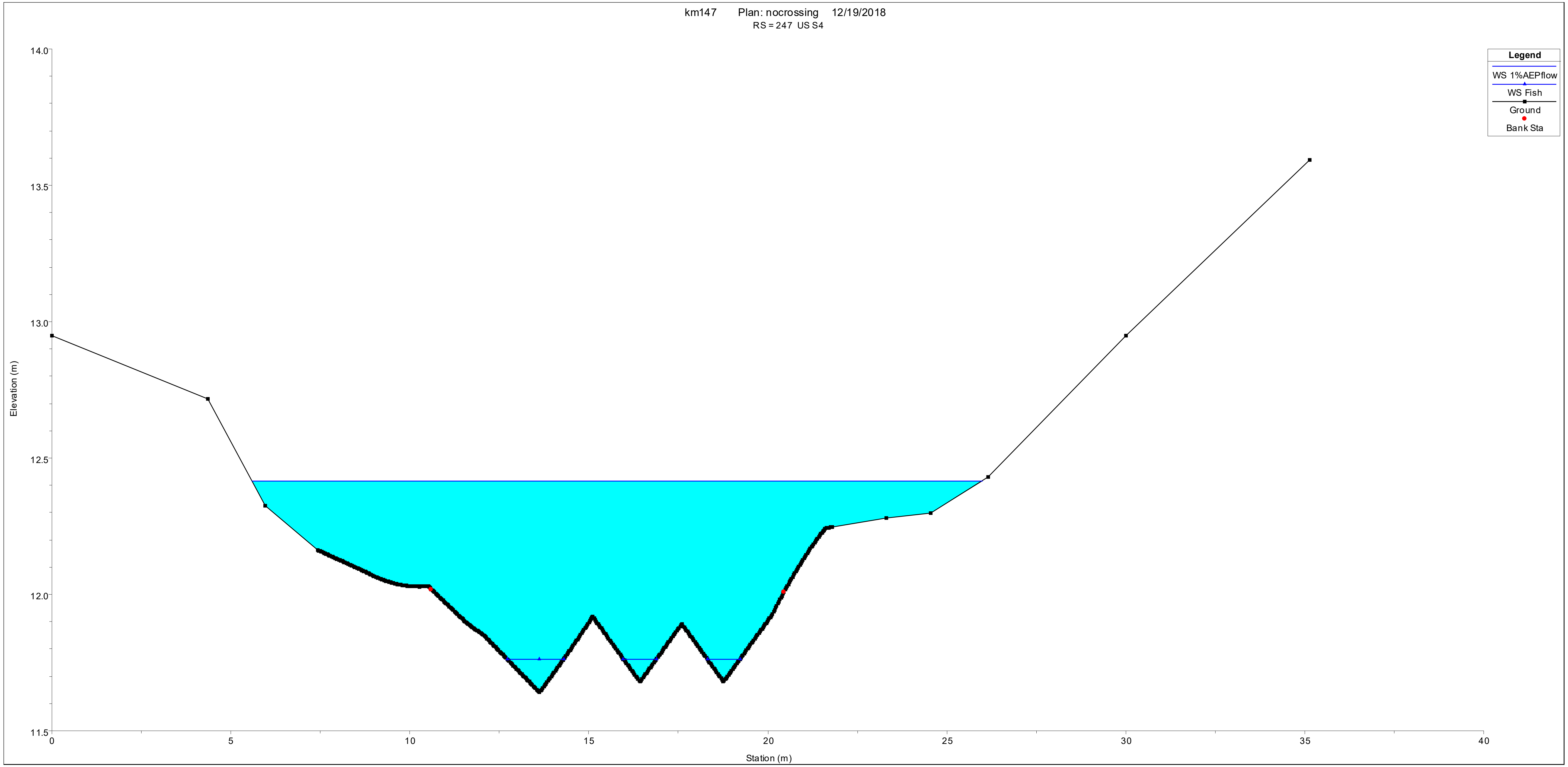


km147 Plan: nocrossing 12/19/2018
RS = 322 US S1
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
14.6
14.4
14.2
14.0
13.8
13.6
13.4
13.2
Station (m)
0
5
10
15
20
25
30
35
40

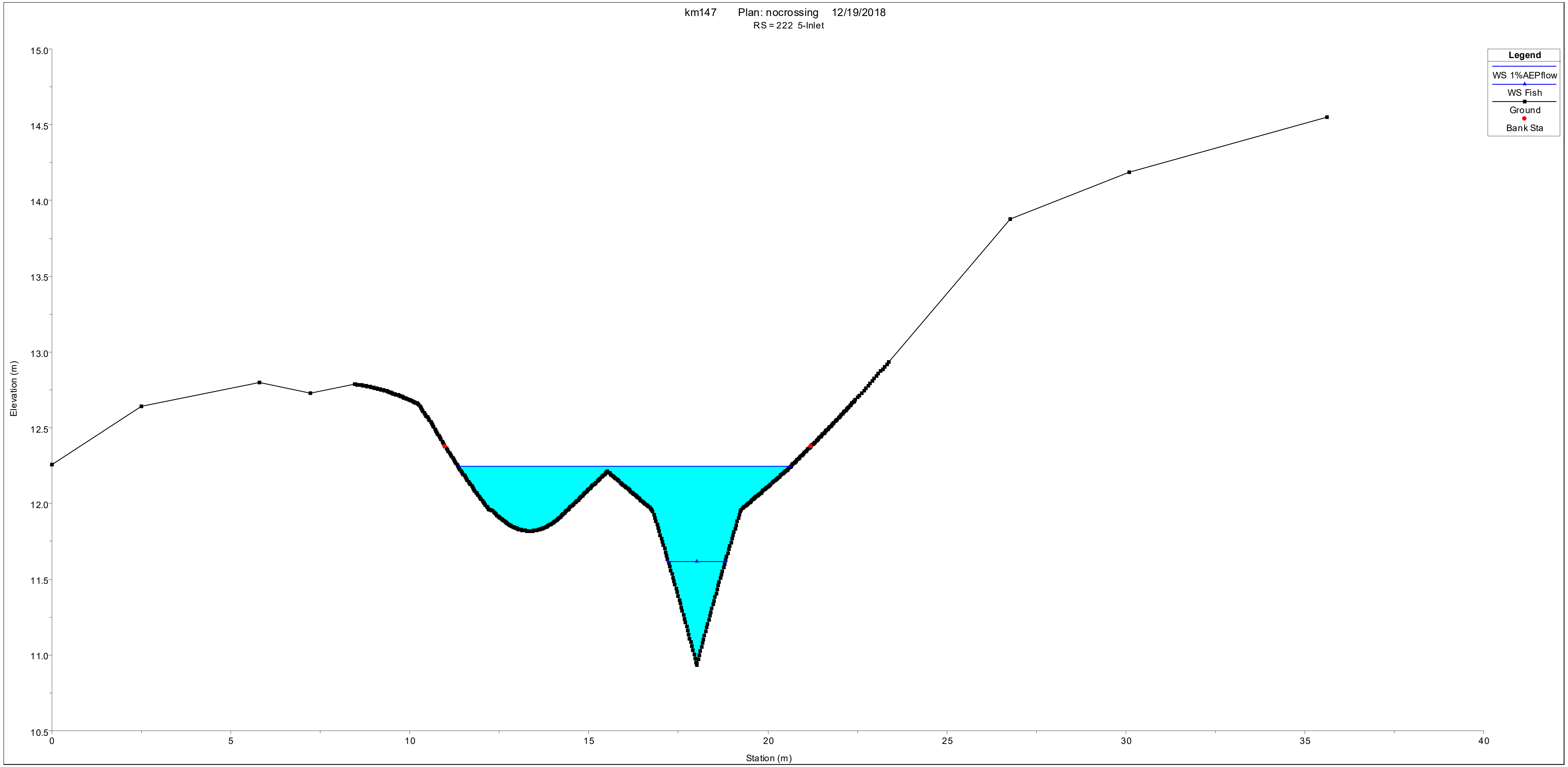

km147 Plan: nocrossing 12/19/2018
RS = 297 US S2
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
13.8
13.6
13.4
13.2
13.0
12.8
12.6
0
5
10
15
20
25
30
35

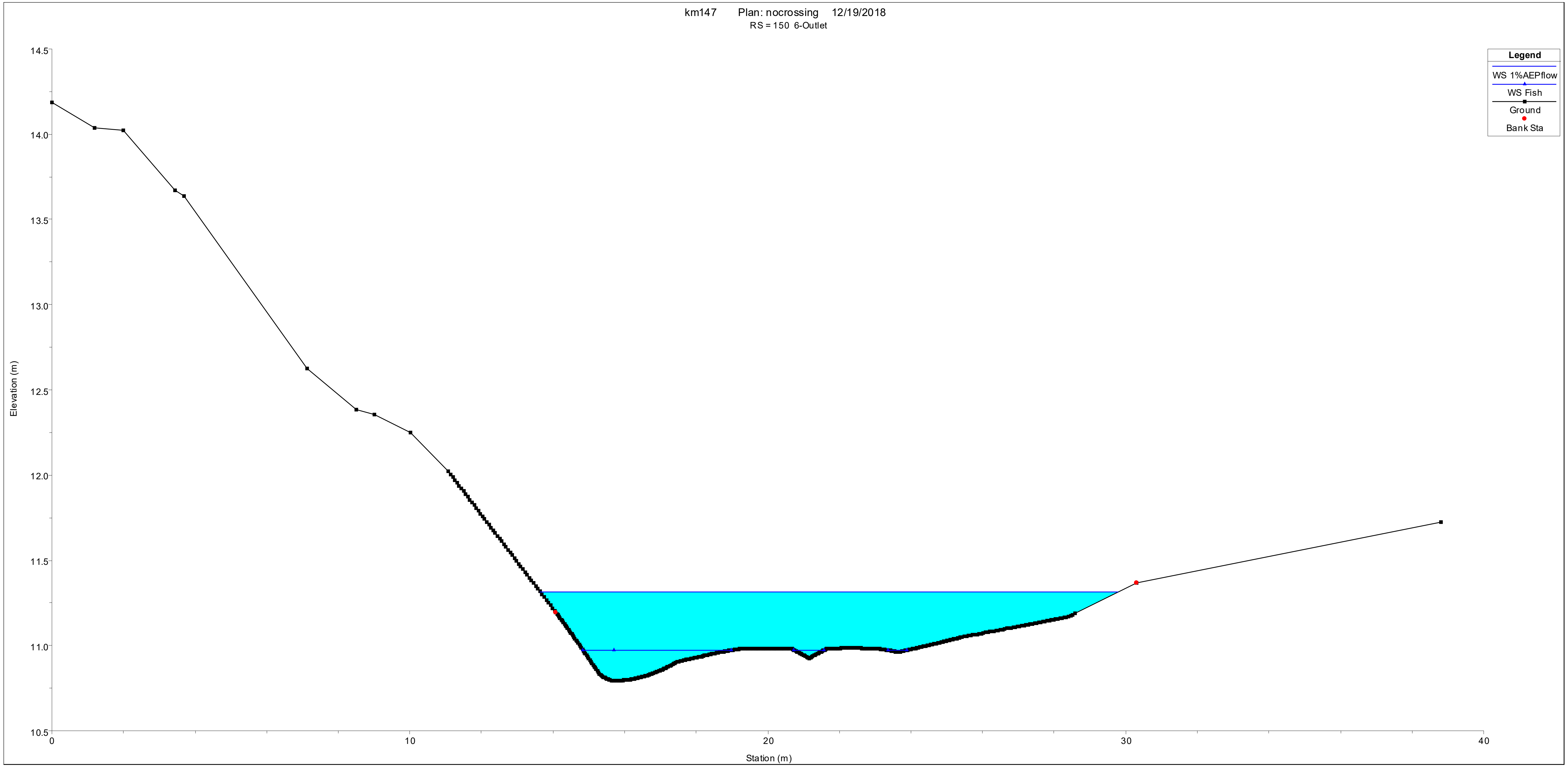


km147 Plan: nocrossing 12/19/2018
RS = 272 US S3
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
13.4
13.2
13.0
12.8
12.6
12.4
12.2
0
5
10
15
20
25
30
35
40
Station (m)

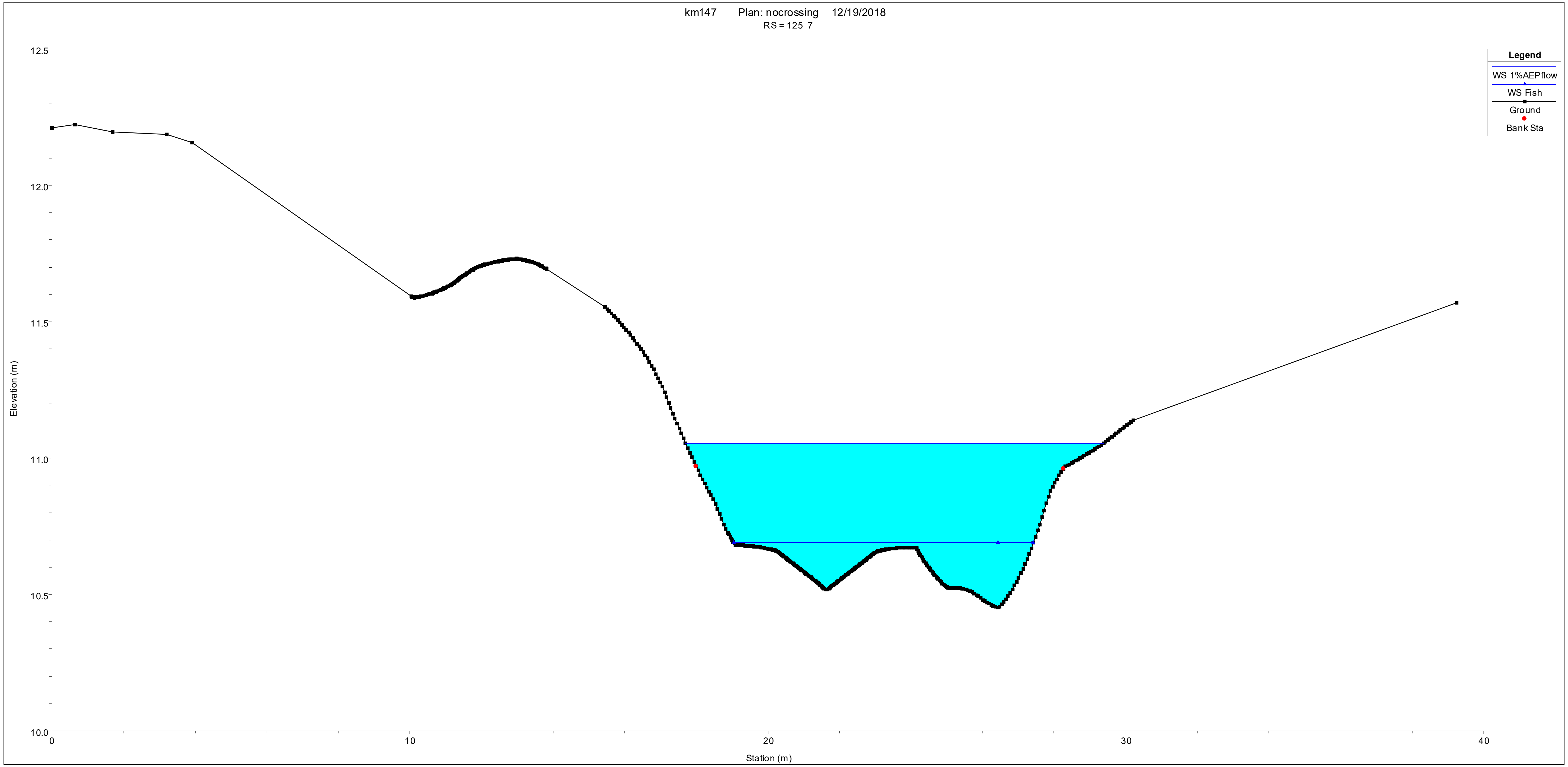


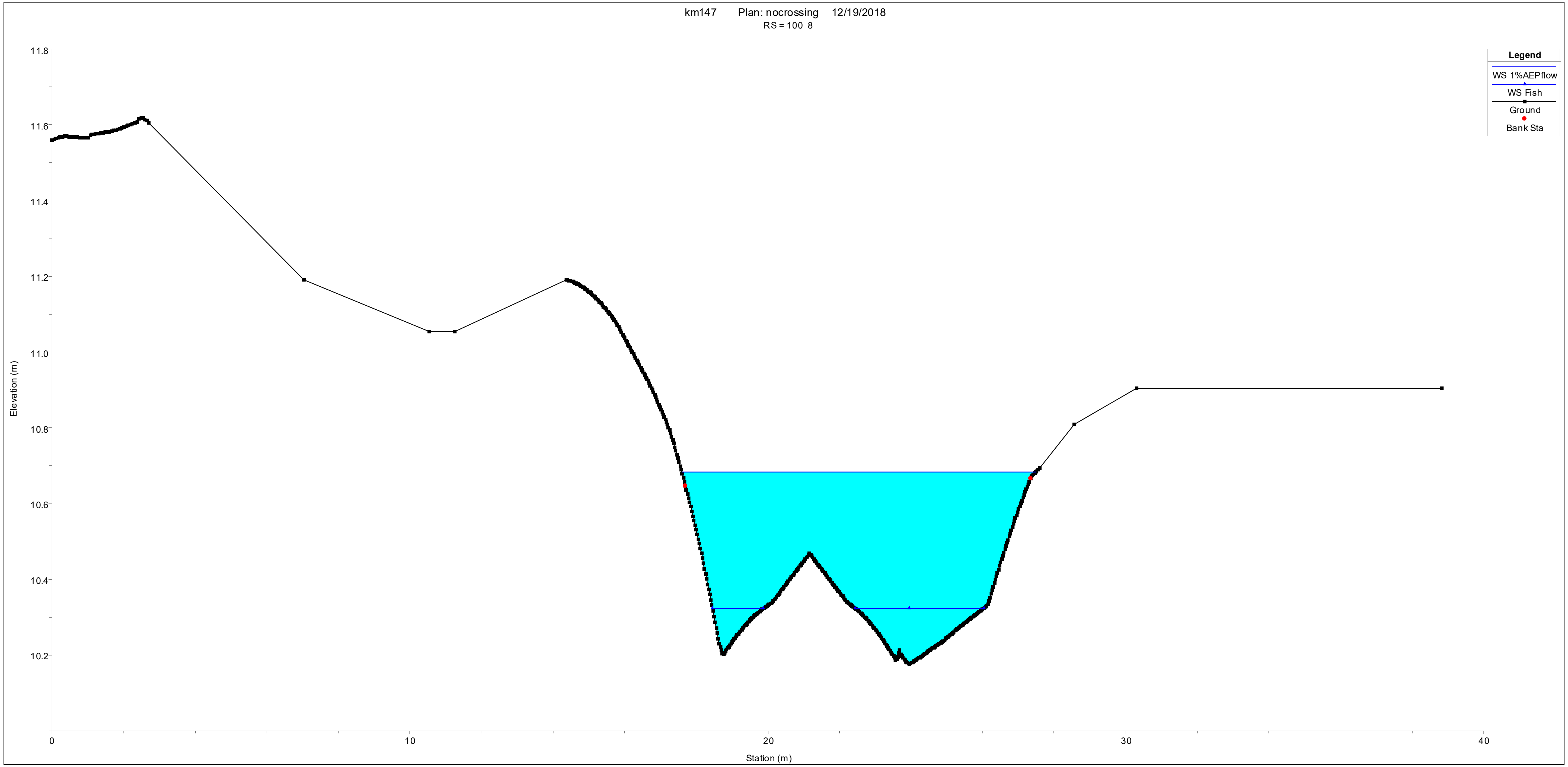
km147 Plan: nocrossing 12/19/2018
RS = 247 US S4
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
14.0
13.5
13.0
12.5
12.0
11.5
0
5
10
15
20
25
30
35
40

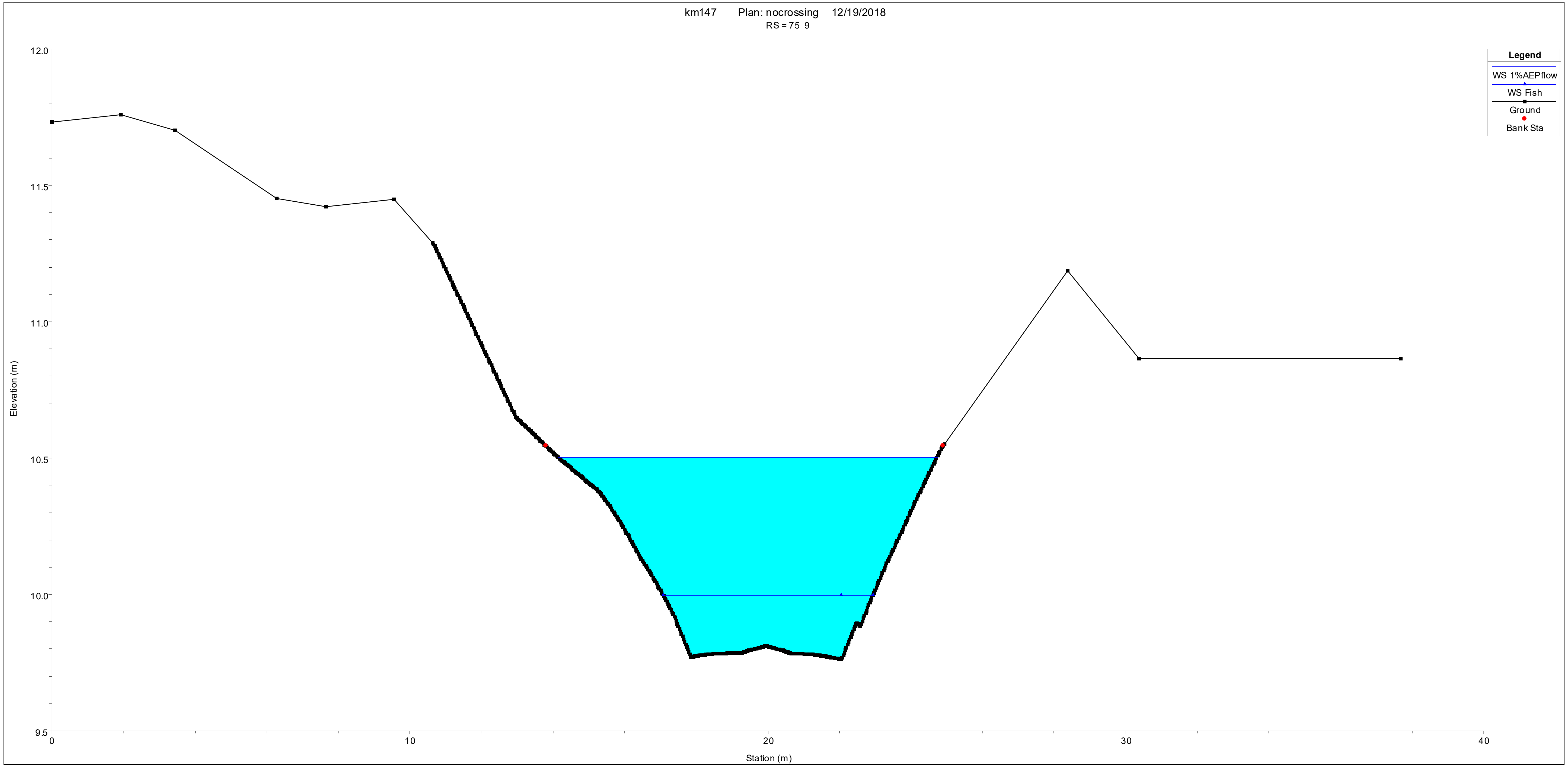

km147 Plan: nocrossing 12/19/2018
RS = 222 5-Inlet
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
0
5
10
15
20
25
30
35
40

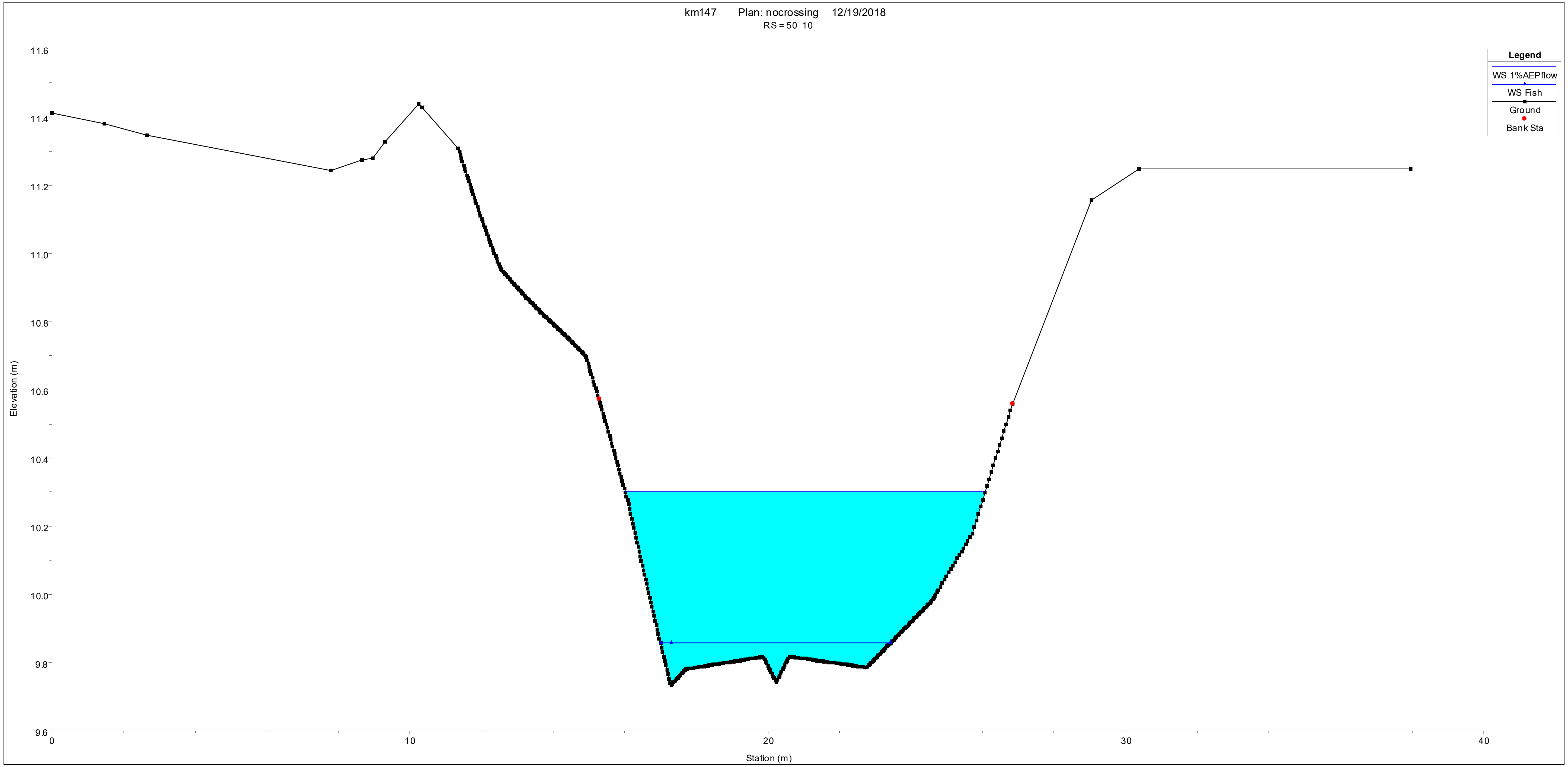


km147 Plan: nocrossing 12/19/2018
RS = 150 6-Outlet
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
0
10
20
30
40

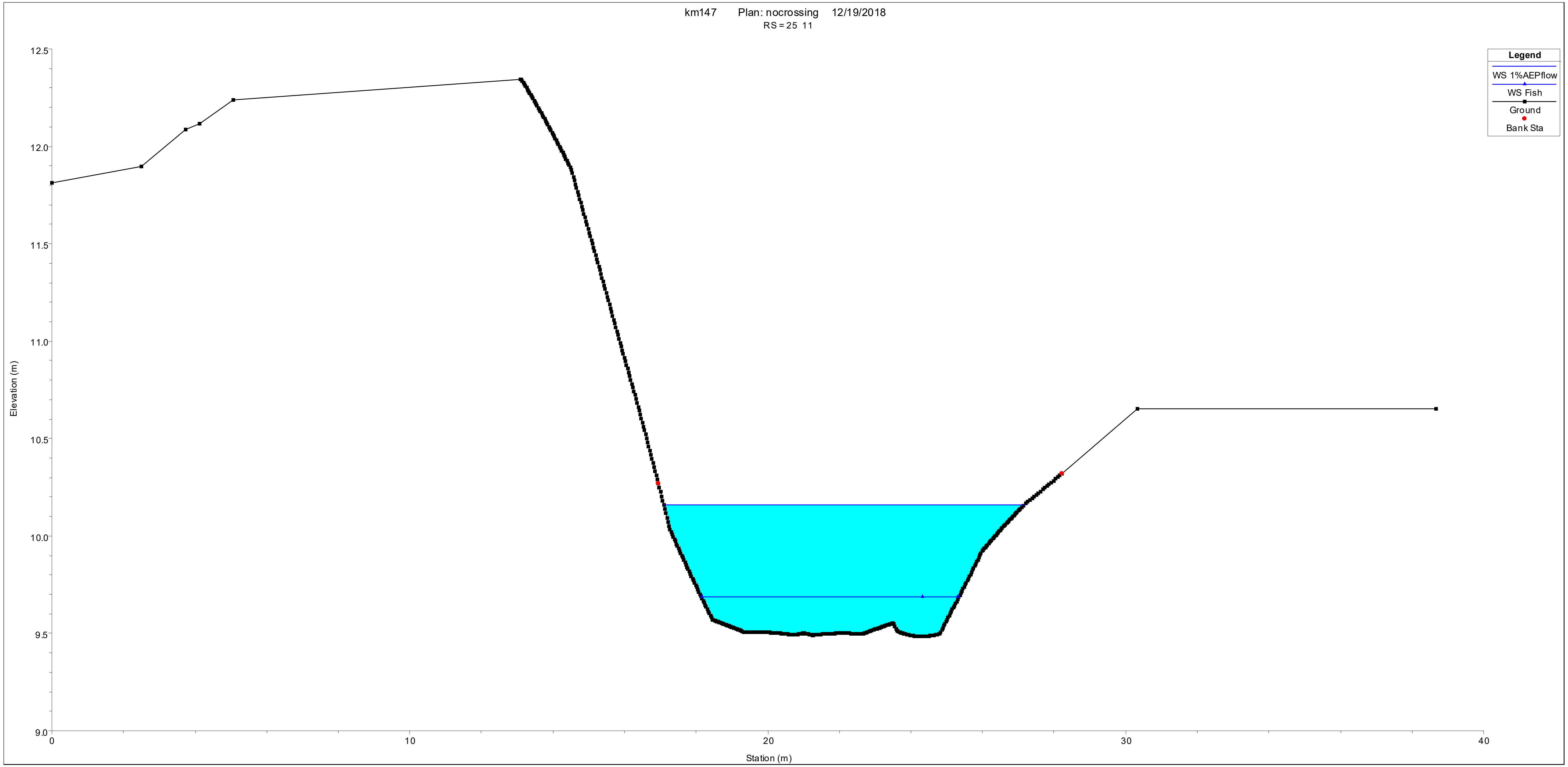

km147 Plan: nocrossing 12/19/2018
RS = 125 7
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
12.5
12.0
11.5
11.0
10.5
10.0
0
10
20
30
40
Station (m)


km147 Plan: nocrossing 12/19/2018
RS = 100 8
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
11.8
11.6
11.4
11.2
11.0
10.8
10.6
10.4
10.2
0
10
20
30
40
Station (m)

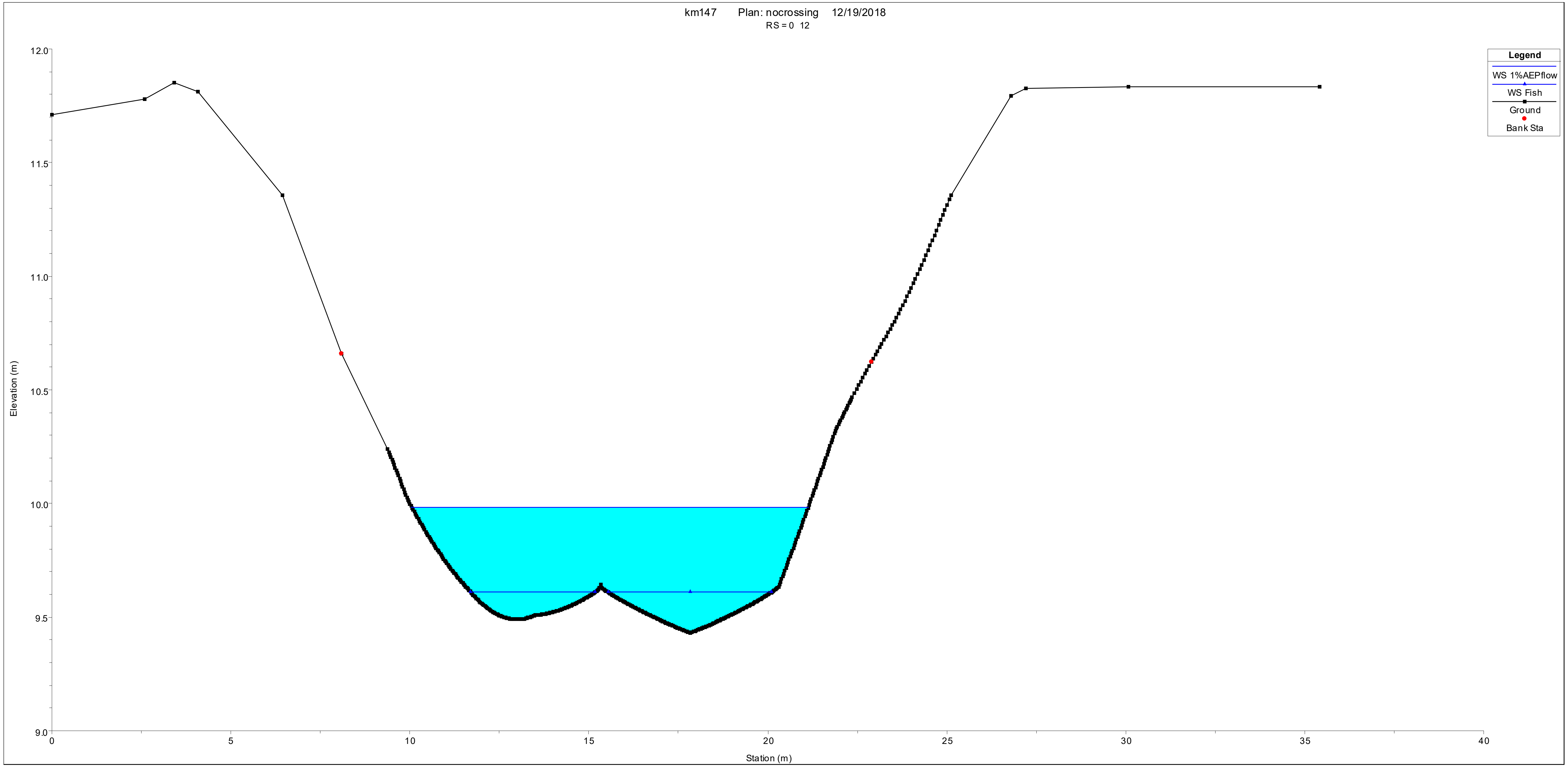

km147 Plan: nocrossing 12/19/2018
RS = 75 9
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
12.0
11.5
11.0
10.5
10.0
9.5
0
10
20
30
40



km147 Plan: nocrossing 12/19/2018
RS = 50 10
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
11.6
11.4
11.2
11.0
10.8
10.6
10.4
10.2
10.0
9.8
9.6
0
10
20
30
40



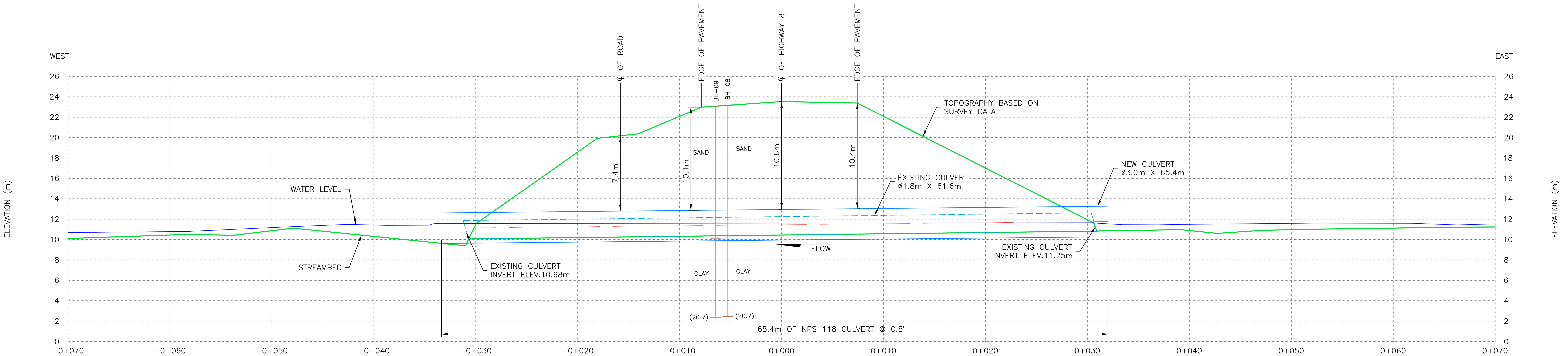
km147 Plan: nocrossing 12/19/2018
RS = 25 11
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
0
10
20
30
40



km147 Plan: nocrossing 12/19/2018
RS = 0 12
Legend
WS 1%AEPflow
WS Fish
Ground
Bank Sta
Elevation (m)
Station (m)
12.0
11.5
11.0
10.5
10.0
9.5
9.0
0
5
10
15
20
25
30
35
40

APPENDIX D – DESIGN DRAWINGS

PLAN VIEW
SCALE 1:200



TOTAL TUNNEL LENGTH 55.8m
TOTAL CULVERT LENGTH 65.4m

PROFILE ALONG CENTRELINE OF EXISTING CULVERT
SCALE 1:200 HORIZONTAL
SCALE 1:200 VERTICAL

REFERENCE DOCUMENT NO.	DATE
1. 18-209 PPP Drafting	2020-02-18
2. 2567-02-API 1102-00	2022-03-21
3. 2567-02-Jacking Force-00	2022-03-21

ENGINEER AND PERMIT STAMPS

PRELIMINARY NOT FOR CONSTRUCTION

PIPELINE SPECIFICATIONS	NPS 118
OUTSIDE DIAMETER (OD)(mm)	3000
WALL THICKNESS (WT)(mm)	25.4
GRADE	GRADE 3
PRODUCT	CULVERT
MATERIAL	STEEL
SPECIFICATIONS	ASTM A252

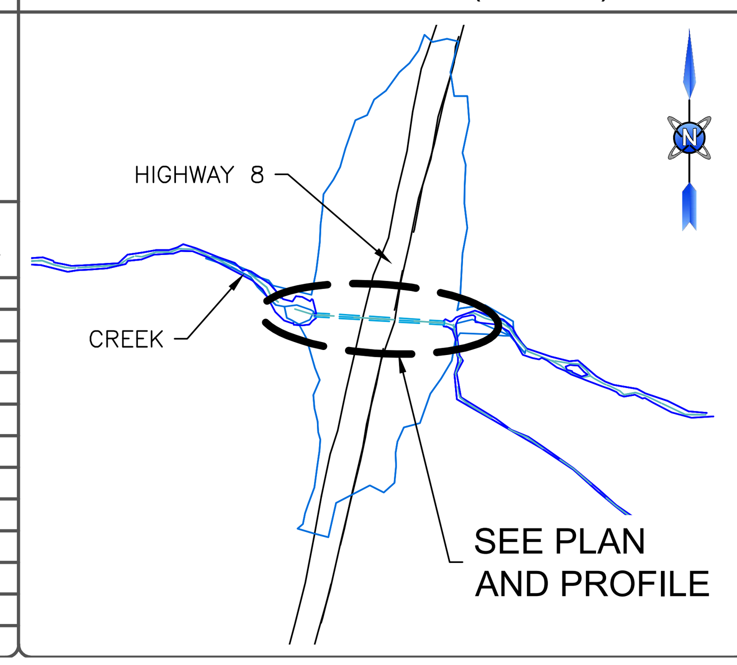
1:200
M 0 5 10 15 20
FT 0 10 20 30 40 50 60 70

PULL FORCE / RIG SIZE / STRESS

JACKING FORCE (w/o BUOYANCY CONTROL):	1,140,000 lbs (w/sf)
MINIMUM RECOMMENDED RIG SIZE:	700 TONNE

DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR PERMIT	2022-04-08	AN	MAL	AH	N/A	JLT	ES
ISSUED FOR REVIEW	2022-04-06	AN	MAL	AH	N/A	JLT	ES

LOCATION PLAN (1:3,000)



UTM - ZONE 8 - NAD 83 (CSRS)

Northwest Territories

GOVERNMENT OF THE NWT
DEPARTMENT OF INFRASTRUCTURE

HIGHWAY 8 CULVERT REPLACEMENT PROJECT
HIGHWAY 8 - NEAR TSIIGEHCHIC AUGER BORE CROSSING
PLAN AND PROFILE - NPS 118
NEAR TSIIGEHCHIC - NWT

SCALE	DWG. #	REVISION	SHEET
AS SHOWN	2567-EG-0201	B	1 OF 8

File Name: S:\Current Jobs\2567-Gov of NWT-CulvertDesign\Eng\Drawings\02-Highway 8 - KM 147.0 near Tsiigehchic\IFP\2567-EG-0201-B BORE_PHASES_NOTES.dwg Date/Time: 2022-04-22 / 1:57:36 PM Last Saved By: Abdulkadir.Nur

SITE PLAN

SCALE 1:250

NOTES

CONSTRUCTION

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE SPECIFIED.
2. ALL LENGTHS ARE ROUNDED TO THE NEAREST METRE AND ALL ANGLES ARE ROUNDED TO THE NEAREST DEGREE UNLESS OTHERWISE SPECIFIED.
3. THE CONTRACTOR SHALL VERIFY ALL TOPOGRAPHICAL SURVEY INFORMATION REPRESENTED ON THIS DRAWING IN THE FIELD PRIOR TO CONSTRUCTION.
4. THIS DRAWING IS BASED ON INFORMATION PROVIDED FROM VARIOUS SOURCES. CCI DOES NOT TAKE RESPONSIBILITY FOR THE ACCURACY OF INFORMATION PROVIDED BY OTHERS.
5. ALL EXISTING UTILITY DEPTHS ARE APPROXIMATE AND SHALL BE VERIFIED IN THE FIELD BY THE CONTRACTOR PRIOR TO ANY GROUND DISTURBANCE. VERIFICATION SHALL BE IN ACCORDANCE WITH OWNER SPECIFICATIONS AND GROUND DISTURBANCE PROCEDURES. LOCATION, WHEN SHOWN ON PLANS, IS APPROXIMATE AND SOME UTILITIES MAY NOT BE DISPLAYED. DEPTHS SHOWN IN RED ARE ASSUMED.
6. THE CONTRACTOR MUST TAKE ALL NECESSARY PRECAUTIONS DURING THE WORK TO AVOID DAMAGING EXISTING AT–SURFACE AND UNDERGROUND FACILITIES, PIPELINES, UTILITIES, OR CABLES AND ADJACENT PROPERTIES. IT IS HIS RESPONSIBILITY TO PROTECT THESE UTILITIES THROUGHOUT THE DURATION OF THE WORK.
7. CONTRACTOR SHALL PREPARE ENTRY LOCATIONS FOR SAFE WORK AND MANAGE GROUNDWATER IN THE AREA AS REQUIRED.
8. THE CONTRACTOR MUST REPORT ANY CHANGES IN THE NATURE OF THE SOIL DURING THE WORK, IN RELATION TO THE GEOTECHNICAL STUDY.
9. THIS ENGINEERED DESIGN IS BASED ON THE FOLLOWING MINIMUM EQUIPMENT REQUIREMENTS:
   A. MINIMUM TBM DIAMETER SHALL BE 3038mm;
   B. JACKING FRAME THRUST CAPACITY SHALL BE 500 TONNE;
   C. THE CONTRACTOR IS RESPONSIBLE FOR THE EXECUTION OF THE WORK UNDER THEIR APPROVED EXECUTION PLAN AND SHALL SUPPLY ALL ADDITIONAL EQUIPMENT TO COMPLETE THEIR PLAN AT THEIR COST. ALL EQUIPMENT SHALL BE SUPPLIED IN GOOD WORKING ORDER, MAINTAINED, FUELED AND SERVICED;
   D. ANY EQUIPMENT NOT OPERATIONAL OR FULFILLING THE REQUIREMENTS OUTLINED IN THE CONTRACT SHALL BE REPAIRED OR REPLACED AT THE CONTRACTORS COST. COST OF EQUIPMENT REPAIR OR REPLACEMENT AND STANDBY OF EQUIPMENT AND PERSONNEL DURING DOWNTIME DUE TO UNSUITABLE OR INOPERABLE EQUIPMENT SHALL BE SOLELY BORNE BY CONTRACTOR.
10. THE TOTAL THEORETICAL THRUST FORCE FOR THE ENTIRE LENGTH OF THIS TUNNEL CROSSING IS 517 TONNES / 1,140,000lbs (INCLUDING A SAFETY FACTOR OF 1.25). CONTRACTOR SHALL PROVIDE THE MAXIMUM THRUST FORCE EXPECTED BASED UPON THEIR APPROVED EXECUTION PLAN.

ENVIRONMENTAL

11. DISPOSAL OF SPOIL SHALL BE IN ACCORDANCE WITH THE GOVERNMENT OF NORTHWEST TERRITORIES (GNWT) GUIDELINES AND THE PROJECT ENVIRONMENTAL MANAGEMENT PLAN.
12. NO REFUELING OF PUMPS OR EQUIPMENT WITHIN, AROUND, OR AMONGST THE RIPARIAN ZONE SHALL BE COMPLETED.
13. EMERGENCY RESPONSE SPILL KITS MUST BE ON–SITE AND AVAILABLE FOR USE FOR THE DURATION OF THE PROJECT AND SHOULD ADHERE TO PROTOCOLS SET FORTH BY FISHERIES & OCEANS CANADA (DFO) OPERATIONAL STATEMENTS.
14. THE CONTRACTOR SHALL ENSURE THAT THE FOLLOWING DOCUMENTATION IS ON–SITE AND READILY AVAILABLE AT ALL TIMES (AT A MINIMUM):
   A. EMERGENCY RESPONSE PROCEDURE (ERP);
   B. ENVIRONMENTAL PROTECTION PLAN (EPP);
   C. MSDS FOR ALL ON–SITE MATERIAL;
   D. CROSSING AND PROXIMITY AGREEMENTS;
   E. COPIES OF TEMPORARY FIELD AUTHORIZATIONS AND/OR LAND USE AGREEMENTS.

GEOTECHNICAL

15. GEOTECHNICAL BOREHOLES BH–08 & BH–09 WERE COMPLETED AT THIS SITE BY TETRA TECH AND CAN BE REFERENCED FROM PROJECT NO: ENG.YARC03234–01.
16. SUBSURFACE CONDITIONS ARE BELIEVED TO BE SUITABLE FOR CONSTRUCTION OF THE PROPOSED INSTALLATION BASED ON THE DATA AVAILABLE.
17. IT IS RECOMMENDED THAT THE CONTRACTOR INDEPENDENTLY EVALUATE THE FEASIBILITY OF CONSTRUCTING THE CROSSINGS WITH DUE CONSIDERATION GIVEN TO SUBSURFACE CONDITIONS AND THE SUITABILITY OF THEIR EQUIPMENT AND PROPOSED CONSTRUCTION PROCEDURES.

REFERENCE DOCUMENT NO.	DATE
1. 80754 KM147	2021-09-16
2. 2567-02-Jacking Force-00	2022-03-21
3. 2567-02-API 1102-00	2022-03-21

CCI

ENGINEER AND PERMIT STAMPS

PRELIMINARY NOT FOR CONSTRUCTION

PIPE SPECIFICATIONS	
	NPS 118
OUTSIDE DIAMETER (OD)(mm)	3000
WALL THICKNESS (WT)(mm)	25.4
GRADE	GRADE 3
PRODUCT	CULVERT
MATERIAL	STEEL
SPECIFICATIONS	ASTM A252

1:250

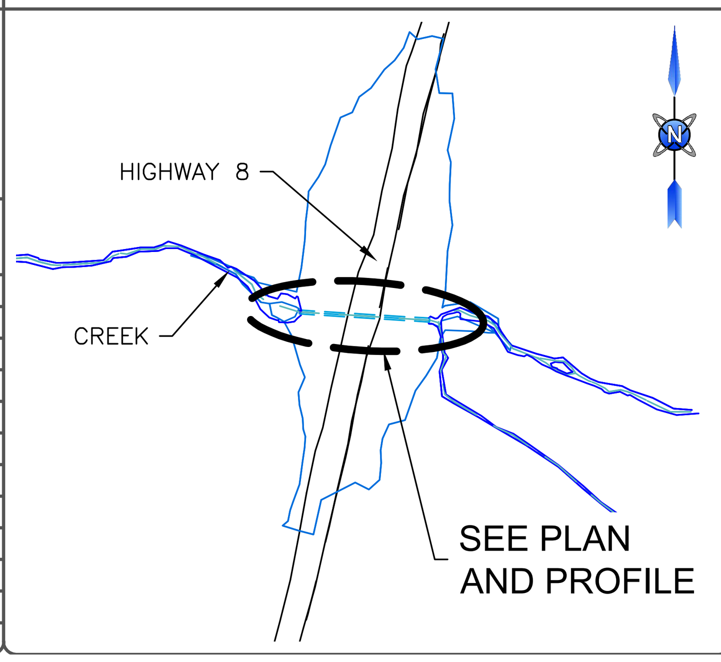
M 0 5 10 15 20 25

FT 0 10 20 30 40 50 60 70 80 90

JACKING FORCE	
JACKING FORCE (w/o BUOYANCY CONTROL):	1,140,000 lbs (w/sf)
MINIMUM RECOMMENDED JACKING FRAME CAPACITY:	700 TONNE

ISSUED FOR PERMIT	2022-04-08	AN	MAL	NB	N/A	JLT	ES
ISSUED FOR REVIEW	2022-04-06	AN	MAL	NB	N/A	JLT	ES

LOCATION PLAN (1:3,000)



UTM - ZONE 8 - NAD 83 (CSRS)

Northwest Territories

GOVERNMENT OF THE NWT

DEPARTMENT OF INFRASTRUCTURE

HIGHWAY 8 CULVERT REPLACEMENT PROJECT

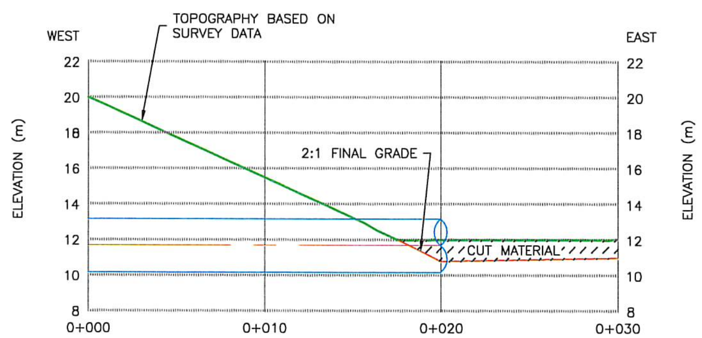
HIGHWAY 8 - NEAR TSIIGEHCHIC AUGER BORE CROSSING CONSTRUCTION LAYOUT AND NOTES

NEAR TSIIGEHCHIC - NWT

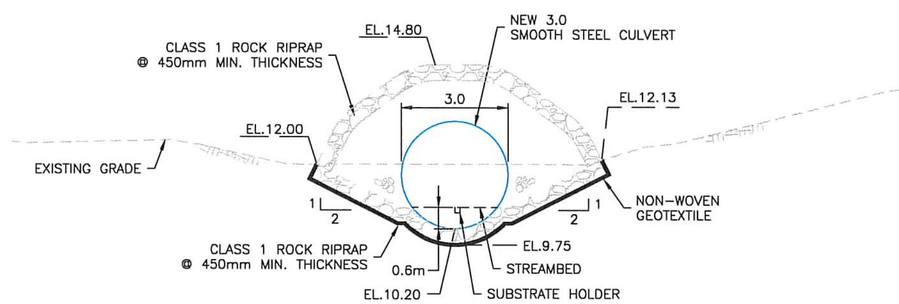
SCALE	DWG. #	REVISION	SHEET
AS SHOWN	2567-EG-0202	B	2 OF 8

File Name: S:\Current Jobs\2567-Gov of NWT-CulvertDesign\Eng\Drawings\02-Highway 8 – KM 147.0 near Tsiigehchic\IFP\2567-EG-0201-B BORE_PHASES_NOTES.dwg Date/Time: 2022-04-12 / 11:58:48 AM Last Saved By: Abdulkadir.Nur

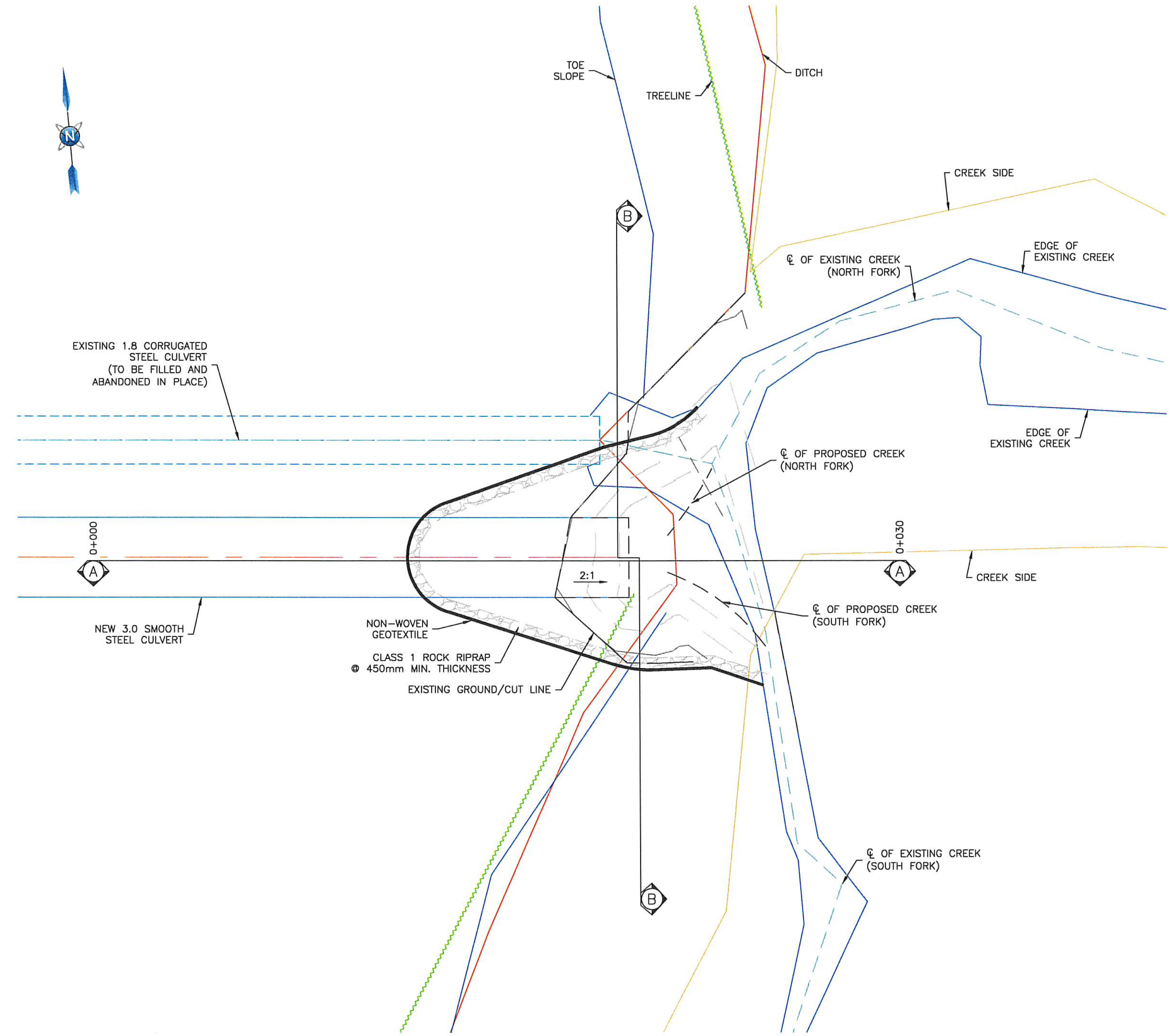
• FOR DESIGN AND MATERIAL NOTES, SEE DRAWING# 2567–EG–0105.



A-A SLOPE CROSS-SECTION
SCALE 1:200



B-B SECTION DETAIL
SCALE 1:100



CULVERT INLET
SCALE 1:100

REFERENCE DOCUMENT NO.	DATE
1. 80754 KM147	2021-09-16
2. 2567-EG-0204	2022-04-06
3. 2567-EG-0205	2022-04-06

CCI

ENGINEER AND PERMIT STAMPS

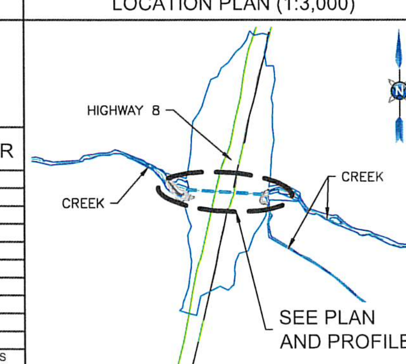
REGISTERED PROFESSIONAL GEOSCIENTIST
N.P. BOELHOUWER
LICENSEE
NT/NU
#L4934
2022-05-11

1:100
M 0 5 10
FT 0 10 20 30

1:200
M 0 5 10 15 20
FT 0 10 20 30 40 50 60 70

DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR PERMIT	2022-04-08	AN	MAL	NB	N/A	JLT	ES
ISSUED FOR REVIEW	2022-04-06	AN	MAL	NB	N/A	JLT	ES

LOCATION PLAN (1:3,000)



UTM - ZONE 8 - NAD 83 (CSRS)

Northwest Territories

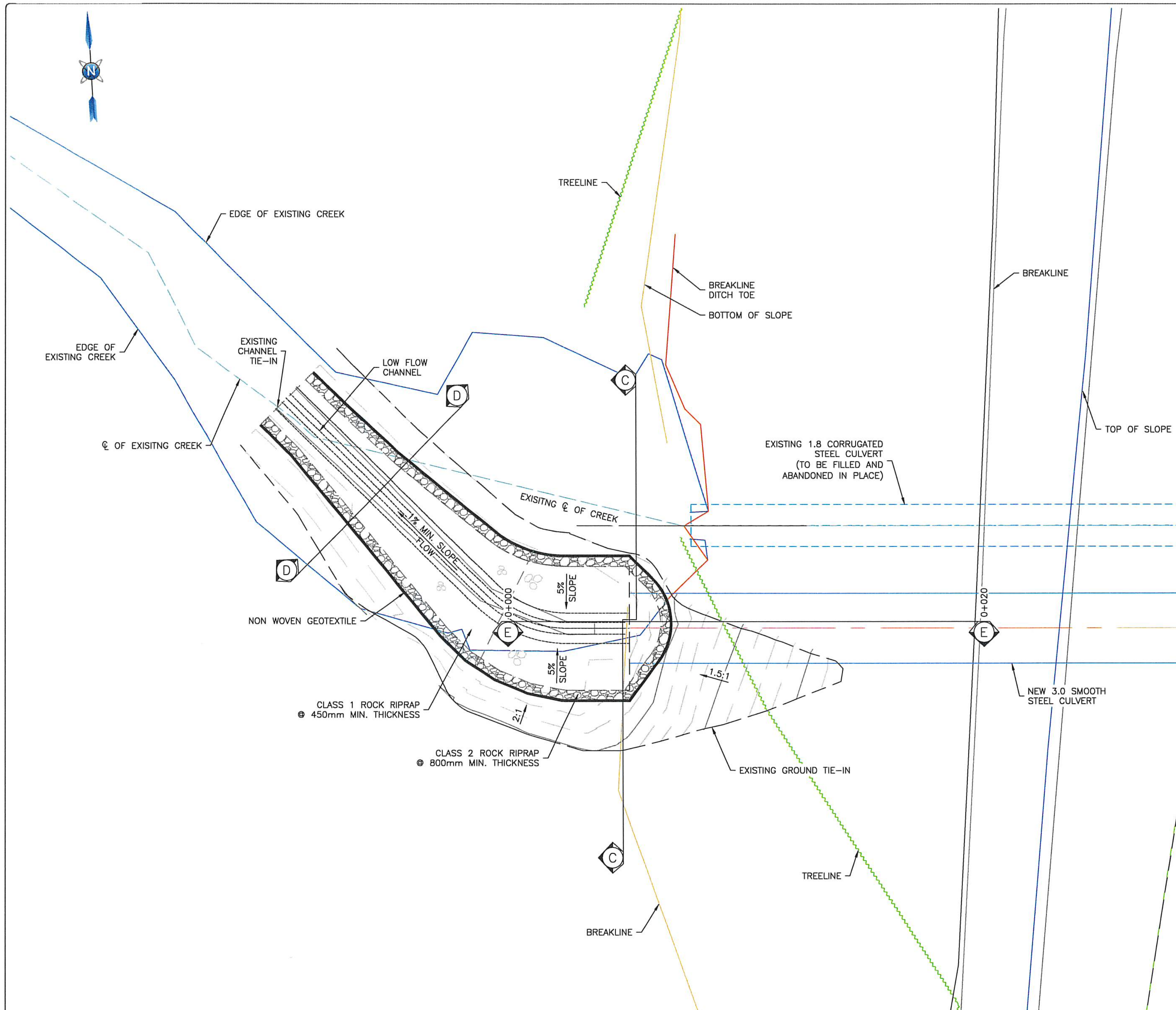
GOVERNMENT OF THE NWT
DEPARTMENT OF INFRASTRUCTURE

HIGHWAY 8 CULVERT REPLACEMENT PROJECT
HIGHWAY 8 - NEAR TSIIGEHCHIC CULVERT INSTALLATION
INLET PLAN AND DETAIL
NEAR TSIIGEHCHIC - NWT

SCALE	DWG. #	REVISION	SHEET
AS SHOWN	2567-EG-0203	B	3 OF 8

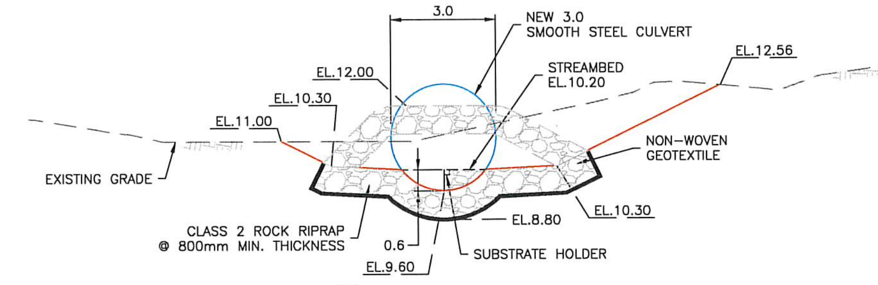
File Name: S:\Current Jobs\2567-Gov of NWT-CulvertDesign\Eng\Drawings\02-Highway 8 – KM 147.0 near Tsiigehchic\IFP\2567-EG-0201-B.dwg Date/Time: 2022-04-06 / 6:09:22 PM Last Saved By: Abdulkadir.Nur

- FOR DESIGN AND MATERIAL NOTES, SEE DRAWING# 2567-EG-0205.



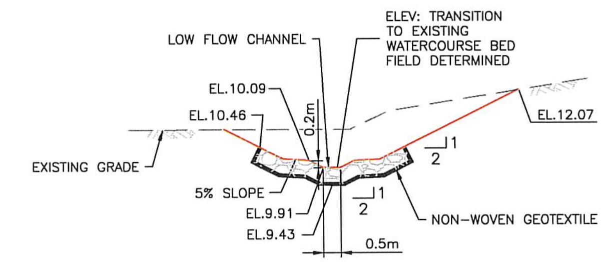
CULVERT OUTLET

SCALE 1:100



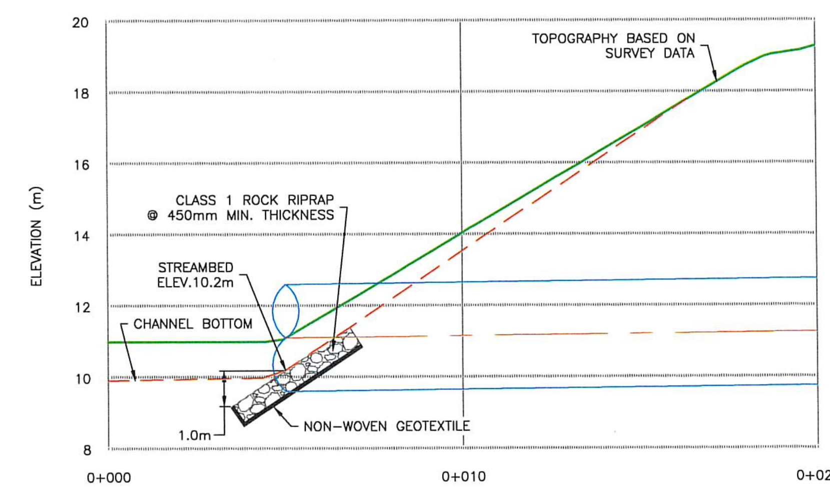
C-C OUTLET SECTION DETAIL

SCALE 1:100



D-D SECTION DETAIL

SCALE 1:100



E-E TYPICAL SLOPE STABILIZATION DETAIL

SCALE 1:100

REFERENCE DOCUMENT NO.	DATE
1. 80754 KM147	2021-09-16
2. 2567-EG-0203	2022-04-06
3. 2567-EG-0205	2022-04-06

CCI

ENGINEER AND PERMIT STAMPS

REGISTERED PROFESSIONAL GEOSCIENTIST N.P. BOELHOUWER LICENSEE NT/NU

#L4934

2022-05-11

PIPELINE SPECIFICATIONS

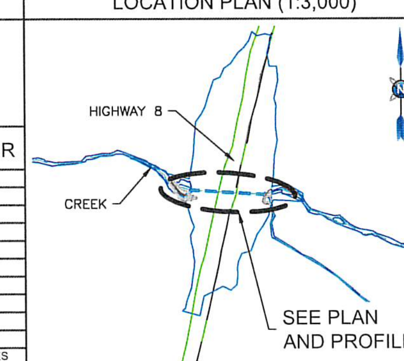
1:100

M 0 5 10

FT 0 10 20 30

DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR PERMIT	2022-04-08	AN	MAL	NB	N/A	JLT	ES
ISSUED FOR REVIEW	2022-04-06	AN	MAL	NB	N/A	JLT	ES

LOCATION PLAN (1:3,000)



UTM - ZONE 8 - NAD 83 (CSRS)

Northwest Territories

GOVERNMENT OF THE NWT

DEPARTMENT OF INFRASTRUCTURE

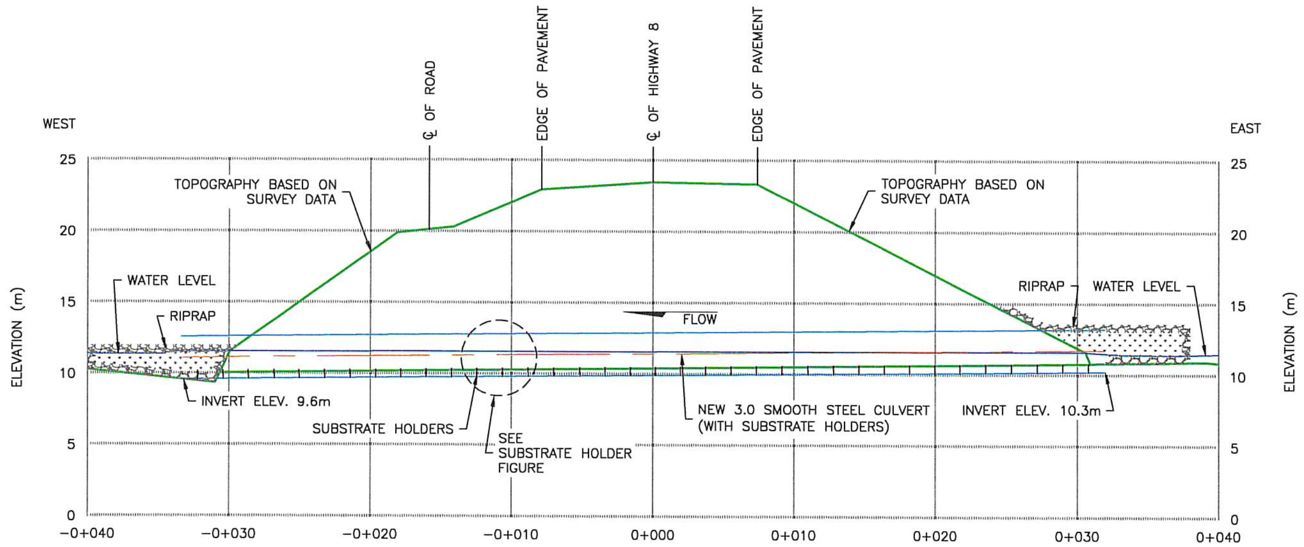
HIGHWAY 8 CULVERT REPLACEMENT PROJECT

HIGHWAY 8 - NEAR TSIIGEHCHIC CULVERT INSTALLATION OUTLET PLAN AND DETAIL

NEAR TSIIGEHCHIC - NWT

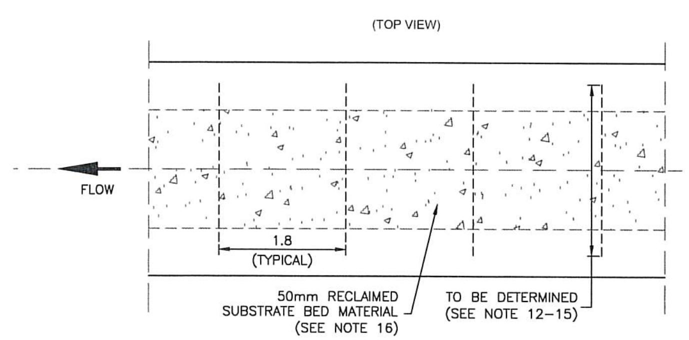
SCALE	DWG #	REVISION	SHEET
AS SHOWN	2567-EG-0204	B	4 OF 8

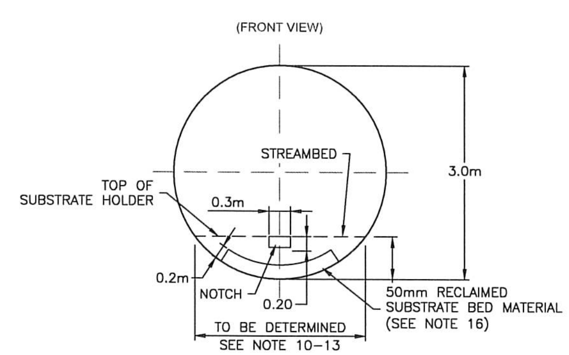
File Name: S:\Current Jobs\2567-Gov of NWT-CulvertDesign\Eng\Drawings\02-Highway 8 - KM 147.0 near Tsiigehchic\IFP\2567-EG-0201-B.dwg Date/Time: 2022-04-06 / 6:09:22 PM Last Saved By: Abdulkadir.Nur



LONGITUDINAL SECTION THROUGH 3.0 CULVERT CENTRELINE

SCALE 1:250





SUBSTRATE HOLDER FIGURE

NTS

HYDROTECHNICAL DESIGN SUMMARY

- DRAINAGE AREA = 14.7km^2
- FLOOD DESIGN DISCHARGE = 8.0m^3/s
- FISH PASSAGE DESIGN DISCHARGE = 1.74m^3/s

GENERAL NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. ALL WORK SHALL BE DONE IN ACCORDANCE WITH ALBERTA TRANSPORTATION STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION.
3. CONTRACTOR TO VERIFY ALL INVERTS OF EXISTING STRUCTURES PRIOR TO COMMENCING WORK. CONTRACTOR TO REPORT TO THE OWNER'S AUTHORIZED REPRESENTATIVE ANY DISCREPANCIES BETWEEN THE MEASURED INVERTS AND THE PIPE LOCATIONS SHOWN ON DRAWINGS PRIOR TO COMMENCING WORK.
4. BEFORE CONSTRUCTION ACTIVITIES COMMENCE, ALL WATER DIVERSION MEASURES AND EROSION CONTROL STRUCTURES SHALL BE INSTALLED ON BOTH SIDES OF THE WATERCOURSE.
5. ALL WORK SHALL BE DONE IN ACCORDANCE WITH PROJECT AGREEMENTS, REGULATORY APPROVALS, ENVIRONMENTAL PROTECTION PLAN AND SITE SPECIFIC REQUIREMENTS.

HEAVY ROCK RIPRAP AND NON-WOVEN GEOTEXTILE FABRIC

6. PRIOR TO INSTALLATION OF THE ROCK RIPRAP, THE APPROXIMATE 100mm OF SUBSTRATE BED MATERIAL SHALL BE STRIPPED AND STOCKPILED SEPARATELY. THE SUBSTRATE BED MATERIAL WILL BE PLACED ALONG THE LOW FLOW CHANNEL AND BETWEEN THE SUBSTRATE HOLDERS UPON COMPLETION OF THE ROCK RIPRAP.
7. HEAVY ROCK RIPRAP AND THE NON–WOVEN GEOTEXTILE SHALL BE SUPPLIED, DELIVERED, AND INSTALLED IN ACCORDANCE WITH THE ALBERTA TRANSPORTATION STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION.
8. PREPARE THE SUBGRADE FOR GEOTEXTILE AND RIPRAP TO THE REQUIRED LINES AND GRADES. COMPACT ANY FILL REQUIRED IN THE SUBGRADE TO A DENSITY OF APPROXIMATELY THAT OF THE SURROUNDING UNDISTURBED SOIL.
9. PLACE NON–WOVEN GEOTEXTILE FILTER FABRIC UNDER ALL HEAVY ROCK RIPRAP. PROVIDE A MINIMUM OF 400mm OVERLAP FOR JOINING TWO PIECES OF GEOTEXTILE TOGETHER. EXTEND GEOTEXTILE AT A MINIMUM OF 150mm BEYOND EDGES OF RIPRAP AND EMBED AT A MINIMUM 100mm AT SIDES OF RIPRAP.
10. AT THE CULVERT INLET, THREE LARGE CLASS 2 ROCK RIPRAP WILL BE PLACED IN ACCORDANCE WITH THE OWNER'S AUTHORIZED REPRESENTATIVE DIRECTION. THE INTENT OF THE CLASS 2 RIPRAP ROCKS IS TO PROVIDE A RESTING AREA FOR FISH. THE ROCK RIPRAP SHALL BE PLACED SO THAT THE TOP OF THE ROCKS ARE AT ELEVATION OF APPROXIMATELY 14.8m AND WILL BE PLACED TO MINIMIZE IMPACT TO THE FLOW.
11. IN THE OUTLET LOW FLOW CHANNEL, RECLAIMED SUBSTRATE BED MATERIAL SHALL BE PLACED WITHIN THE INTERSTITIAL SPACES BETWEEN THE ROCKS TO PROVIDE A CHANNEL FOR FISH MIGRATION. RECLAIMED SUBSTRATE BED MATERIAL SHALL ALSO BE PLACED WITHIN THE CULVERT.
    a. ESTIMATED SURFACE AREA COVERED BY FILTER FABRIC – 183.3m^2
    b. ESTIMATED QUANTITY OF CLASS 1 ROCK RIPRAP – 64.3m^3
    c. ESTIMATED QUANTITY OF CLASS 2 ROCK RIPRAP – 32.3m^3

SUBSTRATE HOLDERS

12. SUBSTRATE HOLDERS TO BE PLACED AT A SPACING OF 1.8m. THE FIRST INTERIOR SUBSTRATE HOLDER AT THE OUTLET SHOULD BE LOCATED AS CLOSE TO THE DOWNSTREAM CULVERT OUTLET AS POSSIBLE AND SPACED ACCORDINGLY FROM THAT POINT TO THE INLET.
13. THE TOP OF THE SUBSTRATE HOLDERS HAVE BEEN DESIGNED TO BE APPROXIMATELY 0.6m ABOVE THE CULVERT INVERT AND ALIGNED WITH THE NATURAL WATERCOURSE BED AT THE INLET AND OUTLET. THE FINAL HEIGHT OF THE SUBSTRATE HOLDERS (ELEVATION 8.0m) WILL PARALLEL THE NATURAL WATERCOURSE BED. TO ENSURE THE TOP OF THE SUBSTRATE HOLDERS ARE ALIGNED WITH THE NATURAL WATERCOURSE BED AT THE INLET AND OUTLET, THE HEIGHT OF EACH SUBSTRATE HOLDER SHALL BE MEASURED AND CUT UPON COMPLETION OF THE INSTALLATION OF THE NEW 3.0m BORED CULVERT.
14. A NOTCH IS TO BE INSTALLED IN THE SUBSTRATE HOLDERS TO PROVIDE FOR FISH PASSAGE DURING LOW FLOWS. THE NOTCH SHALL BE CENTERED IN THE SUBSTRATE HOLDER AND MEASURE 200mm DEPTH BY 300mm WIDTH.
15. SUBSTRATE HOLDERS SHALL BE A MINIMUM OF 10mm THICK CARBON STEEL PLATE AND TO BE CONTINUOUSLY WELDED ALONG THE EDGE OF THE PLATE TO THE CULVERT PIPE BODY. THE WELD SHALL BE A MIN. 10mm FILLET WELD.
16. RECLAIMED SUBSTRATE BED MATERIAL SHALL BE PLACED TO A THICKNESS OF 50mm ALONG THE BOTTOM OF THE CULVERT BETWEEN THE SUBSTRATE HOLDERS.

HIGHWAY EMBANKMENT STABILIZATION AND BACKFILL AREAS

17. ALL EMBANKMENTS SHALL BE GRADED TO A SLOPE OF 1.5 HORIZONTAL TO 1 VERTICAL OR SHALLOWER UNLESS OTHERWISE NOTED.
18. NON–ORGANIC CLAY SHALL BE USED FOR THE BACKFILL MATERIAL. ALL BACKFILL MATERIAL SHALL BE FREE FROM FROZEN LUMPS AND ORGANIC MATERIAL. BACKFILL MATERIAL SHALL BE APPROVED BY OWNER'S AUTHORIZED REPRESENTATIVE PRIOR TO CONSTRUCTION.
19. THE AMOUNT OF FILL REQUIRED WILL VARY ACCORDING TO THE TYPICAL CROSS–SECTION SHOWN ON THE DRAWING.
20. TO ENSURE A PROPER BOND BETWEEN THE EXISTING AND NEW MATERIAL, VEGETATION ALONG THE SIDESLOPE SHALL BE REMOVED AND THE TOPSOIL EXCAVATED AND SALVAGED. THE SURFACE SHALL BE SCARIFIED TO A DEPTH OF 0.15m.
21. ALL MATERIAL PLACED IN EMBANKMENTS SHALL BE SPREAD AND BLADED SMOOTH IN SUCCESSIVE LAYERS, NOT TO EXCEED 0.15m WHEN COMPACTED AND TO THE FULL WIDTH OF THE CROSS–SECTION. EACH LAYER SHALL BE COMPACTED TO A MINIMUM OF 95 PERCENT OF STANDARD PROCTOR DENSITY AT OPTIMUM MOISTURE CONTENT.

NON–WOVEN GEOTEXTILE FILTER FABRIC	
SPECIFICATIONS AND PHYSICAL PROPERTIES	
	CLASS 1M, 1, 2, 3
GRAB STRENGTH	900 N
ELONGATION (FAILURE)	50%
CBR PUNCTURE STRENGTH	550 N
TRAPEZOIDAL TEAR	350 N
MINIMUM FABRIC LAP TO BE 400mm	

File Name: S:\Current Jobs\2567-Gov of NWT-CulvertDesign\Eng\Drawings\02-Highway 8 – KM 147.0 near Tsiigehtchic\FP\2567-EG-0201-B.dwg Date/Time: 2022-04-06 / 6:09:22 PM Last Saved By: Abdulkadir.Nur

REFERENCE DOCUMENT NO.	DATE
1. 18-209 PPP Drafting	2020-02-18
2. 2567-EG-0203	2022-04-06
3. 2567-EG-0204	2022-04-06
4. 2567-EG-0206	2022-04-06
5. 2567-EG-0207	2022-04-06

CCI

ENGINEER AND PERMIT STAMPS

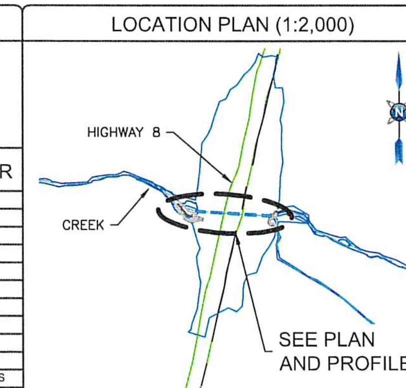
REGISTERED PROFESSIONAL GEOSCIENTIST
N.P. BOELHOUWER
LICENSEE
NT/NU

#L4934
2022-05-11

1:250
M 0 5 10 15 20 25
FT 0 10 20 30 40 50 60 70 80 90

DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR PERMIT	2022-04-08	AN	MAL	AH	N/A	JLT	ES
ISSUED FOR REVIEW	2022-04-06	AN	MAL	AH	N/A	JLT	ES

LOCATION PLAN (1:2,000)



UTM - ZONE 8 - NAD 83 (CSRS)

Northwest Territories

GOVERNMENT OF THE NWT
DEPARTMENT OF INFRASTRUCTURE

HIGHWAY 8 CULVERT REPLACEMENT PROJECT
HIGHWAY 8 - NEAR TSIIGEHCHIC AUGER BORE CROSSING
SUBSTRATE DETAIL AND NOTES
NEAR TSIIGEHCHIC - NWT

SCALE	DWG. #	REVISION	SHEET
AS SHOWN	2567-EG-0205	B	5 OF 8

PLAN : PHASE III

SCALE 1:200

GENERAL NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE SPECIFIED.
2. THE ISOLATION SHALL BE CONSTRUCTED TO MANAGE A MINIMUM CONSTRUCTION DESIGN DISCHARGE OF $1.0m^3/s$.
3. ALL WORK SHALL BE DONE IN ACCORDANCE WITH GOVERNMENT OF THE NORTHWEST TERRITORIES, DEPARTMENT OF TRANSPORTATION – EROSION AND SEDIMENT CONTROL MANUAL.
4. CONTRACTOR TO VERIFY ALL INVERTS OF EXISTING STRUCTURES PRIOR TO COMMENCING WORK. CONTRACTOR TO REPORT TO THE OWNER'S REPRESENTATIVE ANY DISCREPANCIES BETWEEN THE MEASURED INVERTS AND THE PIPE LOCATIONS SHOWN ON DRAWINGS PRIOR TO COMMENCING WORK.
5. CONTRACTOR TO PROVIDE ALL CONSTRUCTION EXECUTION PLANS, INCLUDING THE ENVIRONMENTAL MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN, FOR REVIEW AND ACCEPTANCE PRIOR TO CONSTRUCTION.

PHASE I: BEAVER DAM REMOVAL

6. INSTALL PUMPS ON THE INLET (EAST) SIDE OF THE CROSSING THAT WILL HANDLE THE VOLUME OF FLOW IN THE WATERCOURSE.
7. STRING HOSES THROUGH THE EXISTING CULVERT TO A DISCHARGE LOCATION ON THE WEST SIDE OF THE DEMPSTER HIGHWAY WHERE SCOURING AND DOWNSTREAM SEDIMENTATION FROM DISCHARGE ENERGY IS MITIGATED, DOWNSTREAM OF THE BEAVER DAM LOCATION.
8. DAM THE INLET SIDE OF THE CULVERT AND INITIATE PUMP AROUND OPERATIONS. ENSURE PUMP CAPACITY IS EQUAL TO THE VOLUME OF WATER TRAVELING THROUGH THE WATERCOURSE PLUS CONTINGENCY PUMPS AND HOSES FOR HIGH WATER EVENTS.
9. INITIATE PUMP AROUND OF WATER ENSURING THAT WATER IS NOT ALLOWED TO BUILD UP ON THE INLET SIDE OF THE CULVERT.
10. ACCESS THE OUTLET (WEST) SIDE OF THE CULVERT FROM THE NORTH SIDE OF THE CROSSING.
11. REMOVE THE DAM IMPLEMENTING THE PROCEDURE AND MITIGATION PRESENTED IN DEPARTMENT OF FISHERIES AND OCEANS CANADA'S (DFO) INTERIM CODE OF PRACTICE: BEAVER DAM REMOVAL.
12. ONCE REMOVAL OF THE DAM IS COMPLETE, PUMP DOWN REMAINING WATER LEVEL IN THE POOL.
13. BACKFILL THE POOL WITH CLEAN FILL AND RIP RAP TO FINAL OUTLET APRON ELEVATION.

PHASE II: CULVERT INSTALLATION SITE PREPARATION

14. MAINTAIN PUMP AROUND OF WATER FROM PHASE I.
15. CONSTRUCT AN ISOLATION DAM ON THE OUTLET (WEST) SIDE OF THE CROSSING. ALL ADVICE AND BEST PRACTICES CONTAINED IN THE DFO'S INTERIM CODE OF PRACTICE: TEMPORARY COFFERDAMS AND DIVERSION CHANNELS WILL BE APPLIED.
16. CONSTRUCT A WORK AREA ON THE OUTLET SIDE OF THE CROSSING.
    A. INSTALL THE ISOLATION DAM FROM THE SOUTH EDGE OF THE EXISTING CULVERT, EXTENDING ACROSS THE BACKFILLED POOL AND KEY INTO THE SOUTH BANK OF THE CHANNEL, DIRECTLY ACROSS FROM THE SOUTH EDGE OF THE CULVERT.
    B. DISCONTINUE PUMP AROUND OPERATIONS BY REMOVING THE PUMPS AND HOSES AND ALLOW WATER TO FLOW THROUGH THE EXISTING CULVERT. IF LEAKS ARE FOUND IN THE ISOLATION DAM, REPAIR PRIOR TO MOVING TO THE INLET SIDE OF THE CROSSING.
17. CONSTRUCT A WORK AREA ON THE INLET (EAST) SIDE OF THE CROSSING.
    A. STAKE OUT THE LOCATION OF THE JACKING FRAME.
    B. INSTALL PUMPS IN THE SOUTH FORK OF THE WATERCOURSE, SOUTH OF THE JACKING FRAME LOCATION, THAT WILL HANDLE THE VOLUME OF FLOW IN THE WATERCOURSE.
    C. STRING HOSES FROM THE PUMP LOCATION TO THE NORTH CHANNEL TO A LOCATION WHERE SCOURING AND DOWNSTREAM SEDIMENTATION FROM DISCHARGE ENERGY IS MITIGATED.
    D. INSTALL A DAM ON THE SOUTH SIDE OF THE JACKING FRAME AND INITIATE PUMP AROUND OF WATER TO THE NORTH FORK.
    E. INSTALL THE ISOLATION DAM ON THE NORTH SIDE OF THE JACKING FRAME, ALLOWING WATER TO MOVE FROM THE ISOLATED AREA THROUGH THE EXISTING CULVERT PRIOR TO COMPLETING THE ISOLATION TO THE EDGE OF THE EXISTING CULVERT.
    F. SALVAGE SURFICIAL SOILS FROM THE JACKING FRAME WORK AREA AND STOCKPILE AWAY FROM THE WATERCOURSE.
    G. REMOVE GRADE CUTS FROM THE WORK AREA AND STOCKPILE AWAY FROM THE CROSSING SEPARATELY FROM THE SALVAGED SURFICIAL SOILS.
    H. CONSTRUCT THE JACKING FRAME.
    I. WHEN THE JACKING FRAME IS COMPLETE, CONSTRUCT A DIVERSION CHANNEL AROUND THE EAST SIDE OF THE FRAME AND LINE WITH ROCK COBBLE.
    J. WITH THE DIVERSION CHANNEL COMPLETE, REMOVE THE DAM, DISCONTINUE PUMP AROUND OPERATIONS AND ALLOW WATER TO FLOW AROUND THE JACKING FRAME TO THE NORTH FORK AND THROUGH THE EXISTING CULVERT.
    K. PLACE EQUIPMENT ON THE WORK AREA.
    L. INSTALL SILT FENCING WHERE REQUIRED ON THE EDGE OF THE WORK AREA TO MITIGATE POTENTIAL SEDIMENTATION INTO THE WATERCOURSE.

PHASE III: CULVERT INSTALLATION

18. WHEN THE WORK AREA IS CONSTRUCTED AND EQUIPMENT IS IN PLACE TO BEGIN INSTALLATION OF THE NEW CULVERT, ENSURE THE WORK AREAS ON THE INLET (EAST) AND OUTLET (WEST) SIDES REMAIN ISOLATED.
19. INSTALL 3m CULVERT (SEE 2567-EG-0201).
20. COMPLETE THE RECLAMATION OF THE INLET AND OUTLET SIDES OF THE 3m CULVERT WHILE STILL ISOLATED.
21. REMOVE ANY DEPOSITED SEDIMENT FROM WITHIN THE ISOLATED WORKSITE AND ENSURE ANY DISTURBED INSTREAM AREAS HAVE BEEN STABILIZED PRIOR TO REMOVAL.
22. MAINTAIN SEDIMENT CONTROL MEASURES DURING REMOVAL AND RE-WATERING OF INSTREAM WORKSITE.
    A. INLET SIDE:
    - REMOVE THE TRENCHLESS EQUIPMENT AND JACKING FRAME ON THE INLET SIDE OF THE 3m CULVERT.
    - INSTALL PUMPS IN THE SOUTH FORK OF THE WATERCOURSE, SOUTH OF THE JACKING FRAME LOCATION, THAT WILL HANDLE THE VOLUME OF FLOW IN THE WATERCOURSE.
    - STRING HOSES FROM THE PUMP LOCATION TO THE NORTH CHANNEL TO A LOCATION WHERE SCOURING AND DOWNSTREAM SEDIMENTATION FROM DISCHARGE ENERGY IS MITIGATED.
    - INSTALL A DAM ON THE SOUTH SIDE OF THE JACKING FRAME AND INITIATE PUMP AROUND OF WATER FROM TO THE NORTH FORK.
    - WIDEN THE CHANNEL ON THE INLET SIDE TO ACCOMMODATE FLOW TO THE INSTALLED 3m CULVERT.
    - RECONTOUR THE CHANNEL OF THE ORIGINAL SOUTH FORK OF THE CREEK CHANNEL.
    - RE-ESTABLISH FLOW THROUGH THE SOUTH FORK OF THE CREEK CHANNEL
    - INSTALL ROCK RIP RAP AND ARMOUR THE CHANNEL AND CONTOURED BANK TO THE WATER LINE (2567-EG-0203).
    - SEED AND PLACE COCONUT MATTING OVER THE BANK ABOVE THE WATER LINE.

    B. OUTLET SIDE:
    - COMPLETE THE OUTLET APRON ON THE OUTLET END OF THE 3m CULVERT.
    - INSTALL ROCK RIP RAP AND ARMOUR THE CHANNEL AND CONTOURED BANKS TO THE WATER LINE (2567-EG-0204).
    - SEED AND PLACE COCONUT MATTING OVER THE BANK ABOVE THE WATER LINE.

PHASE IV: E□ISTING CULVERT DECOMMISSIONING

23. MOVE THE ISOLATION DAM ON THE INLET SIDE OF THE CROSSING, ISOLATING THE EXISTING CULVERT AND ALLOWING THE WATER TO MOVE FROM THE ISOLATED AREA THROUGH THE INSTALLED 3m CULVERT, PRIOR TO COMPLETING THE ISOLATION TO THE EDGE OF THE 3m CULVERT.
24. INSTALL THE ISOLATION DAM ALONG THE EAST EDGE OF THE NEWLY CONTOURED OUTLET CHANNEL, EAST OF THE 3m CULVERT.
25. CONSTRUCT A WORK AREA ON THE OUTLET SIDE OF THE CROSSING.
    A. LEVEL THE OUTLET SIDE OF THE EXISTING CULVERT.
    B. PLACE GROUTING EQUIPMENT ON THE WORK AREA.
    C. INSTALL SILT FENCING WHERE REQUIRED ON THE EDGE OF THE WORK AREA TO MITIGATE POTENTIAL SEDIMENTATION INTO THE WATERCOURSE.
26. GROUT THE EXISTING CULVERT.
27. COMPLETE THE RECLAMATION OF THE OUTLET SIDE OF THE DECOMMISSIONED EXISTING CULVERT WHILE STILL ISOLATED.
28. REMOVE ANY DEPOSITED SEDIMENT FROM WITHIN THE ISOLATED WORKSITE AND ENSURE ANY DISTURBED INSTREAM AREAS HAVE BEEN STABILIZED PRIOR TO REMOVAL.
29. MAINTAIN SEDIMENT CONTROL MEASURES DURING REMOVAL AND RE-WATERING OF INSTREAM WORKSITE.
    A. OUTLET SIDE:
    - REMOVE EQUIPMENT ON OUTLET SIDE OF THE EXISTING CULVERT.
    - COMPLETE THE OUTLET APRON ON THE OUTLET END OF THE EXISTING CULVERT.
    - INSTALL ROCK RIP RAP AND ARMOUR THE CHANNEL AND CONTOURED BANKS TO THE WATER LINE.
    - INSTALL SILT FENCING ALONG THE TOE OF THE ROAD SLOPE, BETWEEN THE ROAD FILL AND THE ROCK ARMOUR.
    - COMPLETE SEEDING AND MITIGATION TO MINIMIZE EROSION TO THE WIDENED ROAD EMBANKMENT, INCLUDING SEEDING AND PLACEMENT OF COCONUT MATTING TO THE INSTALLED SILT FENCING.
    - REMOVE ISOLATION DAM ON THE OUTLET SIDE.
    - COMPLETE THE REMAINDER OF THE OUTLET APRON THROUGH THE PLACEMENT OF ROCK RIP RAP, WHERE REQUIRED.

    B. INLET SIDE
    - COMPLETE FINAL RECONTOURING AND CHANNEL/BANK ARMOURING ON THE INLET SIDE OF THE EXISTING CULVERT.
    - INSTALL SILT FENCING AND SEED DISTURBED AREAS ON THE INLET SIDE OF THE CROSSING.
    - INSTALL SILT FENCING ALONG THE OUTLET APRON EDGE.
    - COMPLETE SEEDING AND COCONUT MATTING INSTALLATION OVER WORK AREA ON THE OUTLET SIDE.

PHASE V - FINAL RECLAMATION

30. DEPENDING ON THE SOIL TYPES AND THE PROJECT FOOTPRINT LOCATED AT THE CROSSING LOCATION, ADDITIONAL RECLAMATION MEASURES MAY BE REQUIRED ON THE OUTLET AND INLET SIDE OF THE CROSSING. THESE ADDITIONAL MEASURES CAN INCLUDE:
    - STREAMBANK RESTORATION THROUGH THE INSTALLATION OF LIFTS AND JUTE WRAP, WITH WILLOWS PLACED BETWEEN LIFTS.
    - WILLOW STAKING ON THE WATERCOURSE BANKS TO STABILIZE DISTURBED AREAS AND PROMOTE REGROWTH.
    - ADDITIONAL SILT FENCING WILL BE INSTALLED TO AVOID THE POTENTIAL MOVEMENT OF SOILS AND SEDIMENTATION OF THE WATERCOURSE.
    - ADDITIONAL SEEDING OR INSTALLATION OF COCONUT MATTING TO PROMOTE EXPEDITED REGROWTH AND STABILIZATION OF THE PROJECT FOOTPRINT.

REFERENCE DOCUMENT NO.	DATE
1. 18-209 PPP Draf□ing	2020-02-18
2. 2567-02-API 1102-00	2020-05-19
3. 2567-EG-0203	2022-04-08
4. 2567-EG-0204	2022-04-08
5. 2567-EG-0205	2022-04-08
6. 2567-EG-0206	2022-04-08
7. 2567-EG-0208	2022-04-08

CCI

ENGINEER AND PERMIT STAMPS

PRELIMINARY NOT FOR CONSTRUCTION

PIPELINE SPECIFICATIONS

	NPS 118
OUTSIDE DIAMETER (OD)(mm)	3000
WALL THICKNESS (WT)(mm)	25.4
GRADE	GRADE 3
PRODUCT	CULVERT
MATERIAL	STEEL
SPECIFICATIONS	ASTM A252

1:200

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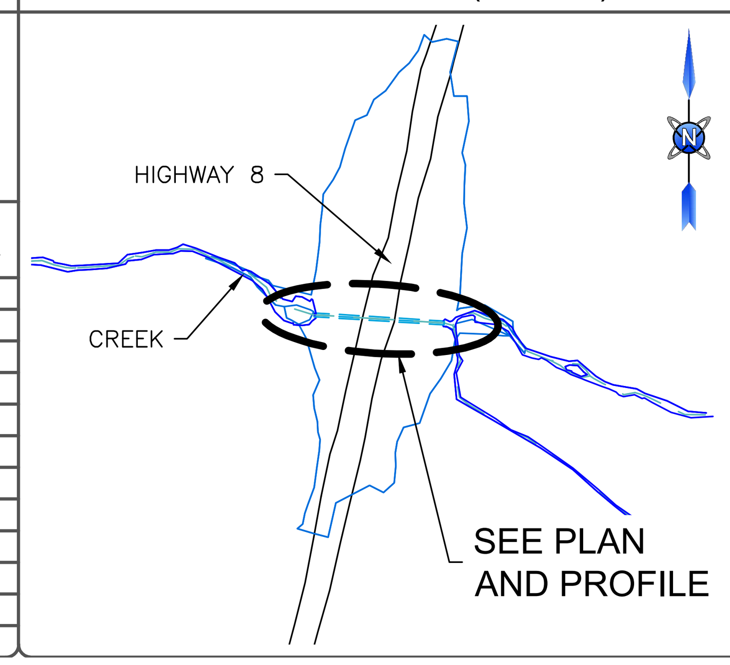
FT 0 10 20 30 40 50 60 70

DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR PERMIT	2022-04-08	AN	MAL	NB	N/A	JLT	ES
ISSUED FOR REVIEW	2022-04-06	AN	MAL	NB	N/A	JLT	ES

LOCATION PLAN (1:3,000)



UTM - ZONE 8 - NAD 83 (CSRS)

GOVERNMENT OF THE NWT

DEPARTMENT OF INFRASTRUCTURE

HIGHWAY 8 CULVERT REPLACEMENT PROJECT

HIGHWAY 8 - NEAR TSIIGEHCHIC AUGER BORE CROSSING
PHASE III AND NOTES

NEAR TSIIGEHCHIC - NWT

SCALE	DWG. #	REVISION	SHEET
AS SHOWN	2567-EG-0207	B	7 OF 8

PLAN : PHASE I
SCALE 1:200

PLAN : PHASE II
SCALE 1:200

REFERENCE DOCUMENT NO.	DATE
1. 18-209 PPP Drafting	2020-02-18
2. 2567-02-API 1102-00	2020-05-19
3. 2567-EG-0203	2022-04-08
4. 2567-EG-0204	2022-04-08
5. 2567-EG-0205	2022-04-08
6. 2567-EG-0207	2022-04-08
7. 2567-EG-0208	2022-04-08

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ENGINEER AND PERMIT STAMPS

PRELIMINARY NOT FOR CONSTRUCTION

PIPELINE SPECIFICATIONS

	NPS 118
OUTSIDE DIAMETER (OD)(mm)	3000
WALL THICKNESS (WT)(mm)	25.4
GRADE	GRADE 3
PRODUCT	CULVERT
MATERIAL	STEEL
SPECIFICATIONS	ASTM A252

1:200
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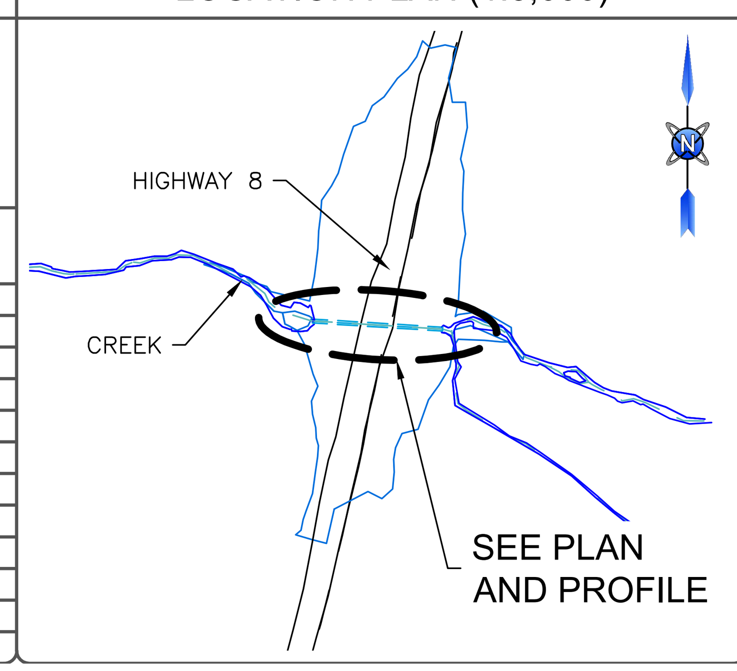
FT 0 10 20 30 40 50 60 70

DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR PERMIT	2022-04-08	AN	MAL	NB	N/A	JLT	ES
ISSUED FOR REVIEW	2022-04-06	AN	MAL	NB	N/A	JLT	ES

LOCATION PLAN (1:3,000)



UTM - ZONE 8 - NAD 83 (CSRS)

GOVERNMENT OF THE NWT
DEPARTMENT OF INFRASTRUCTURE

HIGHWAY 8 CULVERT REPLACEMENT PROJECT
HIGHWAY 8 - NEAR TSIIGEHCHIC AUGER BORE CROSSING PHASE I & II
NEAR TSIIGEHCHIC - NWT

SCALE	DWG. #	REVISION	SHEET
AS SHOWN	2567-EG-0206	B	6 OF 8

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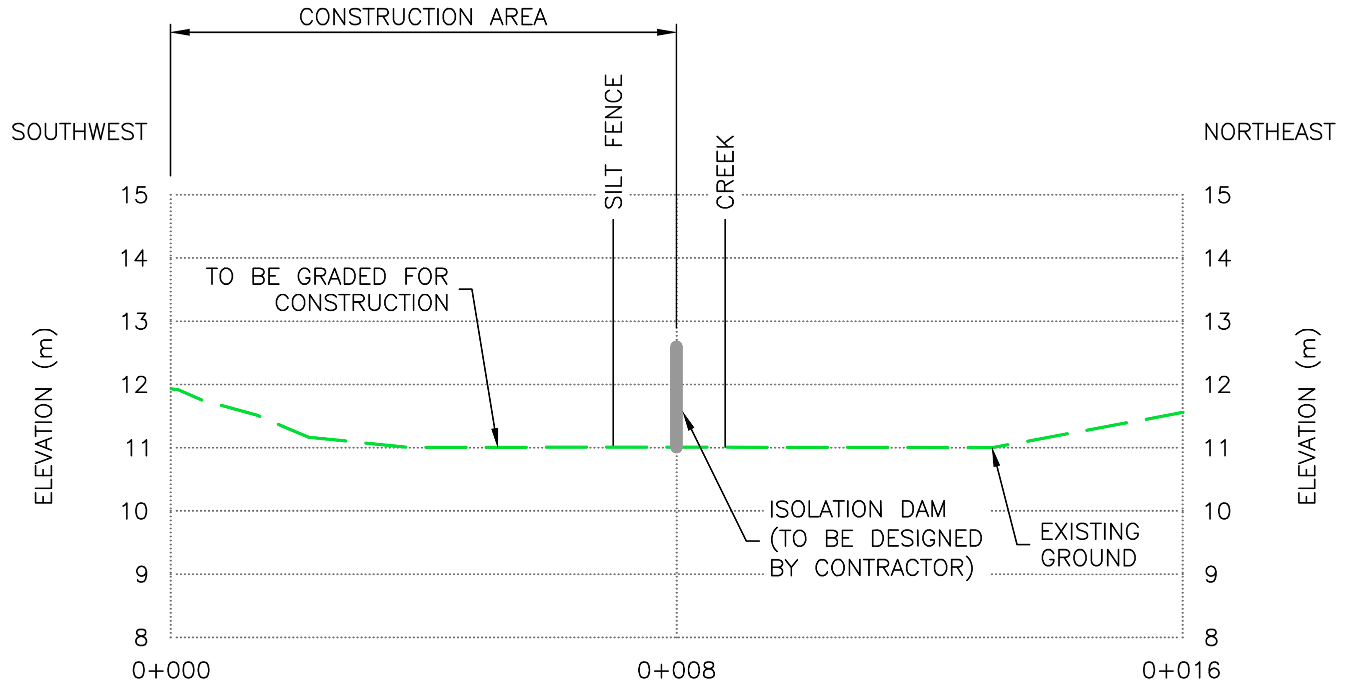
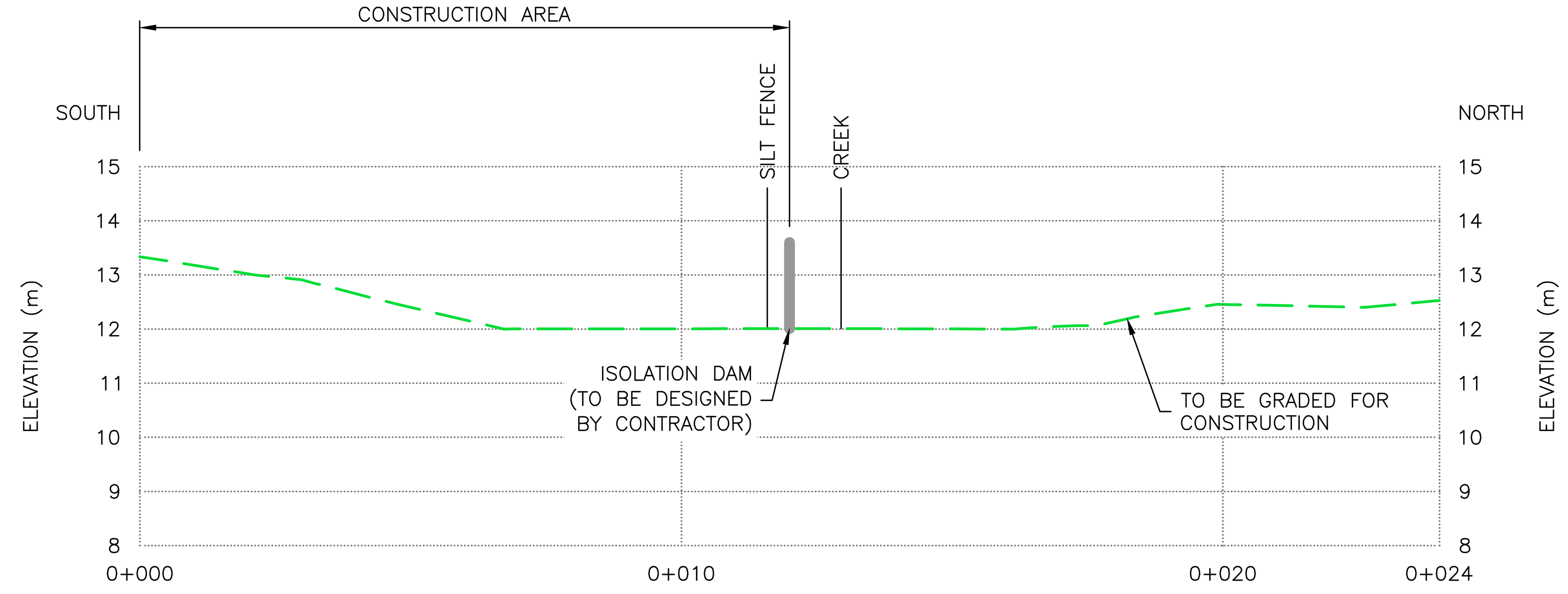


F-F PHASE I OUTLET DETAIL
SCALE 1:100



G-G PHASE I INLET DETAIL
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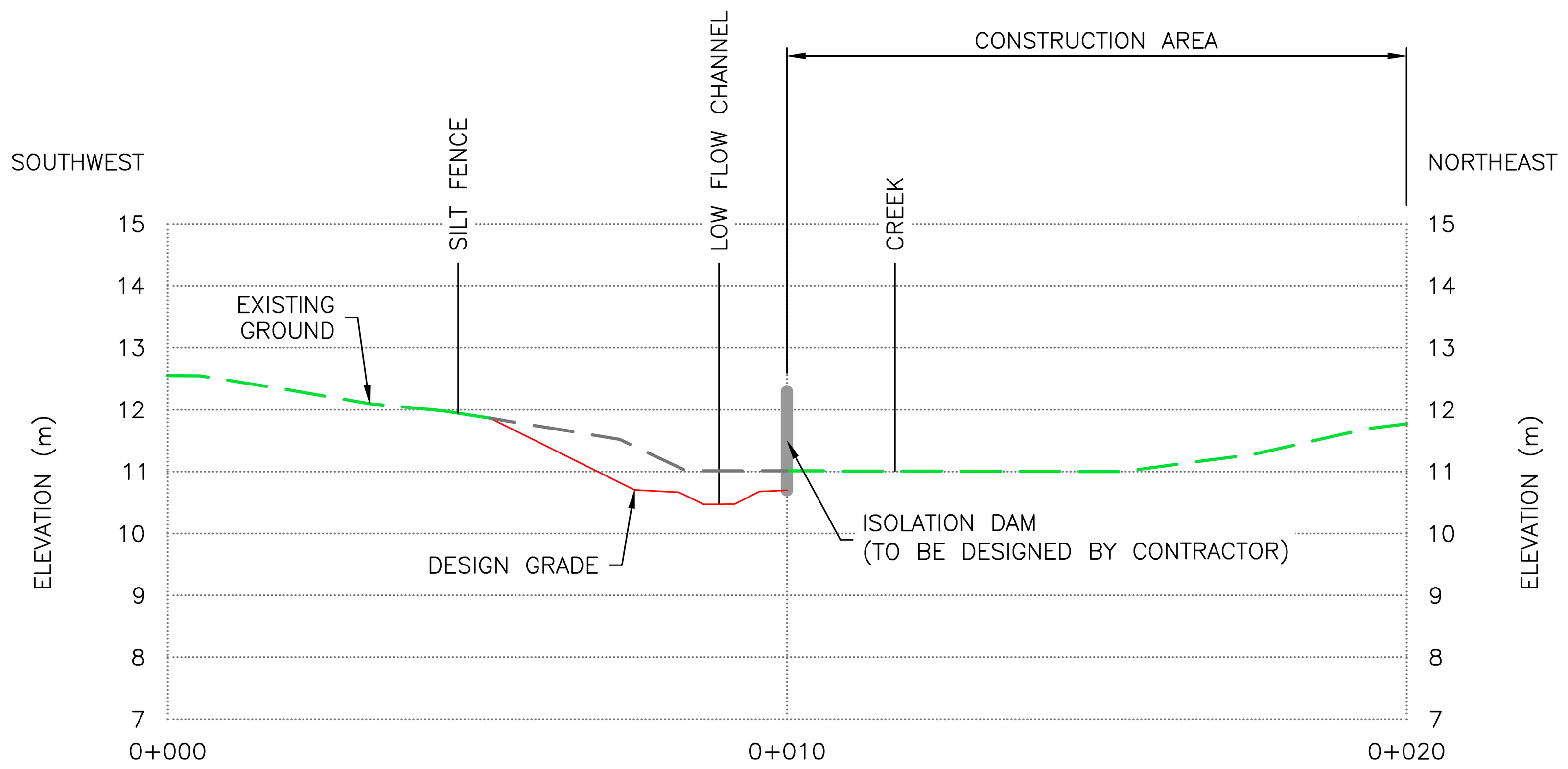
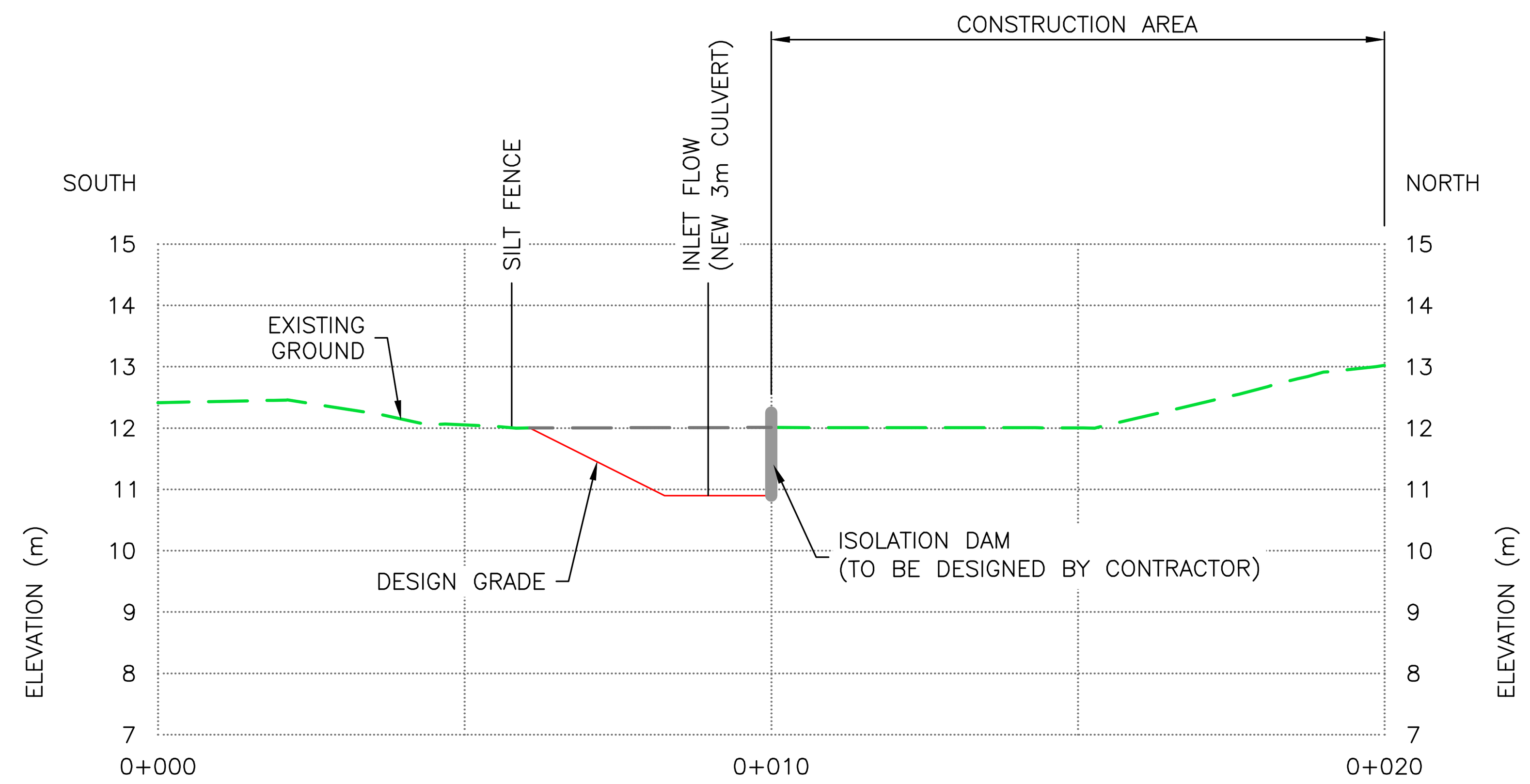


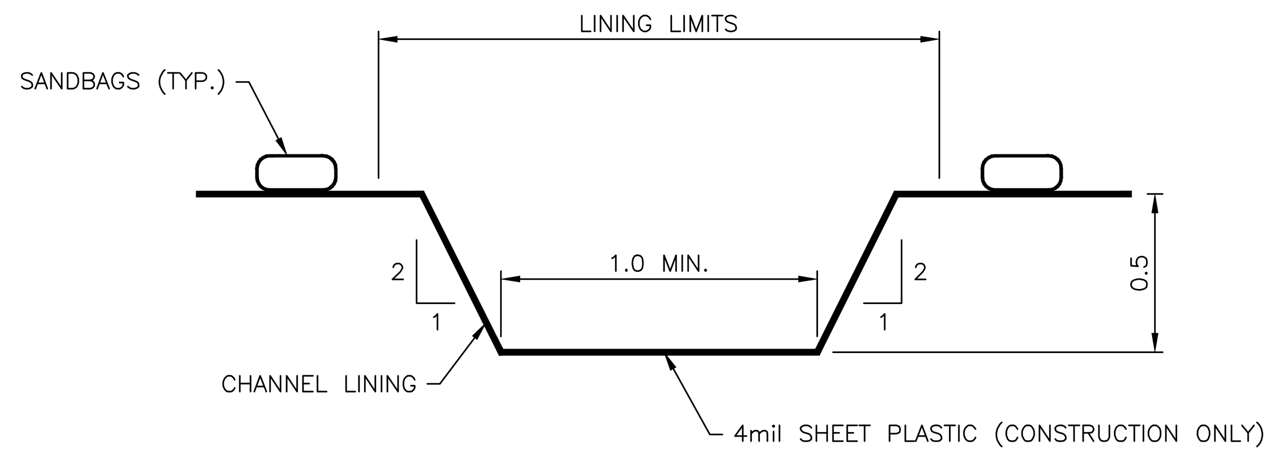
H-H PHASE II OUTLET DETAIL
SCALE 1:100



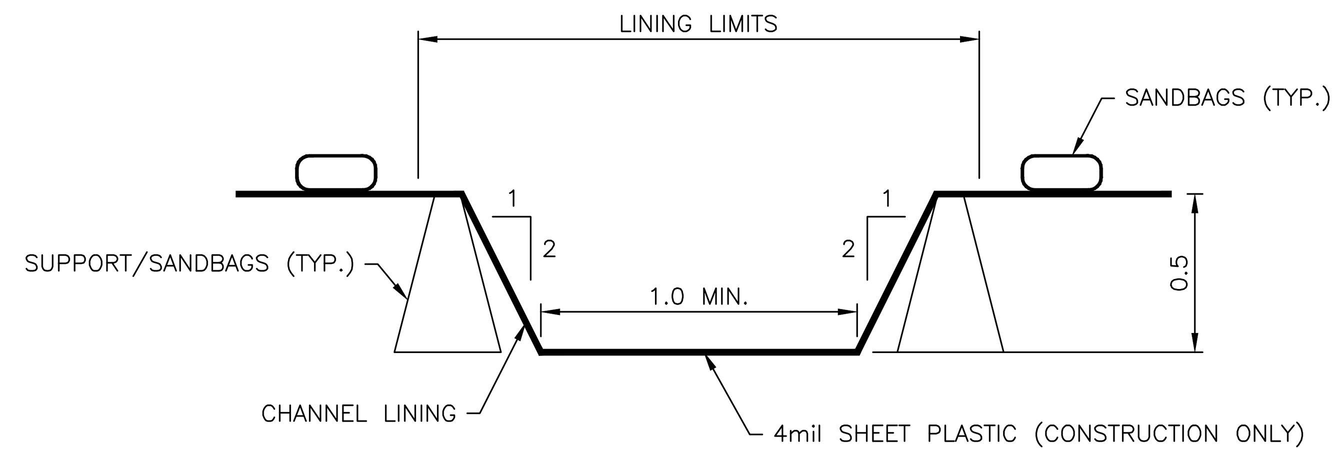
I-I PHASE II INLET DETAIL
SCALE 1:100

- FOR PLAN DETAIL, SEE DRAWING# 2567-EG-0206.

GENERAL NOTES
- CHANNEL MUST MAINTAIN FLOW AT A MINIMUM GRADE OF 1%.
- CONTRACTOR PLANS ARE TO BE SUBMITTED FOR APPROVAL PRIOR TO CONSTRUCTION (SEE NOTE 5 ON DRAWING 2567-EG-0207).



ISOLATION OPTION A
SCALE 1:20



ISOLATION OPTION B
SCALE 1:20

REFERENCE DOCUMENT NO.	DATE
1. 18-209 PPP Draf.ing	2020-02-18
2. 2567-02-API 1102-00	2020-05-19
3. 2567-EG-0203	2022-04-08
4. 2567-EG-0204	2022-04-08
5. 2567-EG-0205	2022-04-08
6. 2567-EG-0206	2022-04-08
7. 2567-EG-0207	2022-04-08

CCI

ENGINEER AND PERMIT STAMPS

PRELIMINARY NOT FOR CONSTRUCTION

1:20 M 0 1 2 FT 0 1 2 3 4 5 6

PIPELINE SPECIFICATIONS

	NPS 118
OUTSIDE DIAMETER (OD)(mm)	3000
WALL THICKNESS (WT)(mm)	25.4
GRADE	GRADE 3
PRODUCT	CULVERT
MATERIAL	STEEL
SPECIFICATIONS	ASTM A252

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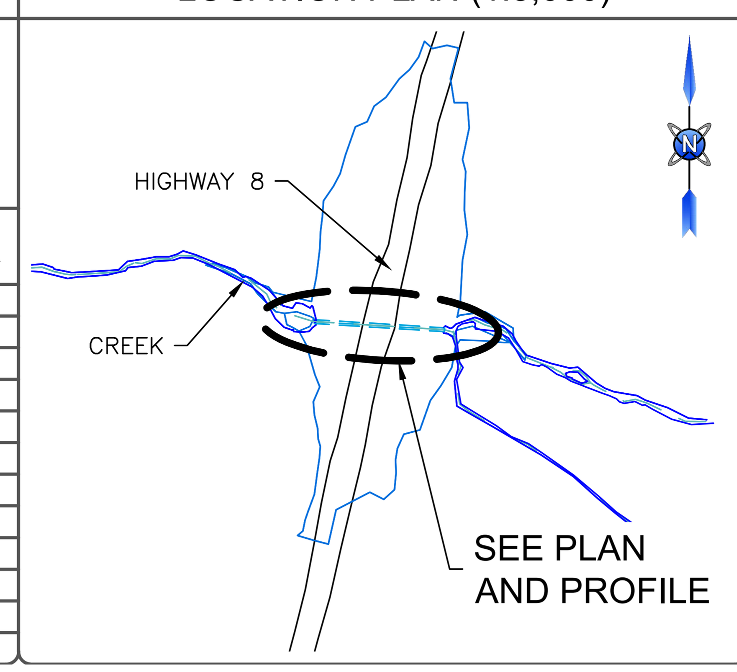
DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR PERMIT	2022-04-08	AN	MAL	NB	N/A	JLT	ES
ISSUED FOR REVIEW	2022-04-06	AN	MAL	NB	N/A	JLT	ES

LOCATION PLAN (1:3,000)



UTM - ZONE 8 - NAD 83 (CSRS)

GOVERNMENT OF THE NWT
DEPARTMENT OF INFRASTRUCTURE

HIGHWAY 8 CULVERT REPLACEMENT PROJECT
HIGHWAY 8 - NEAR TSIIGEHCHIC AUGER BORE CROSSING PHASE I & II PROFILES
NEAR TSIIGEHCHIC - NWT

SCALE	DWG. #	REVISION	SHEET
AS SHOWN	2567-EG-0208	B	8 OF 8

File Name: S:\Current Jobs\2567-Gov of NWT-CulvertDesign\Eng\Drawings\02-Highway 8 - KM 147.0 near Tsiigehchic\FP\2567-EG-0201-B BORE_PHASES_NOTES.dwg Date/Time: 2022-04-12 / 11:58:48 AM Last Saved By: Abdulkadir.Nur