Náįlįcho (Virginia Falls) Float Plane Dock Replacement Hydrotechnical, Geotechnical and Structural Evaluation Nahanni National Park Reserve, NT

PRESENTED TO

Parks Canada

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1.0 INTRODUCTION

1.1 General

Tetra Tech Canada Inc. (Tetra Tech) was retained by Parks Canada Agency (Parks Canada) to provide hydrotechnical, geotechnical, and structural consulting services towards the design of a new floating dock system at the Virginia Falls site within the Nahanni National Park Reserve (NNPR) in the Northwest Territories.

Authorization to proceed with the site evaluation and reporting was provided by Parks Canada on May 19, 2017 via signed contract.

1.2 Project Description

Virginia Falls is a wilderness destination accessible only by float plane, helicopter and canoe/raft. The falls are located 233 km west of Fort Simpson, the main entry point into the NNPR.

There is a present dock system used by both float planes and canoes/rafts that is comprised of a fixed dock founded on helical piles and a floating dock that is constructed of plastic cubes fastened together with plastic bolts (Candock©). The floating portion of the dock and associated ramps are removed prior to the South Nahanni River freeze up and installed after the river ice breakup event each year. The fixed dock was constructed 2004 and has been experiencing foundation issues for several years and requires annual maintenance to provide short-term stability. The floating dock predates the fixed dock and is periodically repaired as pieces are damaged through regular use and from launching and beaching activities.

Parks Canada requires a long-term solution to facilitate access to the facilities at Virginia Falls.

1.3 Scope of Work

The required scope of work was outlined in a proposal dated April 19, 2017 as follows:

- Conduct a hydrotechnical evaluation including a site reconnaissance
- Conduct a geotechnical assessment towards land based anchoring for a new floating dock.
- Develop three conceptual designs for a new floating dock followed by considerations and advantages/disadvantages to different systems with respect to removing and launching, general construction and so on.
- Prepare a report with the above-mentioned evaluations, dock concepts and drawings for review by Parks Canada.

The outcome of this exercise is also to develop a detailed design and tender-ready specifications along with a cost estimate towards tendering the construction of a new float plane dock to an experienced design-build dock contractor.

2.0 METHODOLGY

2.1 Site Background - Information Review

Past reports by Parks Canada, Tetra Tech and by other consultants were reviewed prior to travelling to site to conduct the site reconnaissance. In 2016, Tetra Tech undertook a review of the boardwalk structures which provided some overlap with the current project scope (Tetra Tech 2017).

2.2 Field Work

Albert Leung, P.Eng. and Tim Schaap, P.Eng. of Tetra Tech travelled to Fort Simpson, NT for the dates of June 11 to 15, 2017. Field work took place on June 13 and 14, 2017. Liz Baker, Alex Lothian, Olinto Beaulieu and other Parks Canada staff were present for the field work and other projects underway at that time. Weather delays limited the time on site to two partial days.

River measurements and depth soundings were taken from a small craft and from the existing docks.

A partial level survey and hand held GPS were used to provide a general lay of the land but a full professional survey was not undertaken for this project. Hand augering was limited to the upper 0.45 m of soil as there was still seasonal frost in the ground.

2.3 Hydrotechnical Evaluation

Field work included the gathering of bathymetric data, water velocities, and other features of the South Nahanni River. Ice conditions were taken from past Parks Canada experience and from visually observing the condition of the river shore to determine erosion and other effects of river ice. Office based calculations and evaluations followed and are summarized in Section 6.0 of this report.

2.4 Geotechnical Evaluation

Following the site reconnaissance, a geotechnical assessment was undertaken. Two dock anchoring configurations were developed in the time leading up to the site visit (shore-based and in-stream anchors). The land based anchor concept requires the use of gravity anchors within the flood plain and further inland to keep the floating dock in place.

Design concepts were developed for shore based anchors. As the ground is considered to be largely underlain by permafrost and the near surface soils are fine sand to silt, an anchoring system is not able to resist horizontal loads in the traditional sense. The Rabbitkettle Ferry Crossing project which had similar anchoring loads (Tetra Tech EBA 2014) was reviewed for reference and photos of construction were provided by Parks Canada.

2.5 Dock Design

The dock structural design was based on the results of the hydrotechnical evaluation and geotechnical assessment of the existing float plane dock site. The general arrangement and system design was prepared by our marine structural engineer. Conceptual layouts were prepared prior to travelling to the Virginia Falls site and were discussed on site with all parties. A permanent (non-removable dock) design was not pursued as ice conditions cannot be effectively modelled on this scale of project. As a seasonal dock design was pursued, on-shore and in-stream anchor systems or a combination of the two were evaluated. The ability to launch and remove the dock from the river without the use of a helicopter was also evaluated.

Parks Canada reviewed preliminary drawings and requested that a four dock system be further detailed. Following consultations between Parks Canada and their clients on November 28, 2017, the dock layout was revised to three independent docks for float plane berths. A canoe dock was deleted from the scope.

This report contains dock and anchor layout and design, geotechnical parameters, and tender-ready specifications in Appendix C along with a budget estimate (Section 8.0).

3.0 SUMMARY OF AVAILABLE INFORMATION

Past reports provided by Parks Canada during Tetra Tech's earlier investigations in 2014 and 2017 were reviewed along with our Rabbitkettle Cable Crossing report (Tetra Tech EBA 2014) and our Boardwalk Investigation (Tetra Tech 2017) reporting. These are summarized below.

Project Plan & Options Analysis (Miville, February 2003)

This document was developed by a consultant to evaluate options for moving forward to redevelop the Virginia Falls infrastructure. Included were helical pile foundation for the fixed dock which also acts as an anchor for the seasonal floating dock portion.

Virginia Falls Helipad Inspection (Parks Canada, June 2008)

Failures in the newly constructed helipad were documented in a 2008 report. Helical piles were shifting vertically by as much as 1.2 m on the helipad constructed in close proximity to the float plane dock and within the same wetland region.

Construction Photographs (2003 to 2006, 2016)

Photos documenting the construction of the boardwalks in 2004 and 2005 were reviewed by Tetra Tech. These photos detailed the construction methods employed; primarily manual labour, carpentry and the use of a small skid steer or bobcat with an attachment for rotating helical piles into the ground. All equipment and supplies were typically transported to site via a Twin Otter on floats.

More recent photos from Parks Canada showed a section of boardwalk where the helical piles had fully jacked out of the ground in some cases. The boardwalk had since been relocated to one side and placed on wood blocking on grade.

Geotechnical and Hydrotechnical Evaluation for Replacement of Rabbitkettle River Ferry way, Nahanni National Park Reserve, NT (Tetra Tech EBA 2014)

Tetra Tech conducted a site investigation in February 2014 and followed up with a detailed design for a new cable crossing replacement for the old cable ferryway over the Rabbitkettle River in the NNPR. This location is considered to contain extensive discontinuous permafrost and the design of the new crossing called for a largely above grade gravity anchor to support the cable crossing and is considered to be a case study for the present project.

Geotechnical Investigation for Boardwalk and Helipad Structures, Nahanni National Park Reserve, Rev 01 (Tetra Tech 2017)

Tetra Tech conducted a site inspection of the helical pile supported structures at the Virginia Falls site in the September 2016. This report was a precursor to the present project.

4.0 SITE DESCRIPTION

4.1 Location and Surficial Geology

The Virginia Falls float plane dock is located on the south side of the South Nahanni River, about 600 m upstream of the waterfalls and rapids at 61°36'26"N, 125°45'23"W. See photo #1 and drawing S100 in Appendix B for more details.

The upper Virginia Falls region adjacent to the south bank of the South Nahanni River was mapped as a fluvial deposit with well sorted sands with minor silts, clays and organic cover and prone to occasional flooding. Organic deposits containing peat and forming wetlands that flood annually form the lower regions near the river. Underlying these layers is considered to be glaciolacustrine deposits (Tetra Tech 2017).

4.2 Surface Conditions

The Virginia Falls region largely consists of evergreen/spruce forests and wetlands in the lower elevation areas. The float plane dock is currently established on a wetland beside a small creek that flows north into the South Nahanni River. This localized region is annually inundated by flood waters for a brief period each spring in May or June during the spring freshet. Occasional summer rainstorms can also raise the river level significantly. On either side of this wetland is a slight rise in land categorized as fluvial deposits. The campground occupies the region adjacent and to the southeast (downriver).

4.3 Permafrost

Virginia Falls is within the zone of extensive discontinuous permafrost (50-90% of land contains permafrost), with low ground ice content (less than 10%) and mean annual ground temperatures between 0° and -2°C (Heginbottom et al. 1995). The immediate area surrounding the float plane dock consists of wetlands to the southwest and the river to the north, therefore, permafrost in unlikely to underlie the dock site. The forest immediately to the east and including the canoe rack platform is likely underlain by permafrost due to the shading effects provided by forest cover. The subsurface soils are highly frost susceptible.

Following the Tetra Tech site visit in June, 2017, some clearing of timber was reported by Parks Canada. Removal of vegetation can rapidly degrade permafrost conditions if they exist.

5.0 PERFORMANCE OF THE EXISTING FLOAT PLANE DOCK

The present float plane dock system contains a fixed dock portion and a floating seasonally removable portion.

The fixed dock is land-based and was evaluated along with the boardwalk system and helipad during the 2016 geotechnical investigation (Tetra Tech 2017) and is in need of replacement as it looks to be close to failure.

The floating dock is of Candock© floating construction. While in place, it appears to be performing adequately. It is very lightweight with a very shallow draft and does not seem to have been damaged from river debris strikes or other environmental effects. It does, however, sustain damage during launching and removal each spring and fall as it is hoisting in the air by a helicopter via a long line which is not how these docks are designed by the manufacturer to be handled. The floating dock looks to be relatively simple to repair with new components installed as and when needed for annual upkeep. This type of dock is marketed for small craft and private owners.

Commentary from South Nahanni Air was provided via email on July 13, 2017. Their comments included the fact that the current floating dock bends or flexes too much due to the multiple cube construction and does not contain good tie down points. Existing tie in points are ropes fastened to the plastic loops on the outer edge of the dock. They also indicated that a bumper system would also improve the dock such as old tires fastened to the edge.

6.0 HYDROTECHNICAL STUDY

6.1 General

Hydrologic and hydraulic assessments were undertaken for the South Nahanni River above Virginia Falls. The results of the assessments were used to calculate the environmental forcing on the proposed dock structure. The following paragraphs describe the methodology of the analyses and present the results.

6.2 Hydrologic Assessment

Historical hydrometric data from Environment Canada for the South Nahanni River above Virginia Falls Station (10EB001) was used to estimate flow characteristics, in terms of flow rate and water level, for various return periods. The hydrometric data set includes 56 years of measurements recorded between 1962 and 2017. A frequency analysis was completed based on peak-over-threshold instantaneous flows from this station using Generalized Extreme Value (GEV), Log Pearson type II and Weibull fittings. The results based on Log Pearson Type III were determined to be the most conservative and thus were selected for presenting and for use in the determination of the environmental forcing presented in Section 6.4.

The estimated flow rates and water level elevations with respect to the datum at the level gauge, for various return periods, are presented in Table 6.1. Also included in the Table are the water level elevations with respect to 3.65 m, which is the water level recorded at the level gauge during the time in which the depth and current measurements were taken at the docks (12 PM on June 14, 2017). The design flow rate and water elevation will be used to determine the design flow velocity and water depth on which the environmental forcing calculation and mooring design will be based.

Table 6.1: Summary of Flows for Various Return Period.

Return Period (Years)	Flow (m^3/s)	Water Surface Elevation with respect to the datum at hydrometric station 10EB001(m)	Water Surface Elevation with respect to 3.65 m, the water level elevation measured at 12 PM on June 14, 2017 (m)
200	2540	6.28	2.63
100	2410	6.09	2.44
50	2280	5.90	2.25
20	2100	5.64	1.99
10	1940	5.42	1.77
5	1770	5.18	1.53
3	1630	4.98	1.33
2	1480	4.78	1.13

6.3 Hydraulic Assessment

A one-dimensional HEC-RAS hydraulic model was utilized to estimate the water velocities for various flow events. A depth survey of the channel, collected during the site visit, was used to build the model cross sections. Figure 1 illustrates the surveyed cross section used in the model. The depths were measured using a marked rope with a weight attached to the end.

The model was calibrated using the flow velocity and cross-sectional depth profile measured during the site visit at 12 PM June 14, 2017. A Manning's coefficient of 0.045 for the main channel and of 0.055 for the overbanks were found to reproduce similar velocity and water level distribution as those measured during the field visit.

The channel slope was measured to be approximately 0.1% (0.001 m/m), with 3H:1V side slopes. Table 6.2 summarizes the flow characteristics for various return periods predicted by the model. It should be noted that the flow data used to construct Table 6.2 is based on measurements taken at the site, and is thus considered more reliable than the data in Table 6.1 for purposes of determining design flow velocities in the river at the project site.

Table 6.2: Flood Depth and Velocities for Q2 and Q100 Flood Events

Return Period (Years)	Average Depth at the Cross Section (m)	Main Channel Velocity (m/s)	Overbank Velocity (m/s)
2	8.1	2.42	1.26
100	10.1	2.88	1.60

6.4 Environmental Forcing

In order to properly design the mooring and anchoring system for the docks, the total environmental forcing acting upon the dock structures and the float planes under design flow conditions will be required. Environmental forcing consists of 1) current drag, which is the drag force due to river flow acting on the exposed, submerged surfaces of the docks and float planes, and 2) wind drag, which is the drag force due to air flow acting on the exposed surfaces.

Calculation of both the current drag from river flow and air drag from winds utilizes the drag equations below:

$$F_{dw} = 0.5\,C_{dw} p_w A_w V_w^{\,2} + 0.5\,C_{f_w} p_w S_{w\ contacted}\, V_w^{\,2} \tag{1}$$

$$F_{da} = 0.5\,C_{da} p_a A_a V_a^{\,2} + 0.5\,C_{f_a} p_a S_{a\ contacted}\, V_a^{\,2} \tag{2}$$

where the subscript ‘w’ stands for water and ‘a’ stands for air; F_{dw} and F_{da} are the drag forces from water current and wind; C_{dw} and C_{da} are pressure drag coefficients for water current and wind; C_{fw} and C_{fa} are skin drag coefficients for water current and wind; ρ_{ω} and ρ_{α} are the density of water and density of air; A_w and A_a are the projected wetted and air-exposed areas of the object perpendicular to the flow direction; V_w and V_a are the undisturbed velocities of water current and wind; $S_{wcontacted}$ and $S_{acontacted}$ are the total surface areas in contact with water and air. Basically, the first term on the right side of the above equations is related to the drag force in the water due to the pressure difference between the up river and down river sides of an object, while the second term is related to the drag force due to skin friction from an object’s surface. Similarly, for the part of the structure above water, the first term on the right side of the above equations is related to the drag force due in the air water due to the pressure difference between the up river and down river sides of an object, while the second term is related to the drag force due to skin friction from an object’s surface

While the design river current at the project site can be readily extracted from the results of the frequency analysis as presented in Table 6.2 above, the design wind speed cannot be determined using the same methodology due to lack of available long-term wind data at the project site; the closest wind station with a long-term wind record is located in Fort Simpson, about 230 km east of Virginia Falls. While Fort Simpson is located in a relatively open and flat terrain, Virginia Falls is in the midst of the Mackenzie Mountain Region where winds will likely not correlate with the winds at Fort Simpson; therefore, a frequency analysis cannot be accurately undertaken for winds at Virginia Falls. In lieu of a frequency analysis, the 1-in-50-year design wind pressure of 0.39 kPa applicable to this particular region, as provided by the National Building Code of Canada 2010, was used to back-calculate the equivalent wind speed required to generate such wind pressure. Using the pressure drag equation for wind (the first term in Equation (2)), the equivalent 1-in-50-year wind speed to generate 0.39 kPa of wind pressure has been determined to be 22.5 m/s.

The total environmental forcing on a dock is the sum of the drag force on a float plane and the drag force on the main float and connecting float. To preserve the conservatism in the calculation, a 100-year flow event combined with a 50-year wind event was selected for the design forcing calculation. It is conservative because flow event and wind event, to a very high degree, are independent of each other and the probability of occurrence of an event in which a 100-year river flow and a 50-year wind occur coincidentally is significantly lower than 1-in-100 year. Moreover, part of the conservatism comes from the assumption that the direction of the forcing from the river current is the same as the direction of the wind during a design event. Nonetheless, such conservatism is required to account for all the uncertainties inherent in deriving the design environmental forcing, such as the uncertain effects from debris forcing because debris, if caught by the dock structure, would attract additional forcing from the river currents, which would exert additional forcing on the dock; however the magnitude of the force is unpredictable.

The design environmental forcing was calculated based on the configuration as shown in Drawing S100, showing the dimensions and general arrangement of the dock system. The environmental forcing per dock with and without the Twin Otter float plane were calculated based on two different drafts of the dock system (450 mm and 150 mm). The entire dock system consists of multiple docks; each of the docks consists of one main float and one Twin Otter float plane. The calculation results are tabulated in Table 6.3 below. Also included in Table 6.3 is the environmental forcing without the float plane, which is applicable for the canoe dock where there will not be parked float plane tied to the dock.

Table 6.3: Design Environmental Forcing on the Proposed Floating Docks

Draft of Floating Docks (mm)	Design Environmental Forcing per Dock with a Float Plane (kN)	Design Environmental Forcing per Dock without a Float Plane (kN)
450	13.3	8.0
150	10.0	5.5

7.0 RECOMMENDATIONS

7.1 General

The location of the existing float plane dock could be suitable for a replacement structure. The soil conditions vary and cannot be confirmed with economic means due to the extremely isolated nature of the site. The current anchorage system involves helical piles that were intended to be a long term solution but seasonal frost action has degraded their capacity. Tetra Tech has assumed a 30 year service life is desired for this project. Both on-shore and in-stream anchors have been considered but due to the limited bathymetry obtained and the large forces imposed on the dock, only land-based anchors were evaluated further.

The locations of proposed buried on-shore grillage anchors have been identified by Tetra Tech (Dwg S100) but these should be confirmed in the field and in conjunction with Parks Canada's plan for relocating their boardwalk system as part of their overall site redevelopment strategy. The final elevation of the new grillage structure should be based on the desired elevation of Parks Canada's new boardwalk. Detailed survey information is not available. Limited bathymetry data is available and largely adjacent to and upstream of the existing dock system. While a hydrological assessment of the site was undertaken by Tetra Tech, the rate of river erosion, if any, is unknown due to minimal history and documentation of river conditions. Locating the floating docks too near to shore where unknown bathymetry conditions exist may result in beaching of dock pontoons which may potentially get stuck in river sediments during extreme low water conditions. Placing on-shore anchor grillages, which also act as gangway ramp abutments, too far inland from the river may require removal of material at the river's edge to facilitate the vertical movements of gangway ramps due to changes in river water levels. Extending docks too far into the river may increase the risk of debris strikes.

Recommendations are provided in the following sections for a replacement floating dock system.

7.2 Climate Change Considerations

The impacts of potential climate change should be considered in the design of the new dock system. A procedure for screening the vulnerability of a development to climate change is outlined by the Canadian Standards Association (CSA, 2010).

The sensitivity of the site to climate change is governed by the characteristics of the permafrost at the site. The region is in an area of extensive, discontinuous permafrost, with average anticipated ground temperatures anticipated to be just below 0°C. Because the subsurface soils are largely of fluvial or glaciofluvial in origin with possible ice-rich lenses or layers potentially present on portions of the site, Tetra Tech characterizes the site sensitivity to be "high."

Under a "high" green-house gas scenario, the mean annual air temperature is estimated to increase about 1.1 °C over the next 30 years. The local climate conditions in the mountainous regions of NNPR are unknown but for a 30 year design life, the mean annual air temperature would rise by a total of about 1.1 °C (CSA, 2010). Local permafrost soils may be expected to begin thawing within 30 years if they have not already begun to do so. The practical implication is that foundation settlement could occur. Furthermore, based on the review of available information, it is anticipated that the permafrost in the foundation layer may contain layers or lenses of soil that have excess ground ice due to silt content. Therefore, the consequences of permafrost thaw are considered to be potentially serious, and they are ordinarily characterized as "major" for structures supported by shallow foundations (above or within the permafrost). The consequences are mitigated for this project, however, by the fact that the on-shore anchor structures are somewhat flexible in their design as the system is intended to deal with vertical fluctuations of up to 3.0 m as well as associated horizontal movements in the floating dock as the river level changes over the spring, summer and fall and therefore should be able to accommodate smaller scale incremental settlements over time. As well, adjustments can be made seasonally as the system is re-launched each spring. Therefore, the consequences of permafrost thaw are overall considered “minor” for this site.

Considering the site sensitivity and the associated consequences together results in a risk level “C” (low risk) as defined in CSA (2010). This level of risk warrants a qualitative analysis and the use of expert judgement to develop design parameters for a project with routine design parameters. This level of analysis and judgement has been employed to develop the recommendations for on-shore land-based anchors provided in this report.

7.3 Dock Structures

An aluminum framed modular system utilizing durable polyethylene shell and expanded polystyrene (EPS) fill is recommended for the general construction of the floating dock. The aluminum frame provides a rigidity to provide both park visitors and commercial users of the dock with a stable surface to utilize. The foam-filled dock floats are resistant to ultraviolet rays and damage by animals, ice, bumps by watercraft, floating woody debris and contact deterioration from petroleum products.

The different manufacturers of these types of docks provide warranties for their products; however, warranties may not cover actions such as repeatedly disassembling and reassembling the dock in the water or lifting by helicopter on an annual basis. The construction of the individual components is more heavy duty than the current ‘all in one’ plastic cube construction model that has been used for a number of years.

Three float plane docks have been requested by Parks Canada. Each dock is 3,658 mm x 7,315 mm (12 ft x 24 ft) in area. Each dock is to be connected to land via a 1.2 m wide gangway ramp.

A 350 mm freeboard has been specified for the floating docks. This should be considered a maximum freeboard range as a higher freeboard may cause a tripping hazard while stepping from a float plane pontoon onto the floating dock or potentially trap a float plane pontoon under the dock during docking maneuvers.

Cleats should be installed on the floating dock as required by aircraft.

7.4 Gangway Ramps

Three Aluminum gangway ramps 12,192 mm (40 ft) in length are required to provide access to the floating dock system at the downstream end of the dock and double as providing lateral stability to the floating dock. Hand rails have been removed as per request by Parks Canada as they would become an obstruction to float plane wing tips during seasonally low river level occurrences.

7.5 On-Shore Anchor System

7.5.1 General

The new floating docks are slightly larger than the old docks and are to be engineered and thus required to withstand substantial loadings considering a combination of potential live loads such as flood events, wind loadings on tied up aircraft and large debris strikes on the dock. A system of one upstream on-shore buried grillage anchor with mooring boom and one lateral on-shore anchor is recommended to secure each floating dock.

The upstream on-shore anchorage is planned to consist of a buried metal grillage structure connected to the floating dock via a mooring boom and chain and secured by soil and/or other ballast on the steel grillage.

The lateral on-shore buried anchor will support the gangway ramp which will perform as a stiff leg to secure the dock against the boom tensions and water level change with articulating connections and maintain the dock's position within the river.

7.5.2 Site Preparation

Construction of the buried on-shore anchors is anticipated to be completed by hand, small heli-portable excavator and/or medium or light lift helicopter. The wetlands and forest regions may require prior preparation if the use of heavy equipment is to be utilized as the area will likely provide poor trafficability depending on the weight or equipment and seasonal weather conditions/water table. Granular material is not readily available for improving trafficability. Use of lightweight materials such as wooden planks could facilitate trafficability of a small tracked excavator.

The on-shore anchor grillage should be constructed towards the later months of summer or early fall when river water levels and subsequently the ground water table are lower, the ground is drier and seasonal frost has thawed sufficiently to allow for excavation.

Any excavation work will require review and approval by Parks Canada for cultural and archeological purposes.

Excavated soils should be stockpiled for use at a later date for the on-shore anchors.

If water is present around the construction site, care should be exercised in removing it from excavations. Trenching or other sorts of excavation should be discouraged as it can damage permafrost conditions if they exist. Instead, diverting water by placing material above grade to encourage it to flow away from the construction site would be a better practice.

7.5.3 Buried On-Shore Anchor Construction

The Rabbitkettle project (Tetra Tech 2014) utilized a mechanically stabilized earth concept for building up a gravity anchor with minimal weight using construction materials transported via float plane to site and locally available sandy silty fill soil. The method involved the use of welded wire mesh and geotextiles to create side slopes of 70 degrees through the use of benching the soil in 508 mm or (20 in) segments. This system is reportedly performing well and we recommend using a similar construction method again of reinforced soil backfill in the form of a gravity anchor.

The on-shore anchor construction will be largely below final grade through excavating, installing a metal grillage and backfilling. Horizontal resistance is not reliably improved by burying or 'keying' the anchor into the local frost susceptible soil as the seasonally frozen soil cannot be counted on to support much resistance to horizontal loads. However, by burying the anchor, the volume of imported soil or ballast required to construct the gravity anchor can be minimized to reduce project costs. As the only available heavy equipment at this site is what can be transported by aircraft and the use of helicopters for heavy lifting on site, we consider it much more economical to use in place soil rather than importing material from afar.

The on-shore anchor grillage footprints should be identified while on site with Parks Canada staff. Care should be exercised in locating the grillage no closer than 1,000 mm away from the exposed riverbank.

The depth of grillage foundation excavation should be limited to 1,200 mm deep or 1,500 mm below the underside of Parks Canada's new boardwalk. The location of the dock #1 grillage is near the existing fixed dock and on a lower area of land that is seasonally flooded; therefore the excavation depth will be less than 1,200 mm and instead based on the final elevation of the new boardwalk. The other two dock grillages (docks #2 and #3) are located downriver and in anticipated higher elevation areas and their excavation depths should also be determined on site with Parks Canada with respect to the desired future boardwalk elevation.

The excavation, installation and start of backfill of the grillage should be undertaken as quick as possible; ideally within the same day. Open excavations can damage underlying permafrost, especially during warm weather conditions. Water should not be allowed to flow through the excavation. The grillage locations for docks #2 and #3 may be underlain by permafrost conditions.

Upon completion of excavation, a geosynthetic such as a Miragrid® 2XT biaxial geogrid or similar product with a long term design strength of 17 kN/m or equivalent to enhance friction should be placed on the base of the footing prior to installation of the metal grillage frame and every 300 mm above as backfill is placed.

The grillage members should be rounded edged hollow structural sections or similar without sharp edges that could damage geogrids.

During backfilling, soil should be placed and compacted in lifts no greater than 100 mm thick. Backfilling of the grillage can reuse the excavated native silty sandy or sandy silty soil. Alternatively, imported soil (silt, sand, gravel etc) and other ballast such as steel may be placed intermittently on the grillage in 100 mm compacted lifts. The total height of the backfill should be 1,500 mm as measured from the underside of the grillage.

A vertical geogrid should be placed on the river side of the grillage and sides perpendicular to the river.

Geogrids should be fastened with bodkin bars or similar together and to the grillage frame.

The backfill should be covered with a nonwoven geotextile such as a Mirafi® 1100N-Series or similar product with a maximum aperture size of 0.15 mm to prevent fine soils from washing away during seasonal flooding events. The non-woven geotextile should be fastened to the grillage.

Following completion of on-shore anchor backfill, a geosynthetic such as a Miramesh® GR biaxial geogrid with a 2 mm by 2 mm aperture geogrid or equivalent small mesh geogrid should be used to wrap the entire buried anchor grillage and soil mass on all sides and fastened with ties or staples. Holes should be cut to allow for the vertical members of the grillage to protrude as needed. This small mesh geogrid supports vegetation re-growth. Organic material (peat/moss/vegetative mats) removed and stockpiled prior to excavating the grillage footprint should be placed over top of the completed buried grillage and soil mass. Encouraging re-growth of vegetation will allow the on-shore anchor to blend in with the surroundings and to further stabilize the soils during seasonal flooding and reduce annual freeze thaw action. Water should be discouraged from ponding near the on-shore anchors.

As the grillages that form the on-shore anchors for docks 1 and 2 are at an angle not perpendicular to their respective gangway ramps, the river side corner of the soil mass will require trimming in order to facilitate the gangway ramp and dock during low water events. Failure to do this may result in the ramp's vertical rise and fall being restricted.

Technical specifications in Appendix C contain further details.

Example product information for geosynthetics can be seen in Appendix D.

8.0 COST ESTIMATE

8.1 Dock Design / Build

A dock building contractor quote has been prepared by a southern Canadian company and shown in Table 8.1.

To prepare this cost estimate, the drawing and specifications package was issued to the contractor as a generic drawing package with no ties to the actual project other than that the site was a northern location and not vehicle accessible. Approximate transportation costs were provided to assist the contractor in developing the estimate. There is a significant risk or contingency in their estimate.

Table 8.1: Design / Build Budget Estimate

Item	Estimate
Travel / Transportation	
Crew and Labour	
Installation	
Ramp Fabrication	
Dock and Anchor Fabrication	
Anchors / Chain / Hardware	
Contingency	
Engineering	
Total (Before Taxes)	

8.2 Transportation

A local aviation company was asked to provide a quote for a medium lift helicopter to transport prefabricated dock segments and other equipment from the nearest all season vehicle accessible location to the Virginia Falls site which is considered to be the former CanTung Mine site airstrip (135 km) and the Nahanni Butte winter road access point on Highway 7 (151 km). The quote is for the Highway 7 site which is less remote and logistically challenging than the Cantung Mine airstrip. Fuel caches are located at or near to both sites.

Parks Canada maintains a fuel cache for their own helicopter use at their Sunblood cabin site which is located 8 km northwest of Virginia Falls.

For an estimated 10 to 15 round trips,

Alternatively, twin otter aircraft are available and can access the site during the winter (on skis) and during the summer/fall (on floats). Airplane capacities are higher on skis but this is limited to only a brief window of opportunity when the river ice is thick enough. Fuel caches are established during the winter months. Local fixed wing aviation companies are usually based out of Fort Simpson (235 km) and Yellowknife (598 km).

9.0 CLOSURE

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

Respectfully submitted,
Tetra Tech Canada Inc.

REGISTERED PROFESSIONAL ENGINEER
T. H. SCHAAP
NT/NU
Feb 9/18

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PERMIT TO PRACTICE
TETRA TECH CANADA INC.
Signature
Date
PERMIT NUMBER: P 018
NT/NU Association of Professional Engineers and Geoscientists

REFERENCES

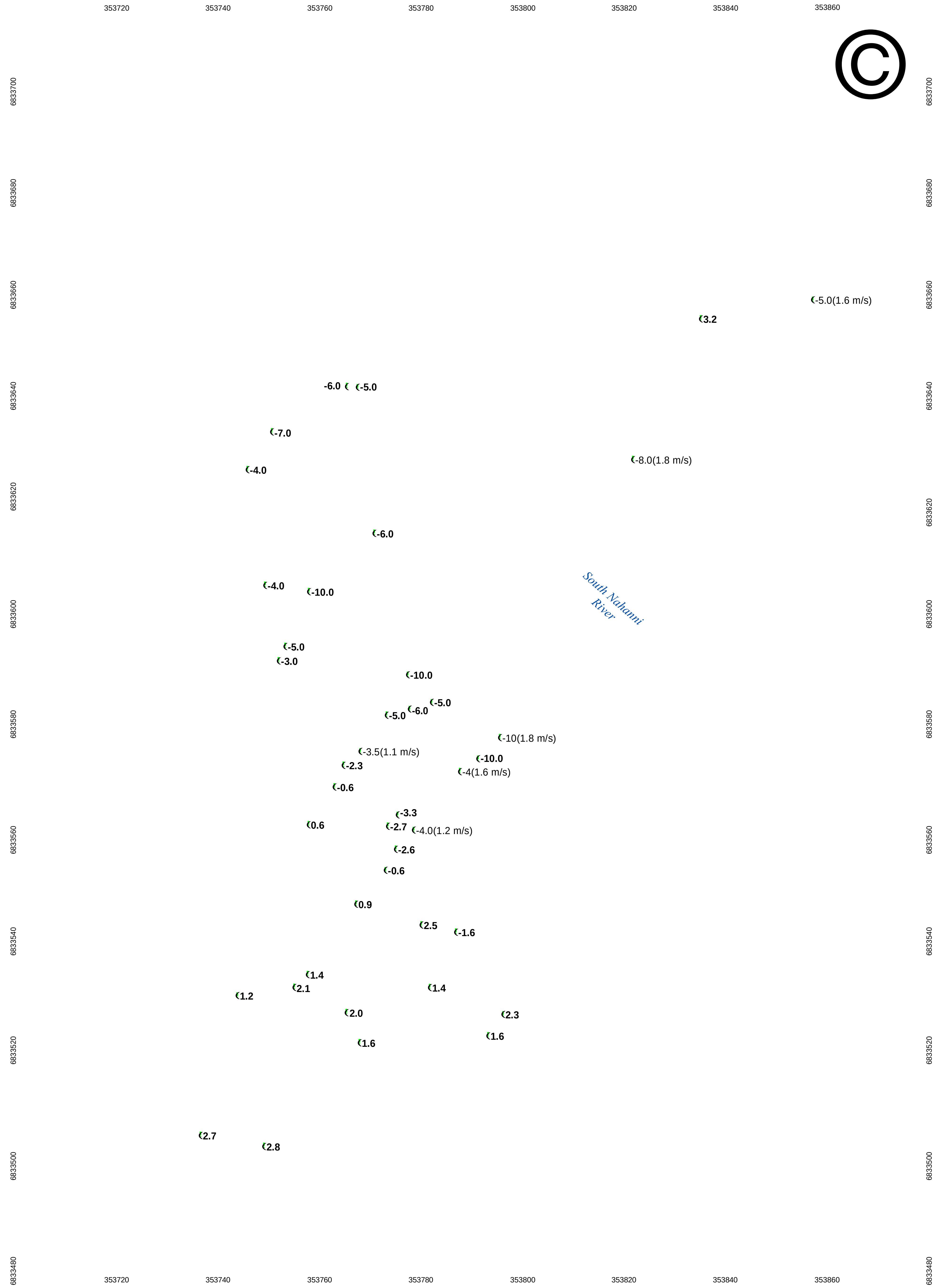
Heginbottom, J.A., Dubreuil, M.A. and Harker, P.T. 1995. Canada Permafrost. In: The National Atlas of Canada, 5th Edition, Sheet MCR 4177, Plate 2.1, Scale: 1:7,500,000. National Atlas Information Service, Canada Centre for Mapping, Geomatics Canada, Terrain Sciences Division, Geological Survey of Canada, Natural Resources Canada, Ottawa.

Tetra Tech EBA Inc. Geotechnical and Hydrotechnical Evaluation for Replacement of Rabbitkettle River Ferryway, Nahanni National Park Reserve, NT. Report submitted to Parks Canada Agency. Tetra Tech EBA File No.: Y14103255-01

Tetra Tech EBA Inc. Geotechnical Investigation for Boardwalk and Helipad Structures, Virginia Falls REZ 01, Nahanni National Park Reserve, NT. Report submitted to Parks Canada Agency. Tetra Tech File No.: YARC03060-01

FIGURES

Q:\Vancouver\GIS\ENGINEERING\YARC\YARC03060-02\Maps\YARC03060-02_Figure01_Dock.mxd modified 6/28/2017 by morgan.zondervan



Elevation (velocity) Measurement

Existing Dock

NOTES

All elevations with respect to water level of 3.6 m (Environment Canada June 14, 2017)

Base data source:
Imagery from DigitalGlobe (2016)

Existing Float Plane Dock and Site Features

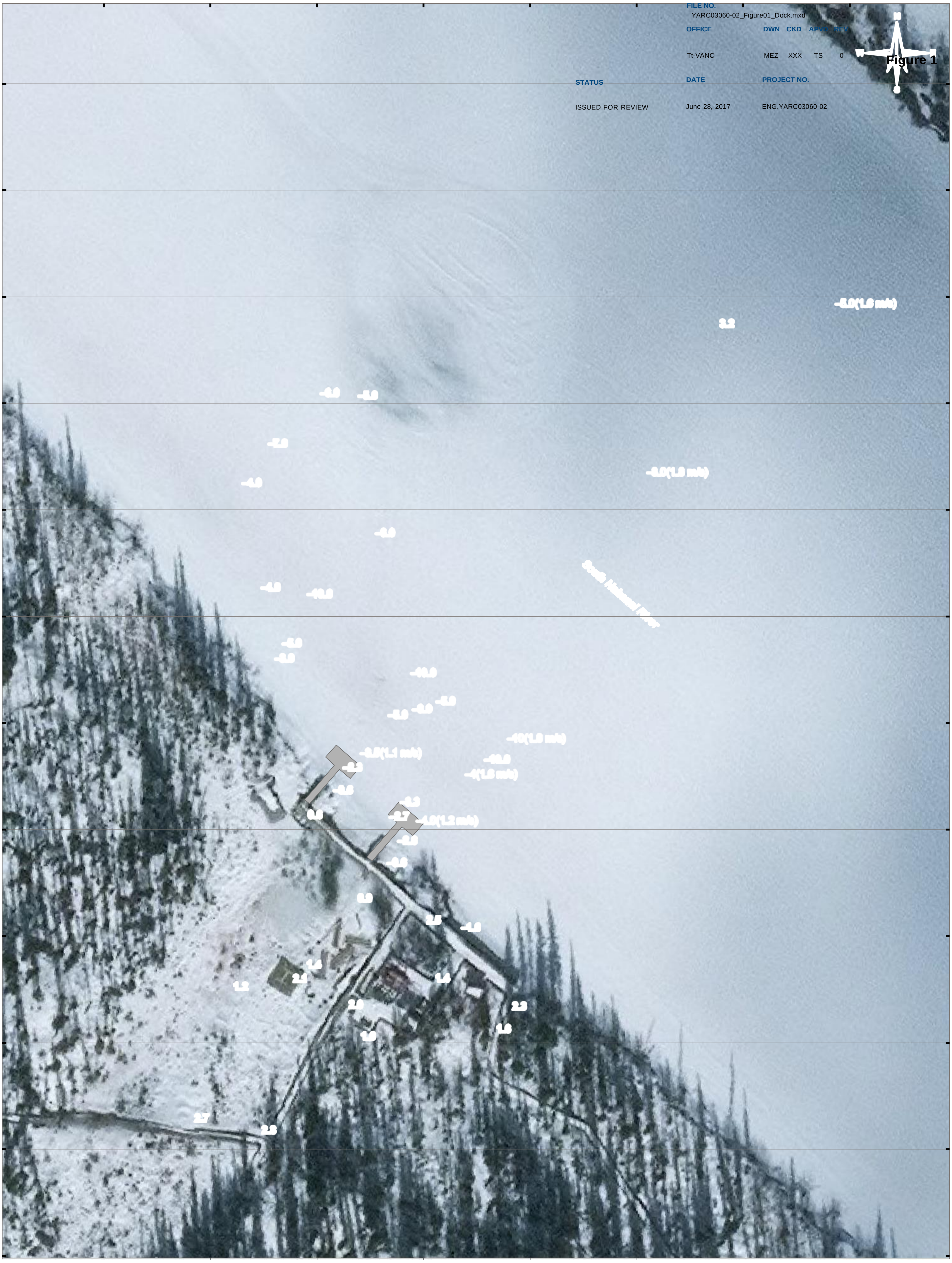
PROJECTION
UTM Zone 10

DATUM
NAD83

CLIENT

Scale: 1:700

10 5 0 10



Metres

FILE NO.
YARC03060-02_Figure01_Dock.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	MEZ	XXX	TS	0

Figure 1

STATUS	DATE	PROJECT NO.
ISSUED FOR REVIEW	June 28, 2017	ENG.YARC03060-02

TETRA TECH

PHOTOGRAPHS

Photo 1	View of the South Nahanni River just above Virginia Falls (lower left).
Photo 2	View of existing float plane dock during disassembly of dock by Parks Canada maintenance staff.
Photo 3	View of existing dock during bathymetry survey of the South Nahanni River.
Photo 4	Existing dock at a typical seasonal low water level. New dock design is for the dock #1 on-shore grillage anchor to be located just behind the existing fixed dock to the left of the ramp (circled).
Photo 5	Existing dock at a typical seasonal low water level. New dock design is for the dock #1 on-shore anchor grillage and gangway ramp abutment to be located just behind the existing fixed dock (circled).
Photo 6	Existing dock during a flood event high water level
Photo 7	A Twin Otter (foreground) and a Cessna 185 (background).
Photo 8	Existing dock and previous boardwalk system. The anchorage for the floating docks is unknown in this photo.

Photo 1: View of the South Nahanni River just above Virginia Falls (lower left). The existing float plane dock is circled (middle right).
Photo taken June 13, 2017

Photo 2: View of existing float plane dock during disassembly of dock by Parks Canada maintenance staff. The river flows right to left (west to east). The proposed new dock will be downriver of the existing dock.
Photo by Parks Canada, September 23, 2016

Photo 3: View of existing dock during bathymetry survey of the South Nahanni River.
Photo taken June 14, 2017

Photo 4: Existing dock at a typical seasonal low water level. New dock design is for the dock #1 on-shore grillage anchor to be located just behind the existing fixed dock to the left of the ramp (circled).
Photo taken September 20, 2016

Photo 5: Existing dock at a typical seasonal low water level. New dock design is for the dock #1 on-shore anchor grillage and gangway ramp abutment to be located just behind the existing fixed dock (circled).
Photo taken September 20, 2016

Photo 6: Existing dock during a flood event high water level.
Photo by Parks Canada June 2006

Photo 7: A Twin Otter (foreground) and a Cessna 185 (background).
Photo taken September 20, 2016

Photo 8: Existing dock and previous boardwalk system. The anchorage for the floating docks is unknown in this photo.

Photo by Parks Canada June, 2004

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

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1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

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

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by persons other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

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The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

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

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

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

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

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

1.9 LOGS OF TESTHOLES

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

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

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

1.11 PROTECTION OF EXPOSED GROUND

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

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

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

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

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

1.14 OBSERVATIONS DURING CONSTRUCTION

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

1.15 DRAINAGE SYSTEMS

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

1.16 BEARING CAPACITY

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

1.17 SAMPLES

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

LIMITATIONS ON USE OF THIS DOCUMENT

HYDROTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

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1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

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The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless expressly agreed to in the Services Agreement, TETRA TECH was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project.

1.8 LEVEL OF RISK

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the hydrotechnical information that was reasonably acquired to facilitate completion of the design.

APPENDIX B

DRAWING PACKAGE

-4.0
-10.0

-5.0
-3.0

-10.0

-5.0
-6.0
-5.0

-3.5
-10.0
-2.3
-4
-0.6
-3.3
0.6
-2.7
-4.0

-2.6
-0.6

0.9

2.5
-1.6

1.4
2.1
1.4
1.2

2.0
2.3

1.6
1.6

South Nahanni River

Nááts'ihch'oh National Park Reserve

Nahanni National Park Reserve of Canada

Tungsten

Virginia Falls Waterdome SITE

Nahanni Butte

Netla

-X.X

a\ENGYARC03062 Nahani Plane Dock\DWG\revised project\YARC03060-02_S100 R4.dwg [S100] February 07, 2018 - 4:06:05 pm (BY: ERIC BURNELL)

ISSUED FOR TENDER

NOTES:

1. THIS DRAWING WAS PREPARED FOR THE EXCLUSIVE USE OF THE PARKS CANADA ("CLIENT") AND IS ISSUED PURSUANT TO THE SERVICES AGREEMENT BETWEEN CLIENT AND TETRA TECH, UNLESS OTHERWISE AGREED IN WRITING WITH CLIENT OR SPECIFIED ON THIS DRAWING, TETRA TECH DOES NOT ACCEPT AND DISCLAIMS ANY AND ALL LIABILITY OR RESPONSIBILITY ARISING FROM ANY USE OR RELIANCE ON THIS DRAWING BY ANY THIRD PARTY OR ANY MODIFICATION OR MISUSE OF THIS DRAWING BY CLIENT, AND THIS DRAWING IS CONFIDENTIAL AND

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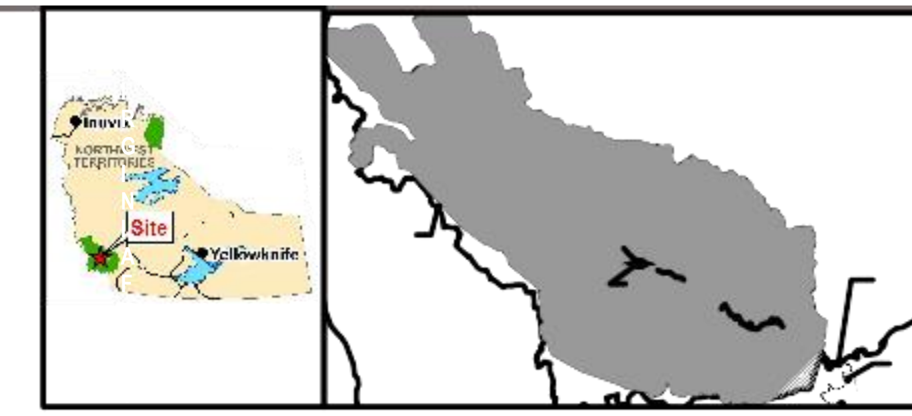

LOCATION

NATIONAL PARK RESERVE

GENERAL ARRANGEMENT

PROJECT DESCRIPTION

1. PARKS CANADA REQUIRES A NEW FLOATING DOCK SYSTEM FOR THREE FLOAT PLANES AND NON-MOTORIZED VESSELS TO REPLACE THE TWO EXISTING DOCKS THAT PROVIDE MOORAGE FOR TWO FLOAT PLANES AND NON-MOTORIZED VESSELS ON THE SOUTH NAHANNI RIVER.
2. TETRA TECH CANADA HAS PREPARED THE RFP DOCUMENT THAT INCLUDES THE PERFORMANCE SPECIFICATION AND THESE PLANS FOR PARKS CANADA TO CALL FOR TENDERS FOR A DESIGN BUILD CONTRACTOR TO PROVIDE A FLOATING DOCK SYSTEM THAT COMPLIES WITH THE GEOMETRY AND MOORING ARRANGEMENT.
3. THE CONTRACTOR SHALL BE A DESIGN BUILD CONTRACTOR WITH EXPERIENCE IN DESIGN / BUILD OF BOTH RECREATIONAL AND COMMERCIAL MARINAS.
4. THE DESIGN INTENT OF THE RFP IS TO ALLOW THE CONTRACTOR TO EMPLOY PROVEN TECHNOLOGY AND STANDARD INDUSTRY PRACTICE FOR THE PERFORMANCE OF THE DOCK SYSTEM AND TO ALLOW THE ASSEMBLY AND DIS-ASSEMBLY ANNUALLY TO BEACH THE SYSTEM PRIOR TO FREEZE UP AND TO LAUNCH THE SYSTEM FOR USE DURING ICE FREE PERIODS.
5. THE DOCK SYSTEM ESSENTIALLY IS TO BE COMPRISED OF THE FOLLOWING:
   1. THREE INDEPENDENT FLOATS, EACH WITH ITS OWN ACCESS RAMP AND MOORING BOOM;
   2. THREE FLOATING DOCKS EACH 7.3m X 3.6m (24 ft X 12 ft);
6. EACH ARTICULATING ALUMINUM RAMP 12.2 m X 1.2m (40 ft X 4 ft) THAT ALSO ALLOW UPSTREAM HORIZONTAL SWING UP TO 300 MILLIMETERS AT LOW WATER TO PROVIDE ACCESS TO SHORE AND STIFF LEG PERFORMANCE TO SECURE THE DOCKS DURING THE 3 METER WATER LEVEL CHANGE. THE RAMP TO BE DESIGNED TO RESIST THE LOADING ECCENTRICITY CAUSED BY THE MOORING BOOM TENSION APPLIED TO THE DOCK THAT THE RAMP AND FLOAT STRUCTURAL FRAMING AND FLOAT AND RAMP HINGES MUST ACCOMMODATE;
7. THE BURIED GRILLAGE FOUNDATIONS HAVE BEEN SIZED GEOTECHNICAL FOR A MOORING BOOM AXIAL DESIGN FORCE TENSION OF 60 KN (6 TONS) THAT INCLUDES ENVIRONMENTAL FORCES FROM HYDRODYNAMIC, WIND AND DEBRIS;
8. THE MOORING LINE IS TO BE DESIGNED BY THE DESIGN BUILD CONTRACTOR AND TO BE COMPRISED OF MARINE CHAIN INSIDE HIGH DENSITY POLYETHYLENE PIPE FILLED WITH EXPANDED POLYSTYRENE FOAM TO PROVIDE POSITIVE BUOYANCY TO NOT CAUSE ANY CHAIN WEIGHT DRAG DOWN FORCES ON THE DOCKS.
9. THE DESIGN BUILD CONTRACTOR SHALL DESIGN THE FLOAT AND RAMP FRAMING TO WITHSTAND THE BOOM'S AXIAL TENSION ACCOUNTING FOR THE ECCENTRICITY THAT INCLUDES YAW MOMENTS IMPOSED ON THE FULL SYSTEM FROM BOOM TO GRILLAGE;
10. THE BACKFILL MATERIAL AND GEOGRID APPLIES A HOLD DOWN FORCE 3.74 kN/m² OF PLAN AREA OF EACH GRILLAGE THAT PROVIDES ADEQUATE A SLIDING RESISTANCE AGAINST THE 60 kN FULL FORCE AND OVERTURNING CONDITION;
11. THE DESIGN BUILD SHALL PERFORM A STRUCTURAL ANALYSIS OF THE BOOM LOADING ON THE FLOAT / RAMP / GRILLAGE SYSTEM USING THE 60 kN DESIGN FORCE TO DESIGN ALL PARTS AND COMPONENTS. THE STEEL SHAPES SHOWN ON THESE DRAWINGS FOR THE GRILLAGES AND PADEYES ARE SUGGESTED SIZES AND PADEYE STYLES FOR PROPER ARTICULATION ONLY AND THE ANALYSIS ABOVE IS REQUIRED WITH ACTUAL FLOAT AND RAMP FRAMING TO BE USED BY THE DESIGN BUILD CONTRACTOR;
12. RUBBER TIRES SHALL BE PROVIDED ALONG THE BERTH FACE FOR THE PLANES AND THE BERTH FACES SHALL HAVE A FREEBOARD OF 350mm;
13. PARKS CANADAS LABOUR FORCE CAN EMPLOY ONLY A LIGHT HELICOPTER WITH A NET LIFT CAPACITY OF 454kg (1,000 LBS) TO BEACH AND LAUNCH THE DOCKS EVERY YEAR;
14. THE EXISTING PLASTIC DOCKS BEND AND OVER STRESS THE PLASTIC TANKS THAT ARE BOLTED TOGETHER WHEN HOISTED WITH TYPICAL LIGHT RIGGING EMPLOYED FOR HELICOPTER LIFTING.
15. THE BASIC DESIGN INTENT FOR THIS NEW DOCK SYSTEM IS TO PROVIDE FLOATATION TANKS FILLED WITH FOAM AND MADE OF DURABLE LIGHT WEIGHT MATERIAL SUCH AS HIGH DENSITY POLYETHYLENE TO PROVIDE POSITIVE BUOYANCY AFTER DEBRIS IMPACT.
16. THE BASIC DESIGN INTENT IS ALSO TO FRAME THE FLOATATION TANKS WITH ALUMINUM MEMBERS WITH THE STRENGTH AND LIGHT WEIGHT TO PERMIT LIGHT HELICOPTER HOIST RIGGING SO THE FLOAT FRAMING PROVIDES SPREADER BAR PROTECTION OF THE DOCKS DURING BEACH AND LAUNCHING ANNUALLY AND THAT DOCK SECTIONS GREATER THAN 454 kg CAN BE DISASSEMBLED INTO SMALLER SECTIONS THROUGH THE USE OF PINNED QUICK RELEASE CONNECTIONS.
17. THE DECKING SHOULD BE A LIGHT WEIGHT GRATED TYPE THAT IS NON SLIP DESIGNED FOR PEDESTRIAN LOADING OF 1 kPa (21 psf).
18. PARKS CANADA SHALL PROVIDE APPROVAL FOR THE REMOVAL METHOD OF POSSIBLE VEGETATIVE MATS ON THE FORESHORE AND RIVER BOTTOM BELOW THE RAMPS THAT COULD INTERFERE WITH THE LOW WATER OPERATION OF THE RAMPS ON DOCKS 1, 2, AND 3.

NUM	DATE	DWN	CKD	APP	DESCRIPTION
A	2018/02/09				ISSUED FOR TENDER

REVISIONS

ISSUING STATUS

PERMIT

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PROJECT No.	OFFICE	DES	CKD	REV	DRAWING
ENGYARC03060-02	VANC	GJG	THS	0	S100
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LEGEND

- BATHYMETRY DEPTHS ARE SHOWN IN METERS

BURIED GRILLAGE ABUTMENT TYP.

Parks Canada Parcs Canada

TETRA TECH

UPSTREAM

DOCK #1

DOCK #2

DOCK #3

DOWNSTREAM

300Ø HDPE PIPE SEGMENT
C/W BOLTED FLANGES AT
PIPE ENDS

2 - CHAIN SLINGS

2-CHAIN SLINGS

300Ø HDPE PIPE SEGMENT
C/W BOLTED FLANGES AT
PIPE ENDS

CONNECT FLANGES
WITH SHACKLES

TYP.

AIRCRAFT FLOAT
7.3m x 3.6m, TYP.

2-CHAIN
SLINGS

* POSSIBLE MEMBERS
DUE TO ECCENTRICITY
OF SECTIONS

1.2mx12.2m
HINGED ALUMINUM RAMP

GRILLAGE
TYPE A

SHORELINE

* POSSIBLE MEMBERS
DUE TO ECCENTRICITY
OF SECTIONS

1.2mx12.2m
HINGED ALUMINUM RAMP

* POSSIBLE MEMBERS
DUE TO ECCENTRICITY
OF SECTIONS

CONNECT FLANGES
WITH SHACKLES
TYP.

CHAIN SECURED TO
GRILLAGE ANCHOR ABOVE
HIGH WATER

RAMP GRILLAGE ABUTMENT,
TYP.

GRILLAGE
TYPE B

CONNECT FLANGES
WITH SHACKLES
TYP.

300Ø HDPE PIPE SEGMENT
C/W BOLTED FLANGES AT
PIPE ENDS

GRILLAGE
TYPE B

CHAIN SECURED TO
GRILLAGE ANCHOR

CHAIN SECURED TO
GRILLAGE ANCHOR

HINGED 1.2m x 12.2 m
ALUMINUM
RAMP

GRILLAGE
TYPE C

SLOTTED
HINGES

PLAN

SCALE: 1:250

NOTE:

1. EACH MOORING BOOM DESIGN FORCE IS 50 kN ARID TENSION
2. DESIGN BUILD TO PERFORM STRUCTURAL ANALYSIS OF THE BOOM-FLOAT-RAMP ACCOUNTING FOR THE ECCENTRICITY OF BOOM TENSION OF 50 kN AND THE RAMP AS A STIFF LEG. FLOAT AND RAMP HINGES ARE A PART OF THE LOAD PATH FOR EACH DOCK.

UPSTREAM

DOWNSTREAM

MOORING CHAIN

EXISTING GRADE

SURFACE CHAIN SLEEVED IN
HDPE PIPE TO GRILLAGE
ANCHOR ON SHORE

FLANGED SLEEVED
CONNECTION BETWEEN
PIPE SEGMENTS

300

BURIED
GRILLAGE
ANCHOR

172 SHIFT UPSTREAM AT LOW WATER

HIGH WATER

HIGH WATER

3000

LOW WATER

LOW WATER

3000

ASSUMED RIVER BOTTOM

1220 ABOVE
HIGH WATER

CONNECTION TO
2 - CHAIN SLINGS

45 m

SEE SECTION 4/103 FOR GRILLAGE TO FLOAT
CONNECTION DETAIL

ELEVATION

SCALE: 1:250

ISSUED FOR TENDER

CLIENT

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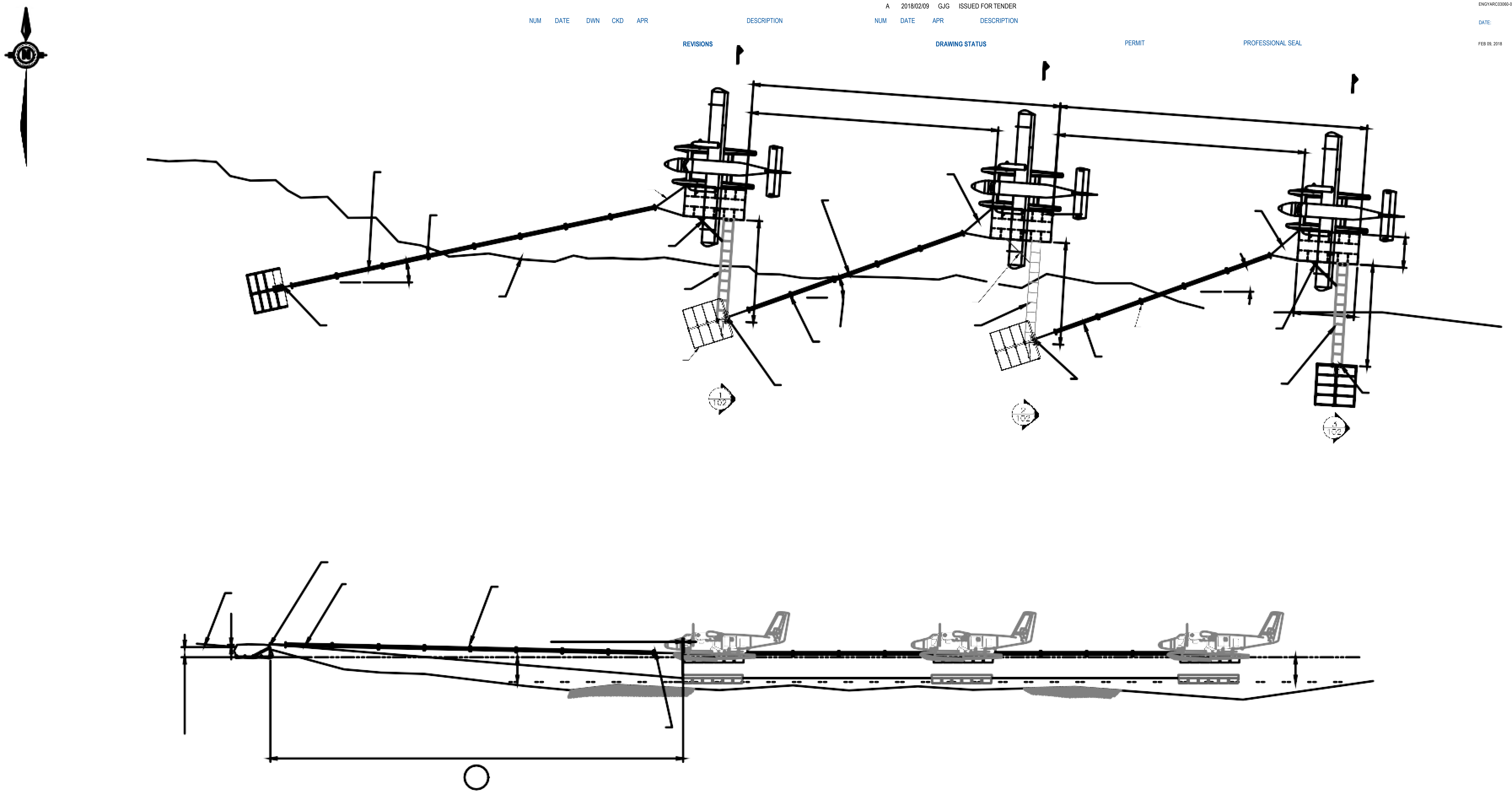
PLAN AND ELEVATION

PROJECT No.	OFFICE	DES	CKD	REV	DRAWING



NUM	DATE	DWN	CKD	APR	DESCRIPTION

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NUM	DATE	APR	DESCRIPTION
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PERMIT

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101

Parks Canada | Parcs Canada

TETRA TECH

12305

FACE OF AIRCRAFT FLOAT

FACE OF ABUTMENT

SLOTTED HINGES PERMITS UPSTREAM MOVEMENT OF 200mm AT LOW WATER

1000 x 1200 TRANSFER PLATE

12195 ALUMINUM RAMP

BOARDWALK BY OTHERS

3658

HWL

COMPACTED BACKFILL & GEOGRID

EXCAVATION

TIRE BUMPERS ALONG PLANE BERTH FLOAT FACE, TYP.

FLOATATION TANKS FOR BEACHING & LAUNCHING

1000

RAMP GRILLAGE ABUTMENT

3000

TYPICAL FLOATS

LWL

EXISTING RIVER BED

SECTION 1/101 HIGH WATER ELEVATION

SCALE: 1:100

11790

FACE OF AIRCRAFT FLOAT

FACE OF ABUTMENT

SLOTTED HINGES PERMITS UPSTREAM MOVEMENT OF 200mm AT LOW WATER

1000 x 1200 TRANSFER PLATE

BOARDWALK BY OTHERS

COMPACTED BACKFILL & GEOGRID

12191 ALUMINUM RAMP

EXCAVATION

1000

RAMP GRILLAGE ABUTMENT

3658

SEE DETAIL

TIRE BUMPERS ALONG PLANE BERTH FLOAT FACE, TYP.

TYPICAL FLOATS

FLOATATION TANKS FOR BEACHING & LAUNCHING

EXISTING RIVER BED

SECTION 1/101 LOW WATER ELEVATION

SCALE: 1:100

12305

FACE OF AIRCRAFT FLOAT

FACE OF ABUTMENT

SLOTTED HINGES PERMITS UPSTREAM MOVEMENT OF 200mm AT LOW WATER

1000 x 1200 TRANSFER PLATE

12195 ALUMINUM RAMP

3658

BOARDWALK BY OTHERS

HWL

COMPACTED BACKFILL & GEOGRID

EXCAVATION

480

TIRE BUMPERS ALONG PLANE BERTH FLOAT FACE, TYP.

1000

RAMP GRILLAGE ABUTMENT

3000

TYPICAL FLOATS

LWL

POSSIBLE VEGETATION MAT TO BE TRIMMED

ASSUMED RIVER BED

FLOATATION TANKS FOR BEACHING & LAUNCHING

SECTION 2/101 HIGH WATER ELEVATION

SCALE: 1:100

THESE FLOATS ARE DOWNSTREAM OF THE BATHYMETRIC SURVEY LINE

11790

FACE OF AIRCRAFT FLOAT

FACE OF ABUTMENT

SLOTTED HINGES PERMITS UPSTREAM MOVEMENT OF 200mm AT LOW WATER

1000 x 1200 TRANSFER PLATE

BOARDWALK BY OTHERS

COMPACTED BACKFILL & GEOGRID

12195 ALUMINUM RAMP

EXCAVATION

1000

3658

POSSIBLE KNOLL (TRIM SHORELINE TO ACCOMMODATE RAMP RISE AND FALL)

TIRE BUMPERS ALONG PLANE BERTH FLOAT FACE, TYP.

FLOATATION TANKS FOR BEACHING & LAUNCHING

TYPICAL FLOATS

SECTION 2/101 LOW WATER ELEVATION

SCALE: 1:100

THESE FLOATS ARE DOWNSTREAM OF THE BATHYMETRIC SURVEY LINE

12305

FACE OF AIRCRAFT FLOAT

FACE OF ABUTMENT

SLOTTED HINGES PERMITS UPSTREAM MOVEMENT OF 200mm AT LOW WATER

1000 x 1200 TRANSFER PLATE

12195 ALUMINUM RAMP

BOARDWALK BY OTHERS

3658

HWL

COMPACTED BACKFILL & GEOGRID

EXCAVATION

480

1000

TIRE BUMPERS ALONG PLANE BERTH FLOAT FACE, TYP.

RAMP GRILLAGE GROUND ABUTMENT

3000

TYPICAL FLOATS

POSSIBLE VEGETATION MAT TO BE TRIMMED

LWL

FLOATATION TANKS FOR BEACHING & LAUNCHING

ASSUMED RIVER BED

SECTION 3/101 HIGH WATER ELEVATION

SCALE: 1:100

THESE FLOATS ARE DOWNSTREAM OF THE BATHYMETRIC SURVEY LINE

11790

FACE OF AIRCRAFT FLOAT

FACE OF ABUTMENT

SLOTTED HINGES PERMITS UPSTREAM MOVEMENT OF 200mm AT LOW WATER

1000 x 1200 TRANSFER PLATE

BOARDWALK BY OTHERS

COMPACTED BACKFILL & GEOGRID

12195 ALUMINUM RAMP

EXCAVATION

1000

RAMP GRILLAGE ABUTMENT

3658

POSSIBLE VEGETATION MAT TO BE TRIMMED (TRIM SHORELINE TO ACCOMMODATE RAMP RISE AND FALL)

ASSUMED RIVER BED

TIRE BUMPERS ALONG PLANE BERTH FLOAT FACE, TYP.

FLOATATION TANKS FOR BEACHING & LAUNCHING

SECTION 3/101 LOW WATER ELEVATION

TYPICAL FLOATS

SCALE: 1:100

THESE FLOATS ARE DOWNSTREAM OF THE BATHYMETRIC SURVEY LINE

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ELEVATIONS

PROJECT No.	OFFICE	DES	CKD	REV	DRAWING
ENGYARC03060-02	VANC	GJG	THS	0	102
DATE:	SHEET No.	DWN	APP	STATUS	
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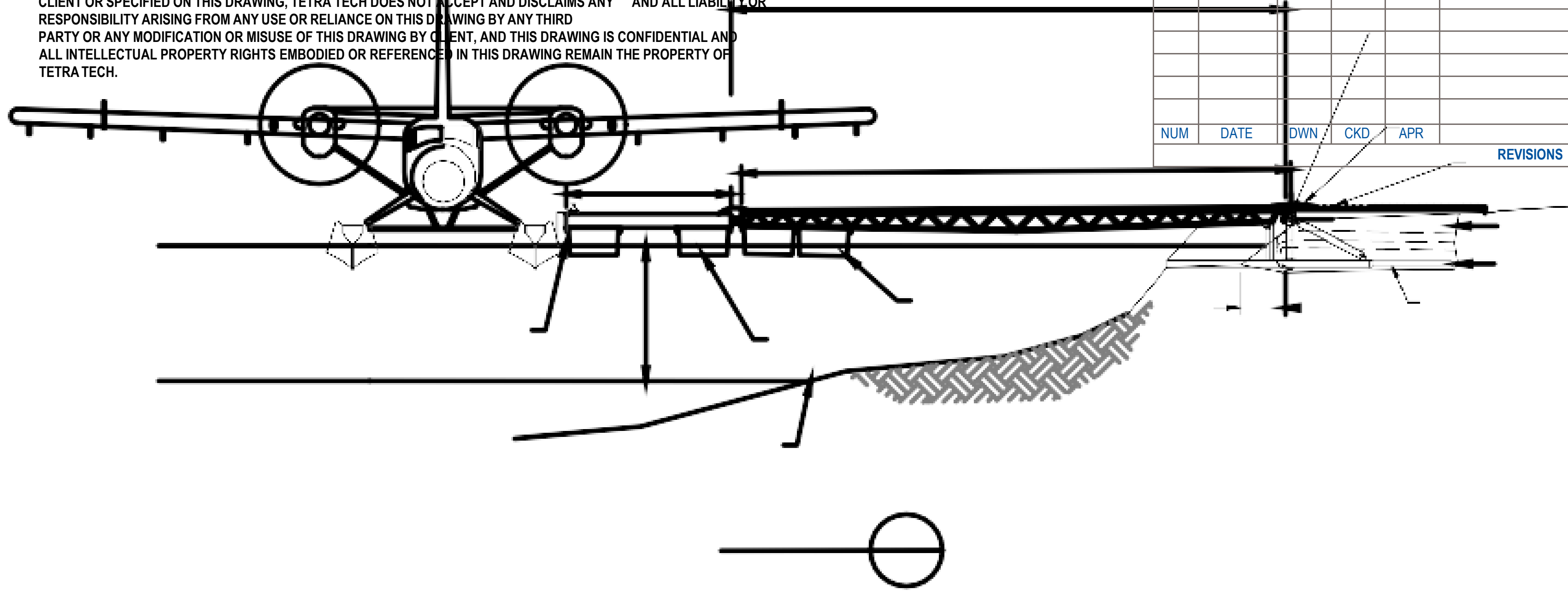

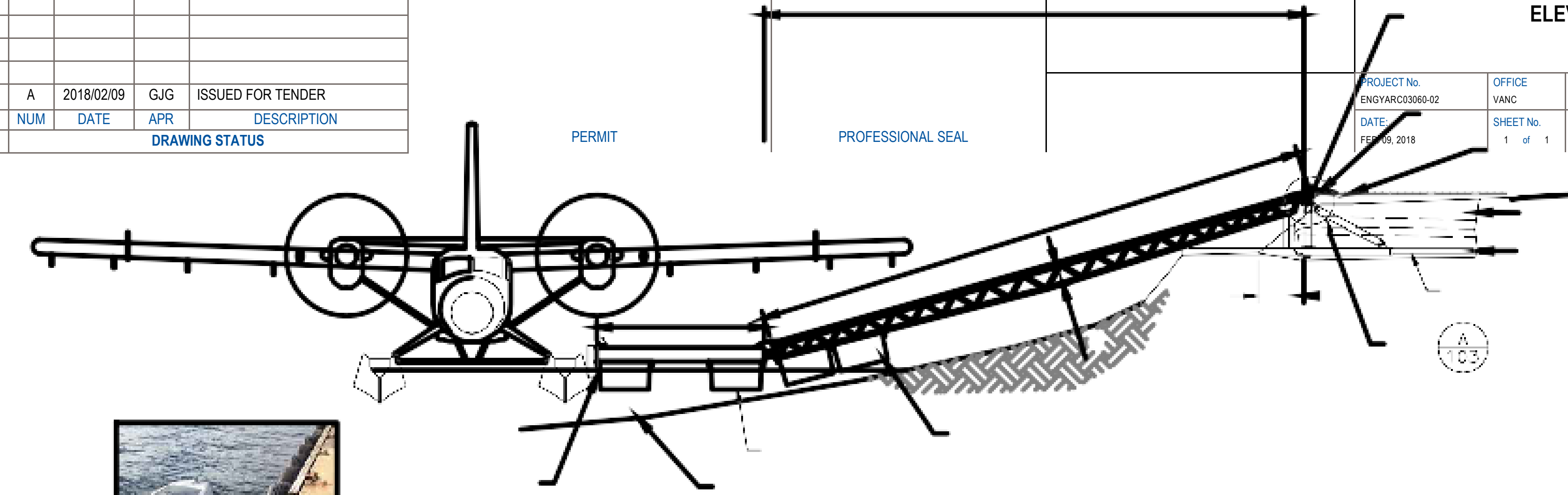

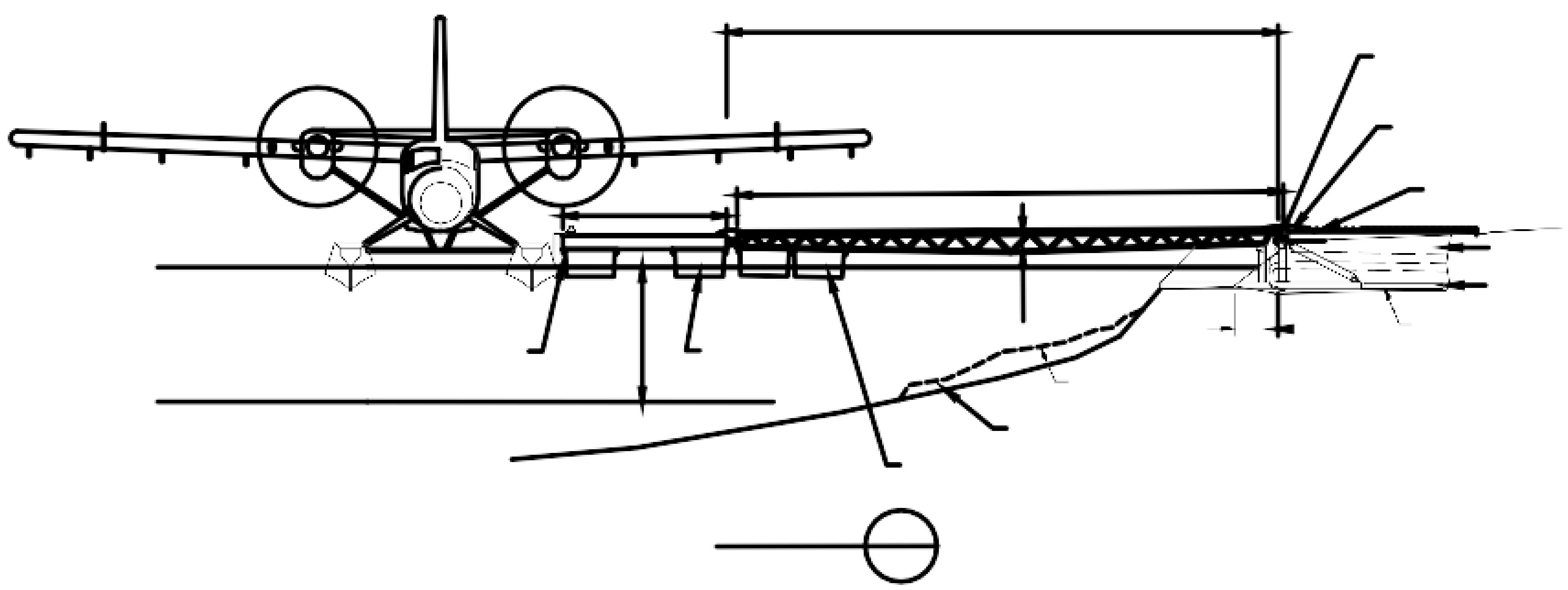

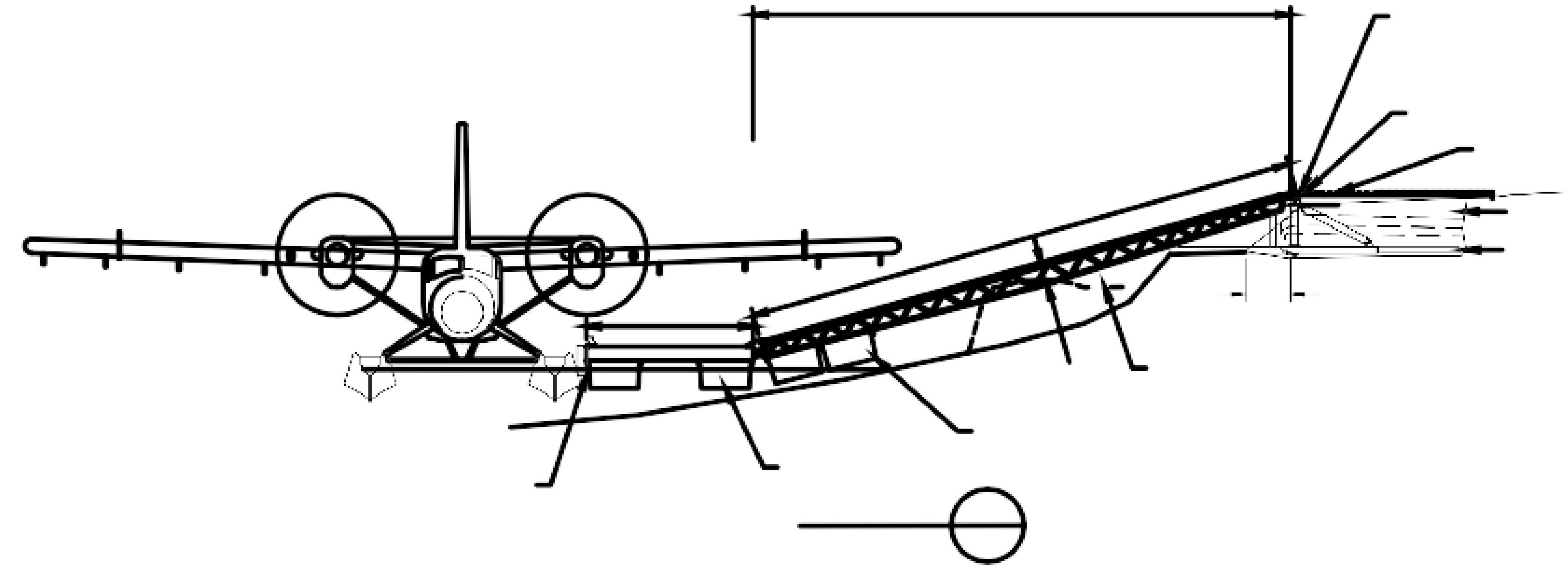

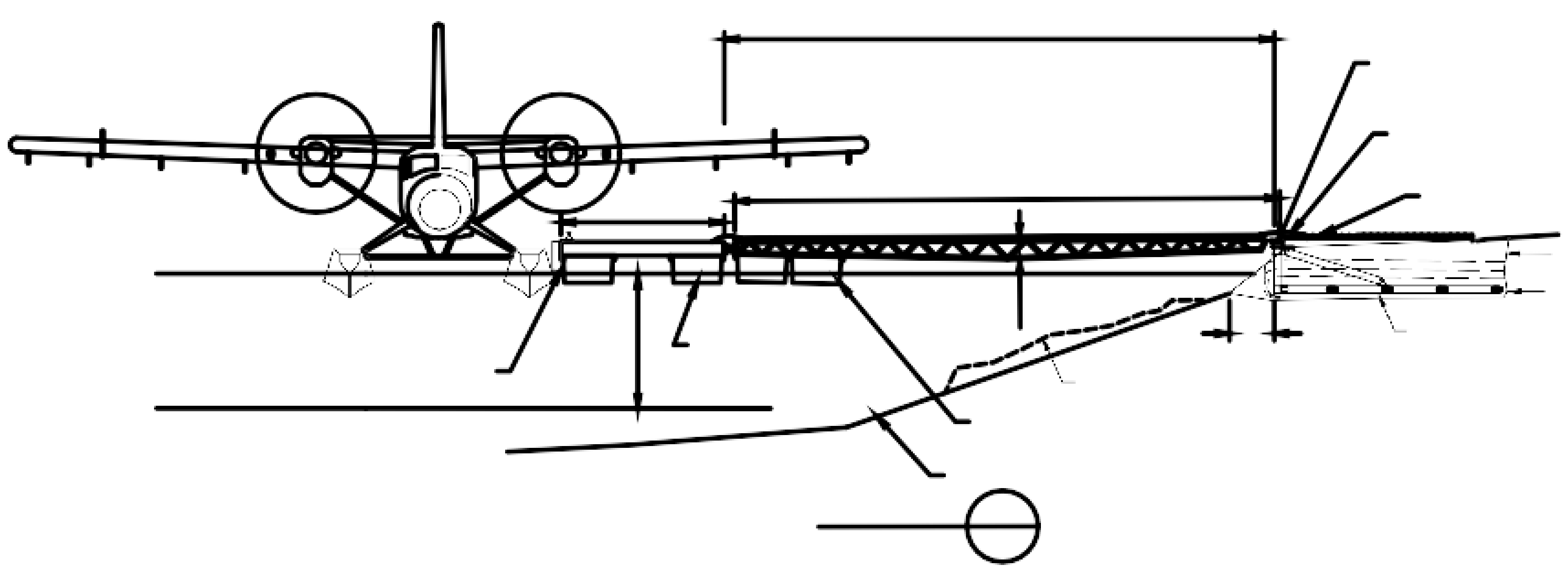

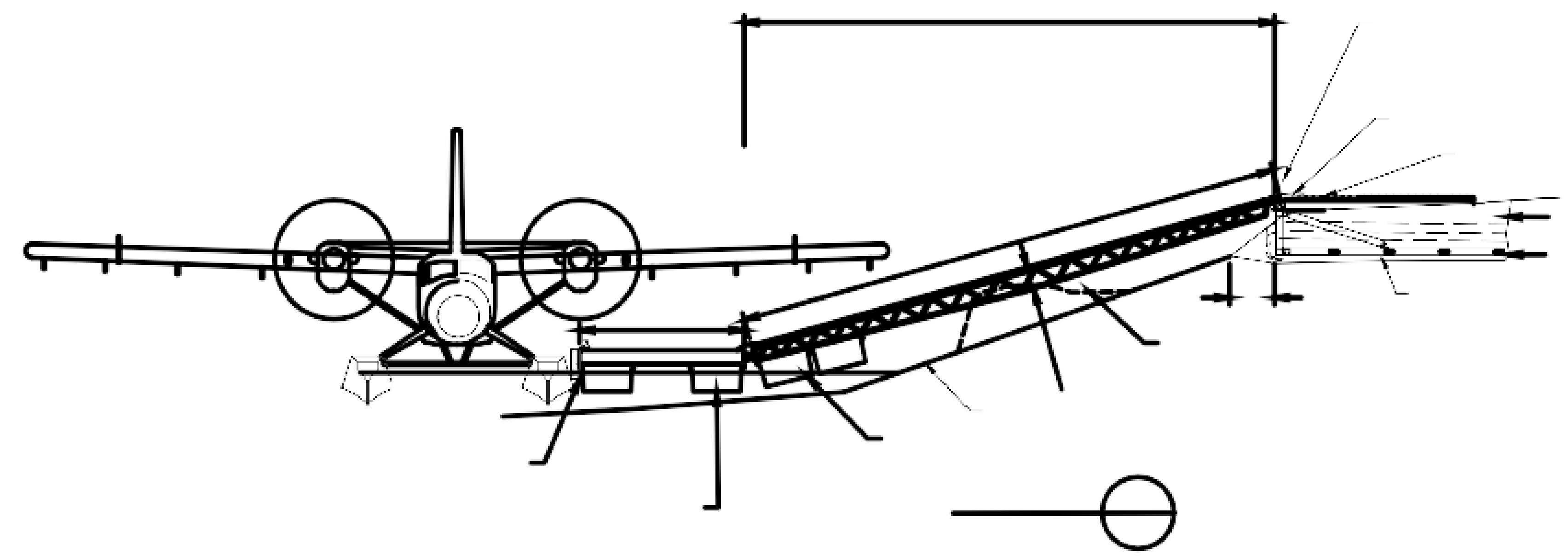

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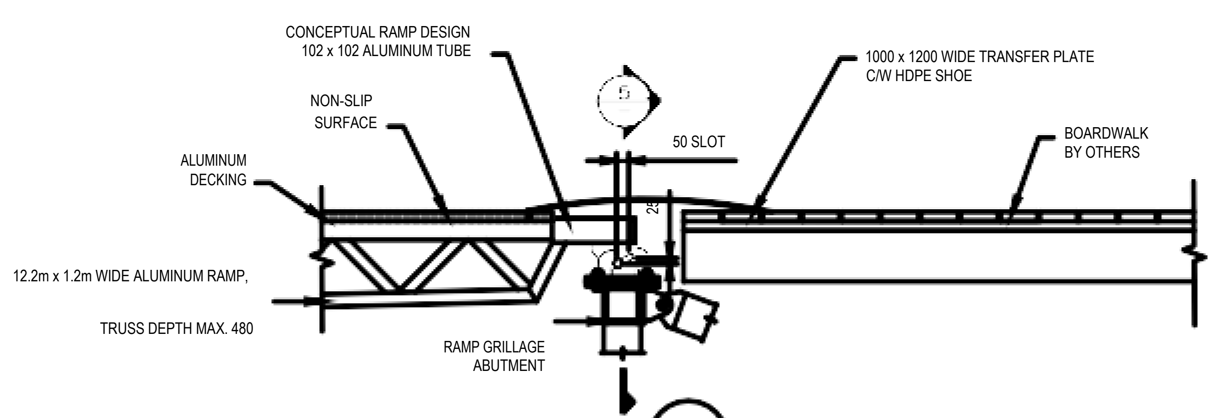
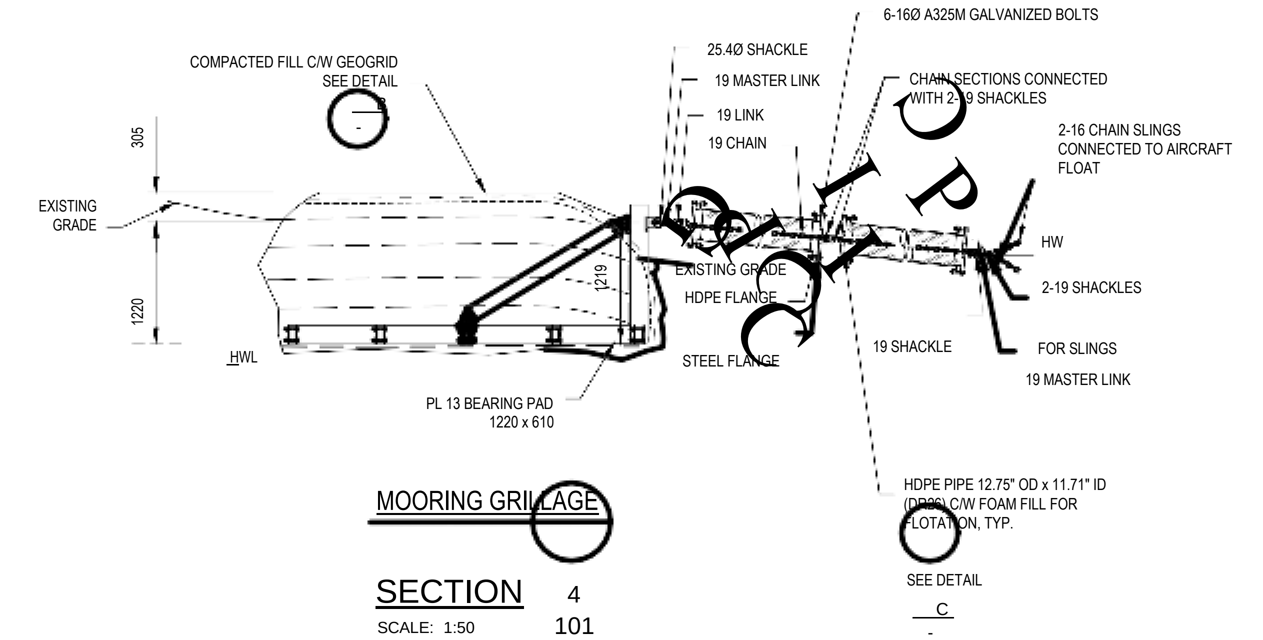
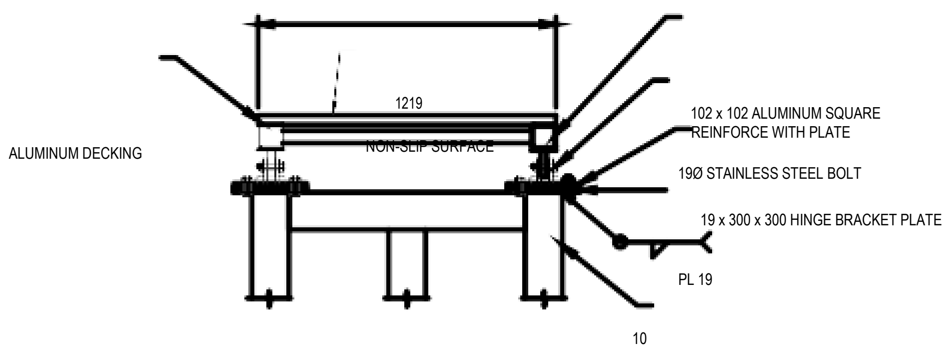


DETAIL A
SCALE: 1:20
102

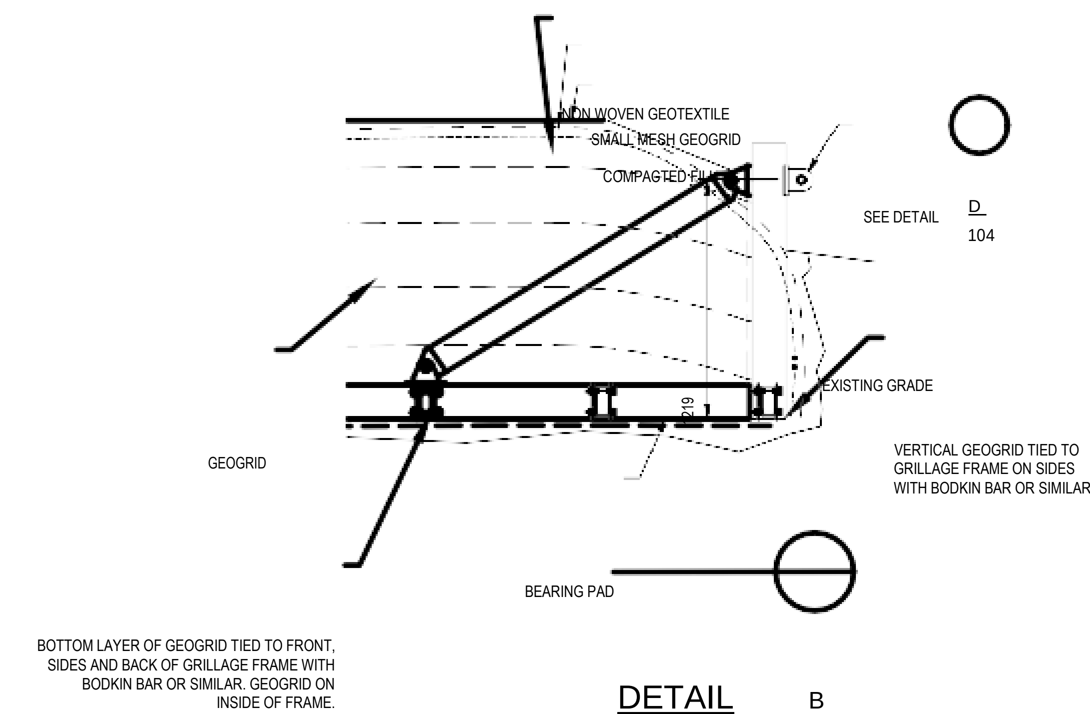


MOORING GRILLAGE

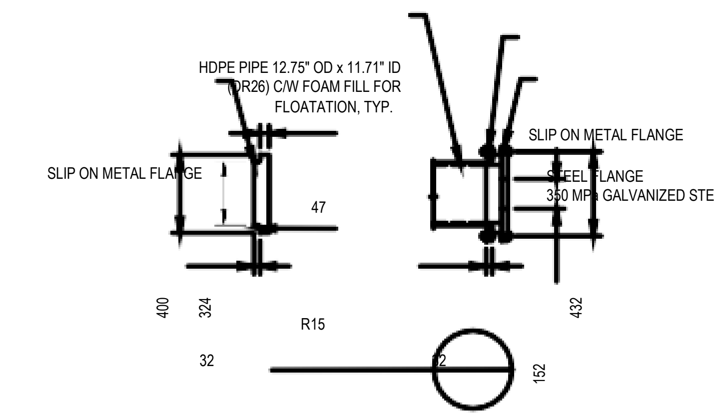
SECTION 4
SCALE: 1:50
101



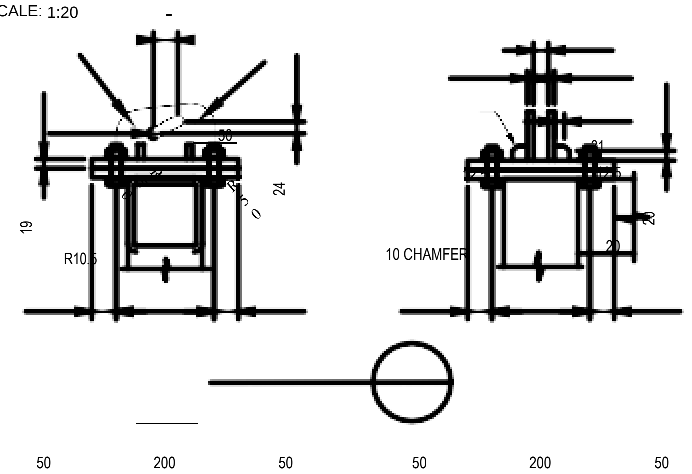
SECTION 5
SCALE: 1:20
-



DETAIL B
SCALE: 1:25
-



DETAIL C
SCALE: 1:25
-



NOTE:

1. SUGGESTED PAD EYE STYLE,

DETAIL DESIGN BY BUILDING CONTRACTOR

DETAIL A
SCALE: 1:10
-

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DETAILS

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NUM	DATE	DWN	CKD	APR	DESCRIPTION	NUM	DATE	APR	DESCRIPTION
REVISIONS						**DRAWING STATUS**			

PROJECT No.	OFFICE	DES	CKD	REV	DRAWING
ENGYARC03060-02	VANC	GJG	THS	0	**103**
DATE:	SHEET No.	DWN	APP	STATUS	
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3658
1194 1194 1156
HSS 127 x 76 x 9.5
HSS 152 x 152 x 13
HSS 152 x 152 x 13
PL 13 x 160 x 152
TABS FOR BOLTING
TYP
1119
3658
PL 9.5
PL 13 PAD
1220 x 610
HSS 127 x 76 x 9.5
8
TYP

GRILLAGE TYPE C - DOCK 3
SCALE: 1:50

3658
1194 1194 1156
HSS 127 x 76 x 9.5
HSS 152 x 152 x 13
HSS 152 x 152 x 13
PL 13 x 160 x 152
TABS FOR BOLTING
TYP
HSS 127 x 76 x 9.5
PL 9.5
3658
PL 13 x 1220 x 610
PAD
281
TYP 8
2 - HSS 127 x 76 x 9.5 x 281 LONG

GRILLAGE TYPE B - DOCKS 1 & 2
SCALE: 1:50

3658
897 895 895 895
HSS 152 x 76 x 13
PL 9.5 x 100 x 100
STIFFENER
TYP.
HSS 173 x 127 x 13
1791
HSS 173 x 127 x 13
3658
PL 13 x 160 x 173
TABS FOR BOLTING
TYP
PL 13 x 1220 x 610
PAD, TYP. 2 PLACES
1791
HSS 152 x 76 x 13
13
TYP

GRILLAGE TYPE A
SCALE: 1:50

19Ø STAINLESS STEEL BOLT
4-19Ø A307 GALVANIZED ANCHORS
PER HINGE BRACKET
2-19 x 300 x 300 HINGE BRACKET
HSS 152 x 152 x 13
HSS 152 x 152 x 13
PL 13 x 160 x 152
TYP
1524
HSS 127 x 76 x 9.5
PL 13 PAD
1220 x 610

SECTION 6
SCALE: 1:50 -

HSS 173 x 127 x 13
℄ RAMP PIN
MOORING POST
SEE DETAIL
HSS 152 x 152 x 13
SEE DETAIL
PL 13 x 160 x 152
TABS FOR BOLTING
TYP
1219
1369
1766
HSS 127 x 76 x 9.5
TYP.

SECTION 6
SCALE: 1:50 -

PL 22 x 152 x 127
35 THICK PLATE
HSS 173 x 127 x 13
ANCHOR 25.4Ø SHACKLE
152
60
22

DETAIL D
SCALE: 1:25 -

SEE DETAIL
HSS 173 x 127 x 13
1219
1400
PL 13 x 160 x 172
TABS FOR BOLTING
TYP
PL 13 x 1220 x 610
PAD

SECTION 8
SCALE: 1:75 -

4-19Ø A307 GALVANIZED ANCHORS
PER HINGE BRACKET
19Ø STAINLESS STEEL BOLT
1119
2-19 x 300 x 300 HINGE BRACKET
1524
PL 13 x 1220 x 610
PAD
1829 1829
3658

SECTION 7
SCALE: 1:75 -

4-19Ø A307 GALVANIZED ANCHORS
PER HINGE BRACKET
19Ø STAINLESS STEEL BOLT
2-19 x 300 x 300 HINGE BRACKET
HSS 152 x 152 x 13
HSS 152 x 152 x 13
1524
1522
HSS 152 x 152 x 13
ELEVATION
1245
HSS 152 x 152 x 13
SEE DETAIL
PLAN

DETAIL A
SCALE: 1:50 -

GRILLAGE FRAME NOT SHOWN FOR CLARITY

230
157 36
HSS 152 x 152 x 13
225 300
PL 13
BOLTS
38
13

DETAIL B
SCALE: 1:10 -

ALL BOLTED CONNECTION
22Ø A490 BOLTS
C/W 2 WASHERS AND NUT
UNO
PL 13 x 160 x 173
TABS FOR BOLTING
TYP
HSS 173 x 127 x 13
TRANSVERSE MEMBER FRAME
BOLTED ONTO CENTER SPINE
HSS 152 x 76 x 13
PL 13
13 TYP
100
40
37 80 173
TYP 13 160

SECTION 10
SCALE: 1:20 -

ALL BOLTED CONNECTION
22Ø A490 BOLTS
C/W 2 WASHERS AND NUT
UNO
PL 13 x 160 x 152
TABS FOR BOLTING
TYP
HSS 152 x 152 x 13
PL 13
TRANSVERSE MEMBER FRAME
BOLTED ONTO CENTER SPINE
TYP 13
HSS 127 x 76 x 9.5
80
36
40
80
152
TYP 13
160

SECTION 9
SCALE: 1:20 -

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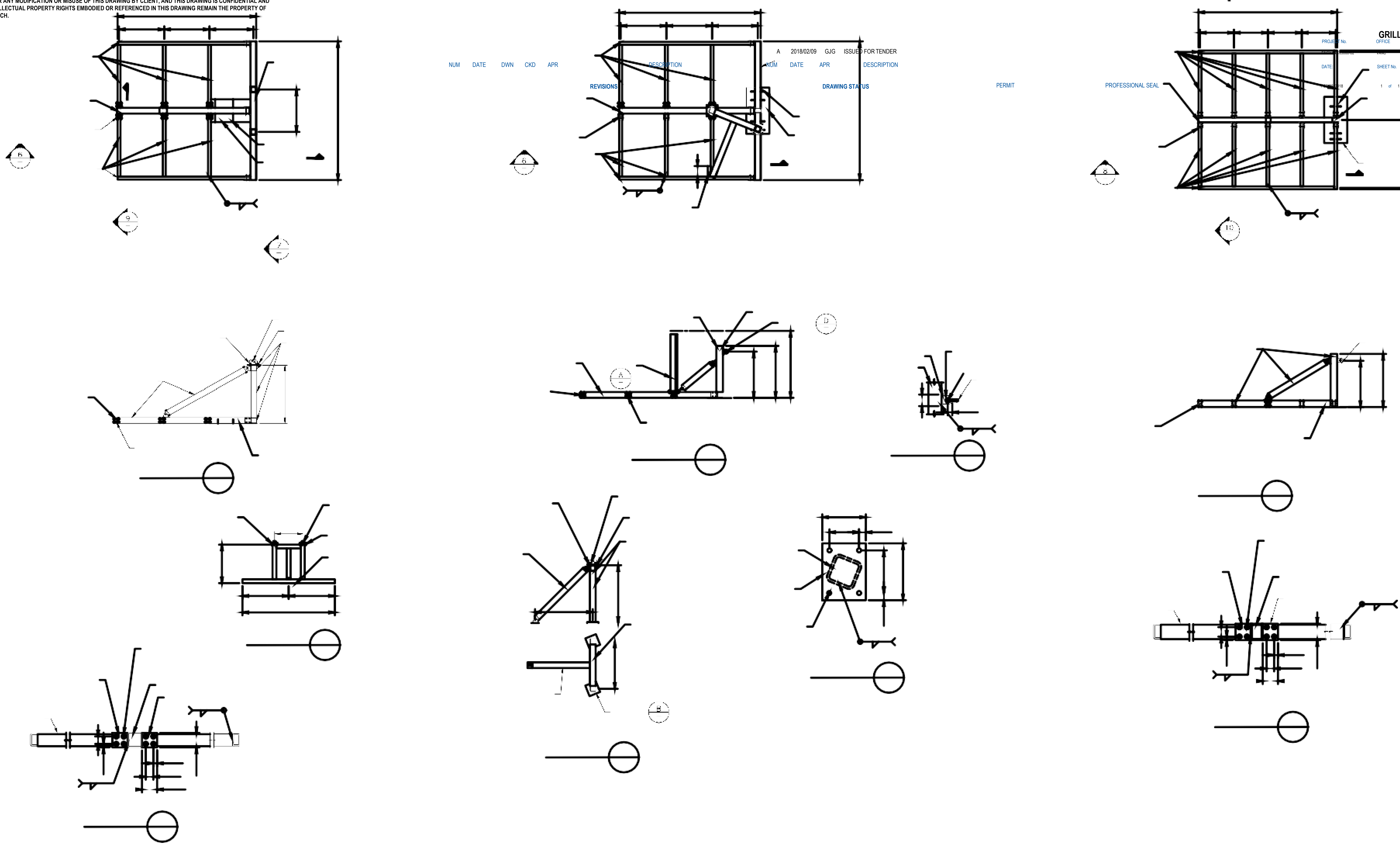

NUM	DATE	DWN	CKD	APR	DESCRIPTION

REVISIONS

NUM	DATE	APR	DESCRIPTION
A	2018/02/09	GJG	ISSUED FOR TENDER

DRAWING STATUS

PERMIT

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CLIENT

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TETRA TECH

GRILLAGE DETAILS

PROJECT No.	OFFICE	DES	CKD	REV	DRAWING
DATE:	SHEET No.	DWN	APP	STATUS	104
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APPENDIX C

NMS PERFORMANCE SPECIFICATION

- See attached

APPENDIX D

GEOSYNTHETIC PRODUCTS or APPROVED EQUAL

TENCATE
Mirafi®

SOIL REINFORCEMENT

Miragrid® 2XT Biaxial Geogrid for Retaining Wall Reinforcement, OR APPROVED EQUAL

TenCate develops and produces materials that function to increase performance, reduce costs and deliver measurable results by working with our customers to provide advanced solutions.

Miragrid® 2XT geogrid is a high strength, high tenacity, high molecular weight polyester geogrid manufactured for use in low height segmental retaining walls and reinforced slope facing stability.

Miragrid® 2XT geogrid is woven and then coated with a polymer coating to provide dimensional stability. The high molecular weight, high tenacity polyester yarns used in the Miragrid® 2XT geogrid result in excellent creep resistance. The high molecular weight polyester fibers are also resistant to the potentially degradative effects of hydrolysis and chemical attack in the range of pH normally encountered in reinforced soil environments.

The Difference Miragrid® 2XT Geogrid Makes:

- Biaxial strength. Same strength in both directions.
- Convenient packaging. Small roll packaging for easier handling and storage.
- Roll widths. Available in 4 feet wide (POP bags), 6 feet wide rolls on pallets and 12 feet wide rolls for maximum flexibility.
- Flexible and tough. Delivers immediate soil to geogrid stress transfer ensuring minimal movement of soil structure.
- Lightweight. At least 33% lighter than most rigid geogrids but durable for construction.
- Cost effective. Creep resistant polyester fibers provide a higher allowable tensile strength, minimizing the required number of geogrid layers.
- Easy handling. No sharp edges which may injure workers.

PACKAGING

Miragrid® 2XT is available in point-of-purchase (POP) display packaging or in commercial size rolls.

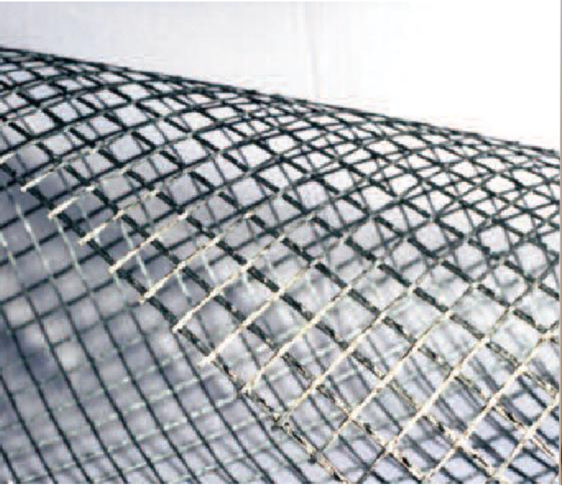
The POP display box contains 10 rolls, each 4 feet wide x 50 feet long (180 ft²), placed in a clear bag. Each POP display box is printed with quantity estimating information (as shown at right).

INSTALLATION GUIDELINES*

The POP packed rolls can either be purchased in the full box (10 rolls/box) or in 3 roll bundles without a box.

Place Miragrid® 2XT a maximum vertical spacing of every 2 SRW units. Provide adequate drainage and compacted fill per SRW unit manufacturer's instructions. Chart is for estimating purpose only. Final design should be performed by a registered, professional engineer to meet all local codes and regulations. No provisions have been made for global/external stability, nor site topography. Use higher strength Miragrid® geogrids in walls over 6 feet in height.

* These guidelines serve as a general basis for installation. Detailed instructions are available from your TenCate representative.



Protective & Outdoor Fabrics
Aerospace Composites
Armour Composites
Geosynthetics
Industrial Fabrics
Synthetic Grass

TENCATE
materials that make a difference

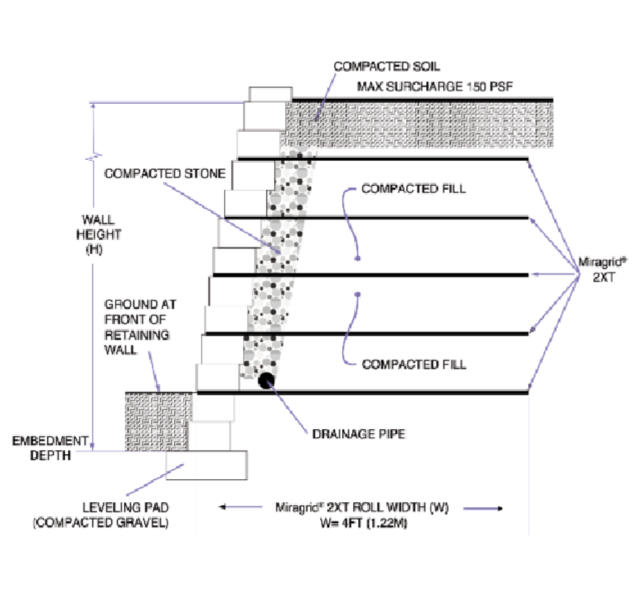
Miragrid® 2XT Biaxial Geogrid

for Retaining Wall Reinforcement

Property	Test Method	2XT
Polymer (coating)	–	PET (PVC)
Tensile Strength @ Ultimate (MARV)	ASTM D6637 (Method B)	2000 lbs/ft (29 kN/m)
Creep Rupture Strength	ASTM D5262/D6992	1379 lbs/ft (20 kN/m)
Long Term Design Strength		1142 lbs/ft (17 kN/m)

Packaging	Units	2XT
Roll Width	ft (m)	12 (3.6)
Roll Length	ft (m)	150 (46)
Est. Roll Wt.	lbs (kg)	109 (49)
Area	yd^2 (m^2)	200 (167)

Miragrid® 2XT Geogrid



Wall Height, H ft (m)	Miragrid® 2XT Roll Width, W ft (m)	# 2XT of layers 6" tall blocks	8" tall blocks
3 (0.91)	4.0 (1.22)	3	2
4 (1.22)	4.0 (1.22)	4	2
5 (1.52)	4.0 (1.22)	5	3
6 (1.83)	4.0 (1.22)	6	4

Miragrid® 2XT Quantity Determination

$$\frac{\text{\# Layers x W x length of wall}}{\text{180 square foot}} = \text{\# of rolls}$$

Example: A SRW wall using 6" tall blocks is 6ft tall x 30ft long.
Derived from table: H = 6ft, W = 4ft, & 6 layers.

$$\frac{\text{6 layers x 4ft x 30ft}}{\text{180sq. ft per roll}} = \text{4 rolls}$$

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materials that make a difference

TENCATE Mirafi®

SEPARATION DRAINAGE

Mirafi® N-Series Nonwoven Polypropylene Geotextiles

for Soil Separation and Drainage

Mirafi® N-Series Nonwoven Geotextiles

TenCate develops and produces materials that function to increase performance, reduce costs and deliver measurable results by working with our customers to provide advanced solutions.

The Difference Mirafi® N-Series Nonwoven Geotextiles Make:

- Construction. Mirafi® N-Series polypropylene nonwoven geotextiles easily conform to the ground or trench surface for trouble free installation.
- Strength. Mirafi® N-Series geotextiles withstand installation stresses with high puncture and tear resistance.
- Drainage. High permittivity properties provide high water flow rates while providing excellent soil retention.
- Environmental. Mirafi® N-Series geotextiles are chemically stable in a wide range of aggressive environments.
- Cost Effective. Mirafi® N-Series geotextiles provide economical solutions to many civil engineering applications including a cost effective alternative to graded aggregate filters.

APPLICATIONS

Mirafi® N-Series nonwoven geotextiles are used in a wide variety of applications including soil separation and drainage applications. Lightweight nonwovens are predominantly used for subsurface drainage applications along highways, within embankments, under airfields, and athletic fields. For these drainage structures to be effective, they must have a properly designed protective filter.

Mirafi® N-Series nonwoven geotextiles eliminates the challenge of determining the aggregate gradation required to match soil conditions, finding a convenient and economical source of a specific aggregate, transporting and placing graded aggregate, and assuring that the constructed in-place drainage system provides effective filter performance.

Heavyweight nonwovens are used in critical subsurface drainage systems, soil separation, permanent erosion control, and geomembrane liner protection within landfills. These geotextiles provide the required strength and abrasion resistance to withstand installation and application stresses to create an effective, long term drainage solution.

INSTALLATION GUIDELINES*

French and Trench Drains Geosynthetic Placement

Cut geosynthetic to proper width prior to placement. Width should be enough to conform to the trench perimeter with at least a 6in (15cm) top overlap. Place the geosynthetic roll over the trench, and unroll enough geosynthetic that the geosynthetic can be placed down into the trench. Anchor the edges of the geosynthetic with heavy objects to prevent the geosynthetic from falling into the trench. Where overlaps are necessary between rolls, allow for 3 ft (1m) overlap from the upstream to the downstream roll.

* These guidelines serve as a general basis for installation. Detailed instructions are available from your TenCate® representative.

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Mirafi® N-Series Nonwoven Polypropylene Geotextiles

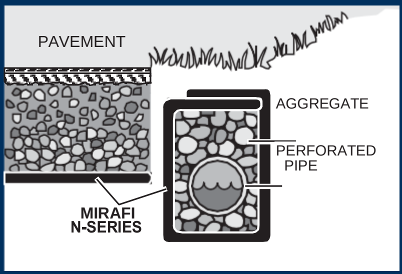
for Soil Separation and Drainage

Property / Test Method	Units	140NL	140NC	140N	160N	170N	180N	1100N	1120N	1160N
MECHANICAL PROPERTIES						Minimum Average Roll Value				
Grab Tensile Strength ASTM D4632										
Strength	lbs (N)	90 (401)	100 (445)	120 (534)	160 (712)	180 (801)	205 (912)	250 (1113)	300 (1335)	380 (1691)
Elongation	%	50	50	50	50	50	50	50	50	50
Trapezoid Tear Strength	lbs	40	45	50	60	75	80	100	115	140
ASTM D4533	(N)	(178)	(200)	(223)	(267)	(334)	(356)	(445)	(512)	(623)
CBR Puncture Strength	lbs	250	250	310	410	450	500	700	800	1025
ASTM D6241	(N)	(1113)	(1113)	(1380)	(1825)	(2003)	(2224)	(3115)	(3560)	(4561)
HYDRAULIC PROPERTIES										
						Maximum Opening Size				
Apparent Opening Size (AOS) ASTM D4751	US Sieve (mm)	50 (0.30)	70 (0.212)	70 (0.212)	70 (0.212)	70 (0.212)	80 (0.18)	100 (0.15)	100 (0.15)	100 (0.15)
						Minimum Roll Value				
Permittivity ASTM D4491	sec^{-1}	2.0	2.0	1.7	1.5	1.4	1.4	0.8	0.8	0.7
Flow Rate ASTM D4491	$gal/min/ft^2$ ($l/min/m^2$)	145 (5907)	140 (5704)	135 (5500)	110 (4481)	105 (4278)	95 (3870)	75 (3056)	65 (2648)	50 (2037)
						Minimum Test Value				
UV Resistance after 500 hrs. ASTM D4355	% strength	70	70	70	70	70	70	70	70	70

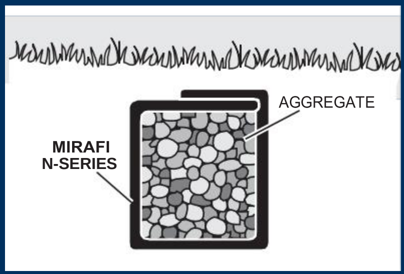
Packaging	Units	140NL	140NC	140N	160N	170N	180N	1100N	1120N	1160N
Roll Width	ft (m)	12.5 (3.8) 15.0 (4.57)	12.5 (3.8) 15.0 (4.57)	12.5 (3.8) 15.0 (4.57)	12.5 (3.8) 15.0 (4.57)	12.5 (3.8) 15.0 (4.57)	12.5 (3.8) 15.0 (4.57)	15.0 (4.57)	15.0 (4.57)	15.0 (4.57)
Roll Length	ft (m)	360 (110)	360 (110)	360 (110)	300 (91.4) 360 (110)	300 (91.4) 360 (110)	360 (110) 300 (91.4)	300 (91.4)	300 (91.4)	150 (46)
Area	yd^2 (m^2)	500 (418) 600 (502)	500 (418) 600 (502)	500 (418) 600 (502)	500 (418) 600 (502)	500 (418) 600 (502)	500 (418) 600 (502)	500 (418)	500 (418)	250 (209)

Note: Values and methods could change without notice

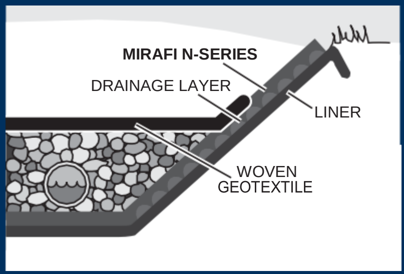
Mirafi® N-Series Nonwoven Geotextiles



Cut-off/Interceptor Drain Along a Roadway Or Another Critical Structure



French Drain Without Pipe



Liner Protection Within a Landfill

PDS.N1217

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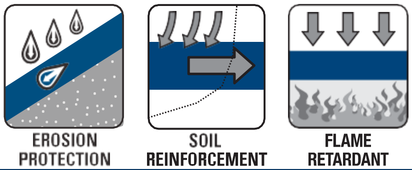


Miramesh® Biaxial Geosynthetics
for Green Permanent MSE Wall and Slope Applications

TenCate develops and produces materials that function to increase performance, reduce costs and deliver measurable results by working with our customers to provide advanced solutions.

TenCate Miramesh® geosynthetics provide surface erosion protection and secondary reinforcement in MSE structures. The erosion protection facilitates establishment of vegetation and provides structural support for the forming of battered and vertical face MSE walls and oversteepened slopes. The secondary reinforcement facilitates compaction and prevents surficial sloughing at the slope face.

The Difference Miramesh® Biaxial Geosynthetics Make:

- Strength. Biaxial strength to provide uniform design strengths and facilitate one layer installation for secondary reinforcement and face erosion protection.
- Vegetation Support. Vegetation testing shows Miramesh® geosynthetics perform better than biaxial geogrids and geotextiles in providing a suitable platform for plant growth. The uniquely designed aperture construction allows for retention of soil particles, while encouraging vegetation growth.
- Flexible. Easily conforms to the slope or wall face to provide a stable platform vegetation.
- Color. Available in green and black color.
- Design Life. Available in 75 to 100 year permanent design life exposed to sunlight.

Miramesh® GR: The original Miramesh® geosynthetic. Miramesh® GR is a green mesh facing to provide an instant green face prior to vegetation growth. It is UV coated to provide 75 to 100 year design life for permanent MSE wall face and slope face.

Miramesh® SG: A synthetic grass face combining Miramesh® GR biaxial geosynthetic with synthetic grass green fibers to produce a finished grass face without the need for vegetation. The synthetic grass fibers provide an extra layer of UV protection, increasing the long term exposed design life. Miramesh® SG provides an immediate finished vegetated face eliminating the need for topsoil, grass seed, plantings, irrigation and maintenance.

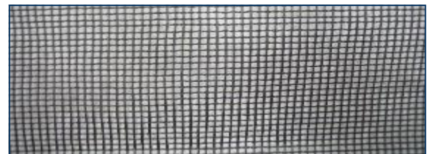
Miramesh® FR: A fire resistant biaxial mesh facing to protect the MSE structure from damage in case of exposure to flames such as wildfires. The fire protection coating meets NFPA – 701 and California State Fire Marshall fire resistant ratings.

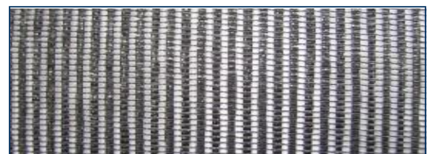
Miramesh® TR: A black mesh facing offering high biaxial tensile strengths with standard UV protection offering economical facing before vegetation growth. Miramesh® TR may act as a temporary or permanent face wrap based on the MSE structure type.

Miramesh® has been used successfully on MSE walls and slopes providing an alternative facing to hard armor concrete and masonry block facing. Miramesh® may also be used under permeable pavers and channel blocks as a separation layer below the units or to separate dissimilar aggregate layers. The unique benefits of Miramesh® geosynthetics allow it to be used in many civil engineering applications based on the project needs.
Please contact your TenCate representative for more detailed information.


Miramesh® GR Biaxial Geosynthetics


Miramesh® SG Synthetic Grass Face


Miramesh® FR Biaxial Geosynthetics


Miramesh® TR Biaxial Geosynthetics

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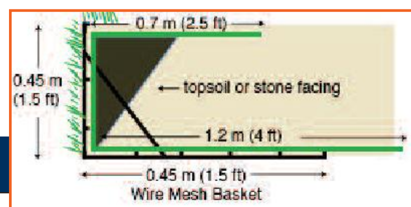
Miramesh® Biaxial Geosynthetics
for Green Slope Applications

Property	Test Method	Units	GR	SG (Patent #7,740,420)	FR	TR
Mechanical Properties (Minimum Average Roll Values)						
Tensile Strength						
MD@ Ultimate	ASTM	lbs/ft (kN/m)	1440 (21.0)	1440 (21.0)	1440 (21.0)	2100 (30.6)
CD@ Ultimate	D4595	lbs/ft (kN/m)	1733 (25.3)	1733 (25.3)	1733 (25.3)	2100 (30.6)
Creep Reduced Strength						
MD	ASTM	lbs/ft (kN/m)	471 (6.9)	471 (6.9)	471 (6.9)	686 (10.0)
CD	D5262	lbs/ft (kN/m)	566 (8.3)	566 (8.3)	566 (8.3)	--
Long Term Allowable Design Load	GRI GT-7					
MD		lbs/ft (kN/m)	407 (5.9)	407 (5.9)	407 (5.9)	594 (8.7)
CD		lbs/ft (kN/m)	490 (7.2)	490 (7.2)	490 (7.2)	--
Aperture Size						
MD	-	in (mm)	0.08 (2)	0.08 (2)[3]	0.08 (2)	0.08 (2)
CD	-	in (mm)	0.08 (2)	0.08 (2)[3]	0.08 (2)	0.12 (3)
Color	-	-	Green	Green	Black	Black
Flame Resistance	NFPA-701 California State Fire Marshall		--	--	Pass	--
UV Resistance (at 500 hours)	ASTM D4355	% Strength Retained	99	90[2]	90	90
Life Expectancy	See Note[1] below	years	75	100	75	--

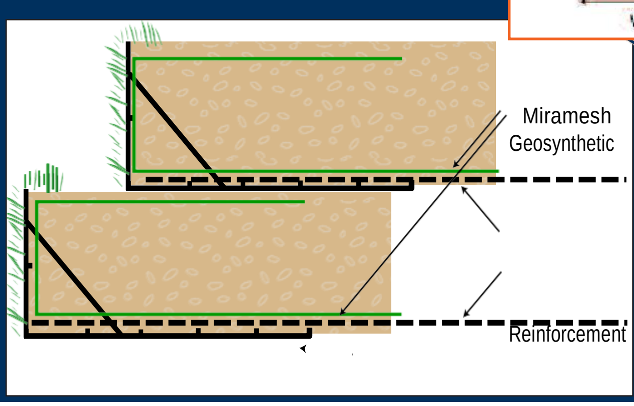
Packaging (Typical		GR	SG	FR	TR
Roll Width	ft (m)	8.0 (2.4)	8.0 (2.4)	8.0 (2.4)	8.0 (2.4)
Roll Length	ft (m)	150 (45.7)	50 (15.2)	150 (45.7)	150 (45.7)
Roll Weight (Typical)	lbs (kg)	51 (23)	51 (23)	51 (23)	52 (24)
Roll Area	yd^2 (m^2)	133 (110)	133 (110)	133 (110)	133 (110)

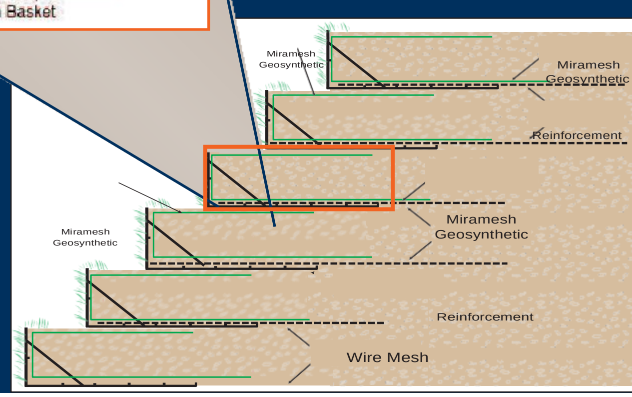
Note: Long Term Allowable Design Load (GRI GT-7, Creep Reduced Strength (ASTM D5262) and Life Expectancy (ASTM D7238) are not covered by our current A2LA accreditation.
Note[1]: Extrapolated from the average half life based on ASTM D7238 (QUV). Data also found on Mirafi® UV Durability Technical Note.



Miramesh® SG Notes:
Note: Miramesh physical properties do not apply to tufted area.
Note[2]: UV Resistance is for tufted area only.
Note[3]: Aperture size only applies to untufted area.

Miramesh® Biaxial Geosynthetics





Wire Mesh

Basket Facing or Temporary Wood Form

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ISO 9001 FM 61026

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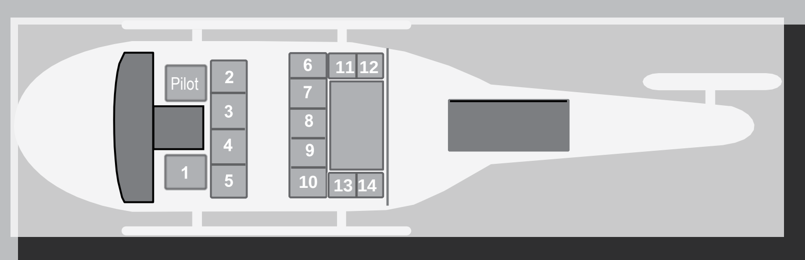
APPENDIX E

DESIGN-BUILD AND TRANSPORTATION QUOTES - removed

Bell 205A-1++

PASSENGER SEATING	14
AVERAGE CRUISE SPEED	115 mph
AVG. FUEL CONSUMPTION	350 ltr/hr
MAXIMUM RANGE* DISTANCE/INT LOAD W/20 MIN RESERVE	345 miles 1957 lbs cargo 3.0 hours
MAX EXT. SLING LOAD**	3850 lbs

****Note specifications above are based on best case scenario on a short haul with favorable weather.**



*Maximum Range represents the distance that can be traveled with full fuel at best cruise speed, the internal load represents the maximum load the client can expect to take along in combined passenger weight and baggage weight for such a flight.

**Maximum External Load Performance figures are obtained and represent standard configuration aircraft, at sea level, standard atmospheric conditions for a five