Baffinland Iron Mines Corporation
Mary River Expansion Project

Foundation Recommendations for Rail Bridges

2019-01-30	0	Approved for Use	E Tiedje	K S Ho	H Ghiabi	
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
			HATCH			**Client**

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1. Introduction and Background

This report provides geotechnical recommendations for the design of deep foundations to support four separate railway bridges, associated with the development of a 110 km long rail line on Baffin Island. The rail line is developed by Baffinland Iron Mines Corp. (BIM) to facilitate the increased production from the Mary River Iron Mine.

It is understood from preliminary designs that the rail bridges will consist of multi-span, steel through plate girders supported on multiple deep foundations, specifically prefabricated steel pipe adfreeze piles, at the bridge abutment locations. All bridges are crossing existing waterways and a separate hydrotechnical scour analysis is being prepared by Hatch at all bridge sites.

2. Available Subsurface Information

In 2018, a geotechnical investigation was conducted by Hatch on behalf of BIM in support of the rail line development. Table 2-1 outlines the available boreholes relevant to the bridge locations.

Table 2-1: Summary of Available Boreholes

Bridge	Available BHs	Ground Surface Elevation (m)	Depth (m)
No. 15-1	BH18-BR15-1	78.0	17.4
	BH18-BR15-2	78.0	16.8
No. 70-2	BH18-BR70-1	124.0	32.5
	BH18-BR70-2	124.0	28.5
No. 86-3	BH18-BR86-1	142.9	39.6
	BH18-BR86-2	143.0	39.6
	BH18-BR86-3	143.4	39.6
No. 102-4	BH18-BR102-1	168.0	9.7
	BH18-BR102-1	166.0	16.9

3. Foundation Recommendations

3.1 Rock-Socketed Piles

Rock-socketed steel pipe piles are the preferred foundation type, where competent bedrock can be practically and economically reached. These foundations have a higher axial capacity and are not typically susceptible to long-term settlement, as compared to adfreeze piles.

Rock-socketed steel pipe piles are constructed by predrilling installation holes to the specified depth and about 100 mm wider than the diameter of the pile. Prior to inserting the steel pipe piles, the holes and hole bottoms should be free of loose soil, rock or ice. Within the rock-socket zone the steel pipes are perforated with slot holes. Grout is poured through the centre of the piles and flows through the slots to fill the annulus space in the rock socket. The grout should be placed to a height of at least 2.0 m above the design bedrock elevation. After grouting, the pile should be lightly vibrated to consolidate the grout and set the surface contact with the pile and bedrock. The remaining annulus space from the grout to the active zone should be backfilled with sand-slurry, and within the active zone with dry sand or approved drill cuttings, as outlined in Section 3.2.

The capacity of rock-socketed steel pipe piles is typically governed by the bond strength at the steel-grout and rock-grout interfaces, i.e., shaft resistance. End bearing resistance should not be relied upon, unless the following conditions are met 1) the base of the pile socket is visually inspected (i.e., CCTV camera) and confirmed to be free of water, mud, ice, or loose material, and 2) the piles are seated in placed before grouting using several strikes from a pile driving hammer. End bearing has not been considered in these recommendations. For a 610 mm pile, and in accordance with the Canadian Foundation Engineering Manual, 4th Ed., Chapter 18, the elastic settlement of the shear socket is estimated to be less than 1 mm per 1000 kN of applied axial load, which is considered acceptable for this project. Significant long-term settlement is not anticipated.

The grout used in the rock-socket should have a minimum compressive strength of 25 MPa. The grout should be specifically designed for arctic applications, with a high early strength and capable of properly curing when placed on a substrate with a minimum temperature of -10 °C.

Prior to installation, the surface of the steel piles within the socket zone should be clean and free of grease, paint, varnish, or similar coatings. However, the upper portion of the piles within the active soil zone should be treated to prevent shear stress development on the piles due to frost heave uplift and thawing-induced down-drag forces. The recommended approach is to wrap the piles with at least three layers of polyethylene sheets. In areas where significant scour is anticipated, active zone treatment may not be practical.

3.2 Adfreeze Piles

Adfreeze piles, or slurry piles, installed in permafrost may be considered where the use of rock-socketed piles is not practical (e.g., very deep bedrock surface).

Adfreeze piles are constructed by first drilling the installation hole to the specified depth. The steel pile is inserted and temporarily braced while the annulus space is backfilled with a water-sand slurry. The slurry is consolidated in place by either inserting a manual 'pencil' vibrator or vibrating the pile. The bracing is left in place while the slurry freezes. The diameter of the drilled installation holes should be 100 mm to 200 mm larger than the pile diameter. In general, larger installation holes may be required for deeper installations. The sand used in the slurry should be clean and well graded with a maximum particle size of 2.0 mm and no more than 5% (by weight) of particles passing 75µm. The water should be clean, fresh water. At the time of placement, the temperature of the slurry should be between 5 °C and 10 °C. If the slurry is too cold, it may prematurely freeze during placement; if too warm, the heat from the slurry may cause excessive disturbance to the permafrost. The slurry in the annulus should extend from the pile toe to a depth of 2.0m below the final grade. The upper 2.0m annulus space should be backfilled with dry sand or approved drilling cuttings. At a minimum, the bottom 1.0 m of the inside of the pile should be filled with slurry, the remaining space inside the piles may be left empty or backfill with soil cuttings. Depending on the location and time of year, a temporary steel casing may be required in areas of thawed soil to prevent the ingress of water into the installation hole.

The axial capacity of adfreeze piles is governed by the interface bond between steel and the frozen slurry. This bond is susceptible to both short-shear failure as well as continuous long-term creep deformation under sustained loads. The appropriate load combinations used for short-term and long-term conditions should be selected by the structural engineer. The allowable long-term pile settlement should be selected based on project requirements.

Prior to installation, the surface of the steel piles within the slurry filled adfreeze zone should be clean and free of grease, paint, varnish, or similar coatings. Although not considered in this design, higher short-term capacities could be obtained by sandblasting the outside of the pile or installing steel ring flanges around the perimeter at regular intervals.

Similar to the rock-socketed piles, the pile surface within the active soil zone should be sufficiently treated to prevent frost heave or down-drag forces.

3.3 Scour Protection

Adequate scour protection should be provided where ever significant scour is anticipated, in accordance with AREMA standards. Please refer to the associated Hydraulic Report for details regarding the scour assessment and recommendations for scour protection (H353004-35000-220-230-0002).

3.4 Thermal Analysis

Site specific, 1-D thermal analysis has been performed and presented in Appendix A. The objective of the thermal analysis is to define the thickness of the active zone and the maximum temperature of the permafrost. It is noted that heat transport due to advection in the overlying water bodies, which is expected to increase the active zone thickness, has not been accounted for in the thermal analysis. To account for this, the recommended design

thickness for the active zone has been conservatively adjusted, based on available ground temperature data, the hydraulic/scour analysis, and site experience.

It is noted, that limited ground temperature within the waterways is available at two of the four bridge sites. This field information has been used to support the assumptions made with regards to the active zone thickness at other bridge sites.

3.5 Lateral Resistance

Lateral pile analyses were performed using the software GROUP (Version 2016.10.13, by Ensoft) to estimate the maximum displacements of the pile caps and the maximum bending moment, shear force, and axial force within the individual piles. Pile group configurations and loading conditions were provided by the structural designer. All structural loads were unfactored in the analysis. The structural capacity of the pile sections must be confirmed by the structural designer.

Pile sections were modeled as short-column, linear elastic elements and Table 3-1 summarizes the section parameters considered for all locations. At the pile-cap connection, pinned conditions were considered at all pier locations, whereas fixed conditions about the lateral axis were considered at the abutment locations. The pile cap was considered as a rigid body.

Table 3-1: Steel Pipe Pile Section Details for the Lateral Analysis.

Parameter	Value
Outside Diameter	610 mm
Wall Thickness	19 mm
Elastic Modulus	200 GPa

A total of 12 cases were analyzed and the results are summarized below in Table 3-2. presents the primary input parameters and detailed output results for each case. The elevation of the base of the pile caps was determined from the bridge design drawings. Ground surface elevations for piers (Regular Bents and Super Bents) follows the post scour ground elevations recommended in the Hydraulic Report, assuming worst-case conditions. At the abutments, a design ground elevation of 1.0 m below the pile cap base was selected.

It is noted that Case 4.1 involves a large distance between the post scour ground surface and the base of the pile cap (11.2m). No structural bracing was considered between piles above the ground surface. This ground clearance is considered excessive for the modelling methodology used and special caution should be used by the structural designer for this case.

Table 3-2: Summary of Lateral Analysis Results

Case	Bridge	Pile Group Type	Loading Type[1]	Max Pile Cap Displacement (mm)			Individual Pile Structural Loads		
				Longitudinal	Lateral	Vertical	Max Bending Moment (kN-m)	Max Shear Force (kN)	Max Axial Force (kN)
1.1	15-1	Regular Bent	Regular	11.7	2.9	0.8	212.9	279.3	841.5
1.2	15-1	Regular Bent	Elevated	15.6	2.9	0.8	277.8	322.7	859.6
1.3	15-1	Super Bent	Regular	12.7	2.9	0.7	194.5	268.1	797.6
1.4	15-1	Abutment	Regular	5.8	0.3	0.1	211.5	252.4	1150.1
2.1	70-2	Regular Bent	Regular	20.8	4.4	1.0	255.5	230.7	867.9
2.2	70-2	Regular Bent	Elevated	27.8	4.4	1.0	334.2	299.7	886.9
2.3	70-2	Super Bent	Regular	18.8	3.9	0.8	221.8	207.9	807.9
2.4	70-2	Abutment	Regular	6.6	0.3	0.3	242.8	192.4	941.3
3.1	86-3	Regular Bent	Regular	33.0	4.2	1.0	427.1	405.4	906.8
3.2	86-3	Abutment	Regular	7.2	0.2	0.3	251.8	218.7	1011.6
4.1[2]	***102-4***	***Regular Bent***	***Regular***	***147.3***	***8.0***	***1.2***	***788.5***	***1168.9***	***1005.2***
4.4	102-4	Abutment	Regular	6.6	0.3	0.1	250.9	227.4	1211.6

Notes:

[1] Loading type refers to the design longitudinal load.

[2] Clearance between the ground surface and the bottom of the pile cap is considered excessive for the analysis method used, values should be considered with caution.

3.6 Bridge Abutments/Backwalls

It is understood that the bridge approaches will be supported laterally at the abutments using precast concrete backwalls. The surface of the backwall should be treated with an adfreeze bond-breaker consisting of a thin layer of cold-temperature grease followed by at least three (3) layers of 6 mils polyethene sheeting. To minimize seasonal frost heave forces, the underside of the abutment and the soil-facing side of the backwall should be lined with a 150mm thick polyethylene void form. The void form will provided a secondary function as insulation. The abutments should be backfilled with free-draining, crushed granular fill, such as Type 25 Fill. The lateral earth pressure acting on the backwall may be determined using a triangular earth pressure profile, with a lateral earth pressure coefficient of $K_a = 0.24$.

4. Site Specific Recommendations

4.1 Bridge No. 15-1

Table 4-1: Summary of Foundation Design Recommendations for Bridge No. 15-1

Overburden Soils	Silty Sand to Sandy Silt Occasional Cobbles and Boulders Ice-poor to Ice-rich
Bedrock	Gneiss
Design Top of Permafrost Elevation	Piers: 72.8 m Abutments: 75.0 m
Design Top of Bedrock Elevation	66.5 m
Depth of Frost Treatment	2.5 m

Rock-socketed steel pipe piles are recommended for Bridge No. 15-1. The piles may be designed with an allowable shaft capacity of 500 kPa at the pile-grout interface, for the length of socket installed below the design top of bedrock elevation. The socket length should be a minimum of 2.0 m and a maximum of 6.0 m in length. The structural capacity of the piles must be confirmed by the structural engineer.

In accordance with Table 9-1-6 of the 2018 AREMA Manual, Bridge No.15-1 should be considered Site Class B for seismic design.

4.2 Bridge No. 70-2

Table 4-2: Summary of Foundation Design Recommendations for Bridge No. 70-2

Overburden Soils	Silt to Sandy Silt to Silty Sand to Sand, Occasional Cobbles and Boulders, Ice-poor to Ice-rich
Bedrock	Siltstone to Dolomitic Limestone
Design Top of Permafrost Elevation	Piers: 118.9 m Abutments: 122.3 m
Design Top of Bedrock Elevation	100.5 m
Depth of Frost Treatment	2.5 m

Bridge No. 70-2 may be supported on adfreeze piles installed into the overburden soils. The adfreeze piles may be designed with a factored short-term allowable shaft capacity of 150 kPa at the pile-slurry interface for the portion installed below the design active zone, or a minimum of 2.5 m below the final ground surface. The long-term shaft capacity is dependent on the permitted pile settlement, as outlined in Table 4-3. The adfreeze piles shall have a minimum embedment length of 7.0 m and a maximum embedment of 25.0 m below the design top of permafrost elevation. The structural capacity of the piles must be confirmed by the structural engineer.

Table 4-3: Allowable Long-term Adfreeze Shaft Capacities for Bridge No. 70-2

Allowable Long-Term Settlement	50 mm / 25 years	30 mm / 25 years	15 mm / 25 years
Allowable Long-Term Shaft Stress (unfactored)	51 kPa	42 kPa	31 kPa

As an alternative, rock-socketed steel pipe piles may be considered for Bridge No. 70-2. The piles may be designed with an allowable shaft capacity of 500 kPa at the pile-grout interface, for the length of socket installed below the design top of bedrock elevation. The socket length should be a minimum of 2.0 m and a maximum of 6.0 m in length. The structural capacity of the piles must be confirmed by the structural engineer.

In accordance with Table 9-1-6 of the 2018 AREMA Manual, Bridge No.70-2 should be considered Site Class C for seismic design.

4.3 Bridge No. 86-3

Table 4-4: Summary of Foundation Design Recommendations for Bridge No. 86-3

Overburden Soils	Sand, Ice-poor to Ice-rich
Bedrock	Not Available
Design Top of Permafrost Elevation	Piers: 138.2 m Abutments: 141.4 m
Design Top of Bedrock Elevation	Not Available (below 103.3m)
Depth of Frost Treatment	2.5 m

Bridge No. 86-3 may be founded on adfreeze pile installed in the underlying permafrost soils. The adfreeze piles may be designed with a factored short-term allowable shaft capacity of 150 kPa at the pile-slurry interface for the portion installed below the design active zone, or a minimum of 2.5 m below the final ground surface. The long-term shaft capacity is dependent on the permitted pile settlement, as outlined in Table 4-5. The adfreeze piles shall have a minimum embedment length of 7.0 m and a maximum embedment of 25.0 m below the design top of permafrost elevation. The structural capacity of the piles must be confirmed by the structural engineer.

Table 4-5: Allowable Long-term Adfreeze Shaft Capacities for Bridge No. 86-3

Allowable Long-Term Settlement	50 mm / 25 years	30 mm / 25 years	15 mm / 25 years
Allowable Long-Term Shaft Stress (unfactored)	55 kPa	45 kPa	33 kPa

In accordance with Table 9-1-6 of the 2018 AREMA Manual, Bridge No.86 should be considered Site Class C for seismic design.

4.4 Bridge No. 102-4

Table 4-6: Summary of Foundation Design Recommendations for Bridge No. 102-4

Overburden Soils	Gravelly Sand to Sand and Gravel Occasional Cobbles and Boulders, Ice-poor to Ice-rich
Bedrock	Gneiss
Design Top of Permafrost Elevation	Piers: 156.7 m Abutments: 164.9 m
Design Top of Bedrock Elevation	156.5 m
Depth of Frost Treatment	2.5 m

Rock-socketed steel pipe piles are recommended for Bridge No. 102-4. The piles may be designed with an allowable shaft capacity of 500 kPa at the pile-grout interface, for the length of socket installed below the design top of bedrock elevation. The socket length should be a minimum of 2.0 m and a maximum of 6.0 m in length. The structural capacity of the piles must be confirmed by the structural engineer.

In accordance with Table 9-1-6 of the 2018 AREMA Manual, Bridge No. 102-4 should be considered Site Class B for seismic design.

5. References

- AREMA Manual, 2018
- H353004-10000-229-230-0005, Rev. 2, 2016-2017-2018 Rail Geotechnical Investigation Factual Data Report.
- H353004-35000-220-230-0002, Rev. 0, Rail Bridge Design Hydraulic Report
- H353004-00000-229-210-0001, Rev. 0, Geotechnical Design Basis.
- EBA 2008, Memorandum: Mary River – Pile Foundations Revision C, File: E14101009.001
- Andersland, B.A., Ladanyi, B., 2004, "Frozen Ground Engineering", Second Edition, ASCE, John Wiley and Sons, Inc.
- Nixon, J.F., 1978, “Foundation Design Approaches in Permafrost Area”, Canadian Geotechnical Journal, 1978, Vol.15, pp.96-112.
- Weaver, J.S, Morgenstern, N.R. “Pile Design in Permafrost”, Canadian Geotechnical Journal, 1981, Vol. 18, 357-370.

- Canadian Foundation Engineering Manual, 4th Ed.

Appendix A
Ground Temperature Modelling

A.1 Approach

The ground temperature profile was modelled using the Finite Element Method (Temp/W, (GeoStudio 2016, version 8.16) for each bridge site based on site-specific subsurface conditions. The primary objective of this analysis is to support the foundation design of the four rail bridges, which are underlain by permafrost. The variation in the seasonal fluctuation ground temperatures with depth has been estimated, including the thickness of the active zone, for each bridge site.

A.1.1 Soil Model

All subsurface layers (soil and bedrock) have been modelled using the Simplified Thermal Model, which considers two physical states: frozen (≤ 0°C) and unfrozen (> 0 °C) each with unique thermal properties. The model accounts for the heat released/absorbed due to the latent heat of fusion of the pore water. Instantaneous freezing is considered to occur at 0 °C. This soil approach is considered acceptable for modelling granular soils and rock.

The model only considers heat transport in the in the soils through conduction only.

A.1.2 Boundary Conditions and Initial Conditions

The upper thermal boundary was considered as a defined temperature condition (i.e. prescribed ground surface temperature). The mean monthly air temperature from Pond Inlet, NU (as published by the Government of Canada) has been used as the basis of the site temperatures. As discussed in the Geotechnical Design Basis report, it is recommended that the considered mean daily air temperature be increased to account for the anticipated effects of global over the design life of the railway bridges. For this analysis, the mean air temperature has been increased by 50% of this recommended temperature increase between 2010 and 2039, as outlined in Table A-1. The ground surface temperature was equated to the mean daily air temperature using a freezing factor (n_f) and thawing factor (n_t) where appropriate. These parameters are intended to account for factors such as snow cover and radiated heat transport and are typically a function of the ground surface conditions. For the purposes of this analysis, the following factors were conservatively selected for all four bridge sites: n_f = 0.9 and n_t = 2.0 (Andersland and Ladanyi, 2004).

The lower thermal boundary (depth of 25.0m) was modelled as a unit-flux boundary with a constant value of 0.06 J/s/m^2. The sides boundaries of the model were considered as zero-flux, leading to 1D conditions for this analysis.

The initial temperature of the model was a uniform value of -10 °C, with a ground surface temperature corresponding to January. The upper and lower boundary conditions were applied for a total of 10 years (cycling between years) and the final year (January to December) was used to determine the minimum and maximum temperature profiles for each site. After 10 years, the temperature at the lower boundary condition varied between -10.0 °C and -10.5 °C across all sites.

Table A-1: Considered Mean Air Temperature

Month	Mean Daily Average Temperature, Pond Inlet NU (1981 – 2010) (°C)	Recommended Mean Temperature Increase from 2010 to 2039 [Geotechnical Design Basis] (°C)	Considered Mean Daily Air Temperature, [100% Mean Daily Average Temperature + 50% Mean Temperature Increase] (°C)
January	-33.4	3.8	-31.5
February	-33.7	3.8	-31.8
March	-30.0	2.7	-28.7
April	-21.9	2.7	-20.6
May	-9.3	2.7	-8.0
June	2.4	1.9	3.4
July	6.6	1.9	7.6
August	4.8	1.9	5.8
September	-0.8	3.5	1.0
October	-9.7	3.5	-8.0
November	-21.7	3.5	-20.0
December	-28.2	3.8	-26.3

A.2 Site Specific Temperature Profiles

Site specific ground temperature profiles were determined for each bridge site based on the observed subsurface conditions, as outlined in the Rail Geotechnical Investigation Factual Data Report. Thermal properties were interpreted based on the reported information, the Geotechnical Baseline Report, and published values (Andersland and Ladanyi, 2004; GEO-SLOPE), where appropriate.

A.2.1 Bridge No. 15-1

Table A-2: Temp/W Model Input Parameters, Bridge No. 15-1

Stratigraphic Unit	Silty Sand	Gneiss (Bedrock)
Depth Below Ground Surface	0.0 m – 10.7 m	10.7 m – 25.0 m
Frozen Thermal Conductivity	2.8 J/s/m/°C	2.5 J/s/m/°C
Unfrozen Thermal Conductivity	1.8 J/s/m/°C	2.5 J/s/m/°C
Frozen Volumetric Heat Capacity	2.6e6 J/m^3/°C	2.7e6 J/m^3/°C
Unfrozen Volumetric Heat Capacity	1.9e6 J/m^3/°C	2.7e6 J/m^3/°C
Volumetric Water Content	0.41 m^3/m^3	0.03 m^3/m^3

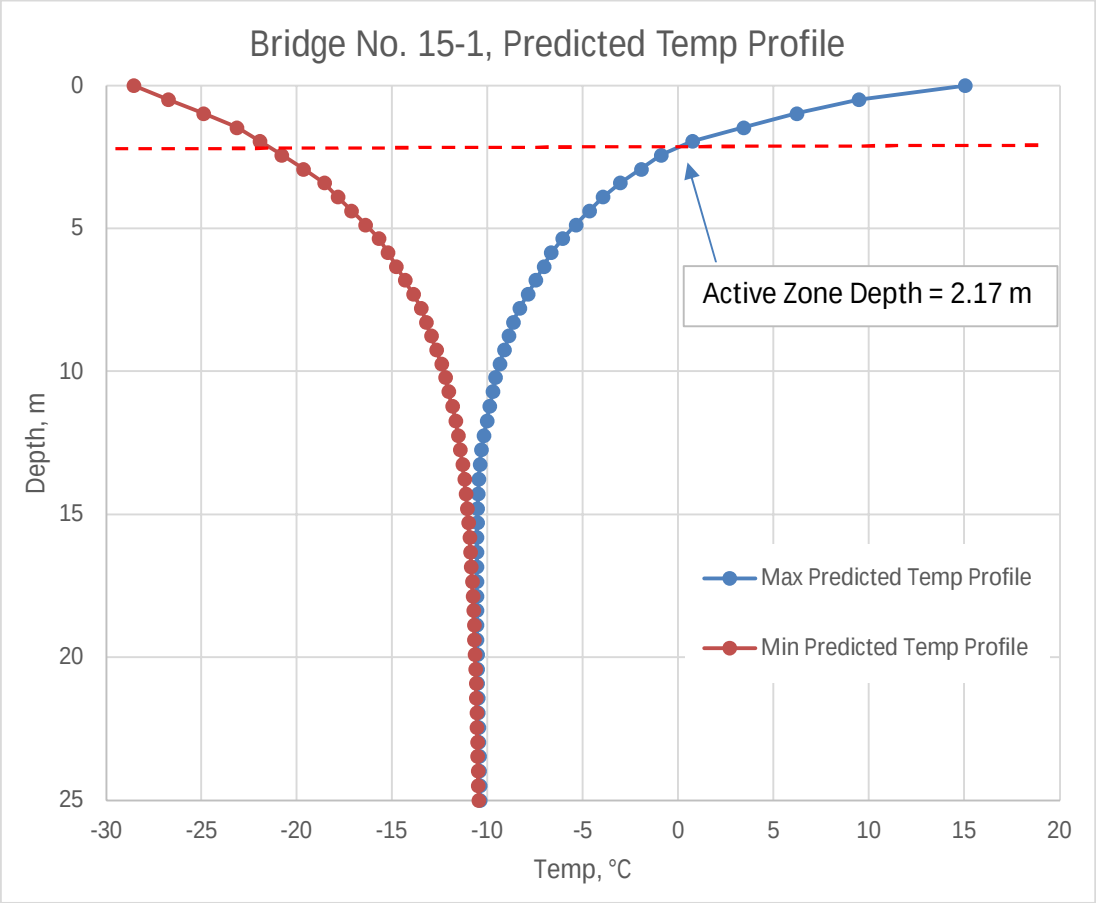


Figure A-1: Predicted Ground Temperature Profile at Bridge No. 15-1

A.2.2 Bridge No. 70-2

Table A-3: Temp/W Model Input Parameters, Bridge No. 70-2

Stratigraphic Unit	Sandy Silt
Depth Below Ground Surface	0.0 m – 25.0 m
Frozen Thermal Conductivity	2.2 J/s/m/°C
Unfrozen Thermal Conductivity	1.4 J/s/m/°C
Frozen Volumetric Heat Capacity	2.5e6 J/m^3/°C
Unfrozen Volumetric Heat Capacity	1.9e6 J/m^3/°C
Volumetric Water Content	0.41 m^3/m^3

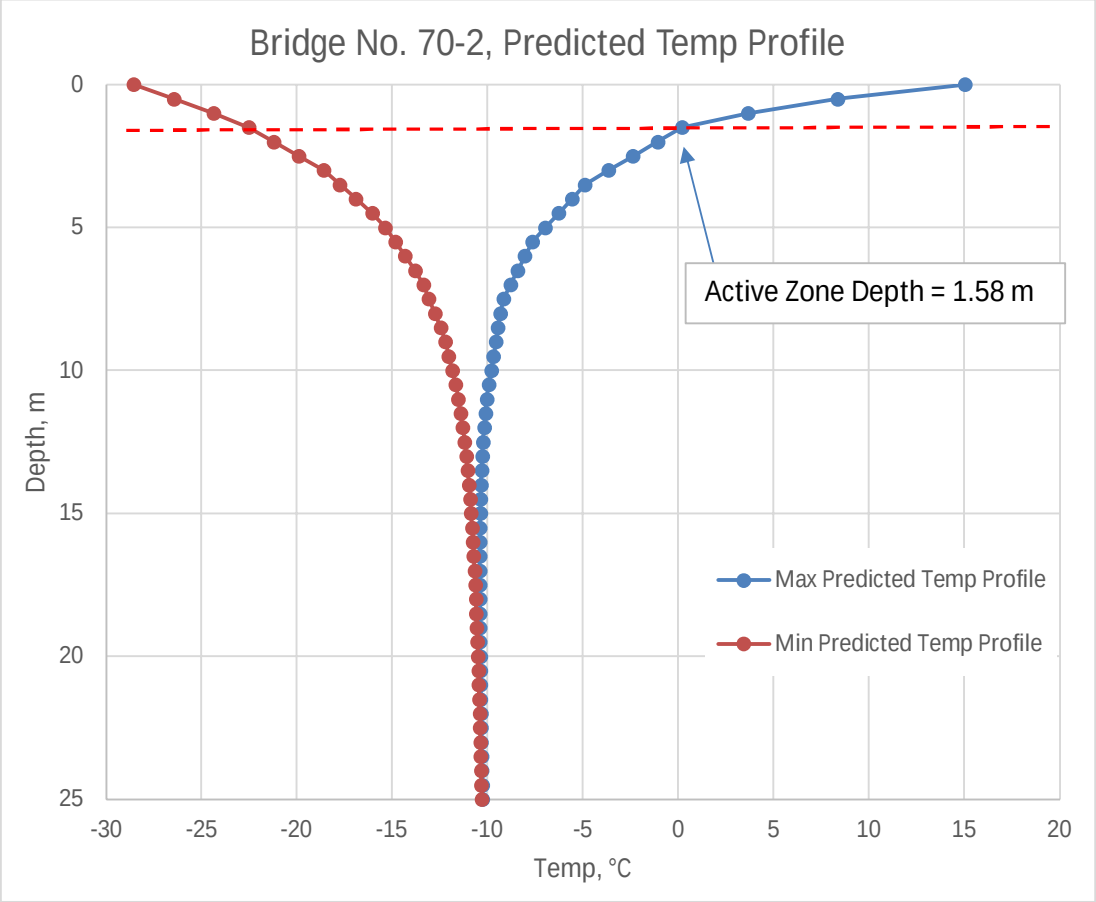


Figure A-2: Predicted Ground Temperature Profile at Bridge No. 86-3

A.2.3 Bridge No. 86-3

Table A-4: Temp/W Model Input Parameters, Bridge No. 86-3

Stratigraphic Unit	Sand to Sand and Gravel
Depth Below Ground Surface	0.0 m – 25.0 m
Frozen Thermal Conductivity	3.0 J/s/m/°C
Unfrozen Thermal Conductivity	1.5 J/s/m/°C
Frozen Volumetric Heat Capacity	2.8e6 J/m^3/°C
Unfrozen Volumetric Heat Capacity	1.9e6 J/m^3/°C
Volumetric Water Content	0.45 m^3/m^3

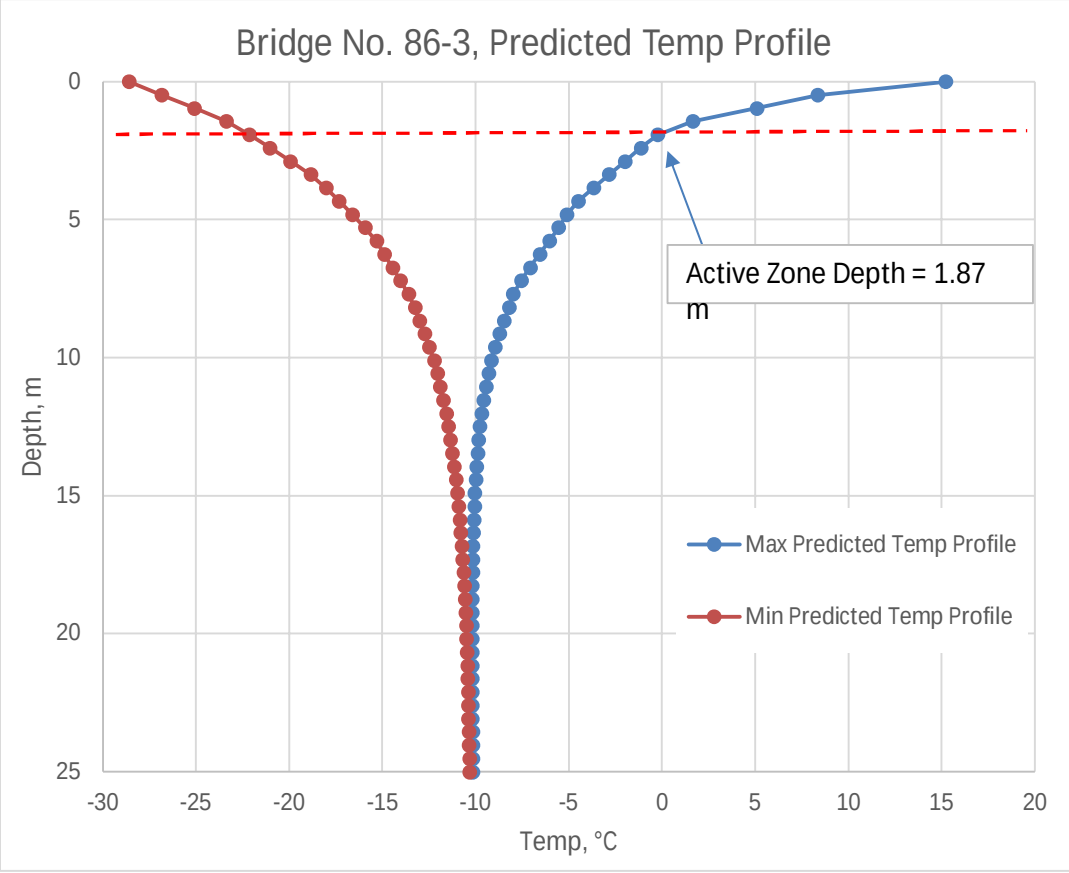


Figure A-3: Predicted Ground Temperature Profile at Bridge No. 86-3

A.2.4 Bridge No. 102-4

Table A-5: Temp/W Model Input Parameters, Bridge No. 102-4.

Stratigraphic Unit	Sand to Sand and Gravel	Gneiss (Bedrock)
Depth Below Ground Surface	0.0 m – 8.5 m	8.5 m – 25.0 m
Frozen Thermal Conductivity	3.0 J/s/m/°C	2.5 J/s/m/°C
Unfrozen Thermal Conductivity	1.5 J/s/m/°C	2.5 J/s/m/°C
Frozen Volumetric Heat Capacity	2.8e6 J/m^3/°C	2.7e6 J/m^3/°C
Unfrozen Volumetric Heat Capacity	1.9e6 J/m^3/°C	2.7e6 J/m^3/°C
Volumetric Water Content	0.45 m^3/m^3	0.03 m^3/m^3

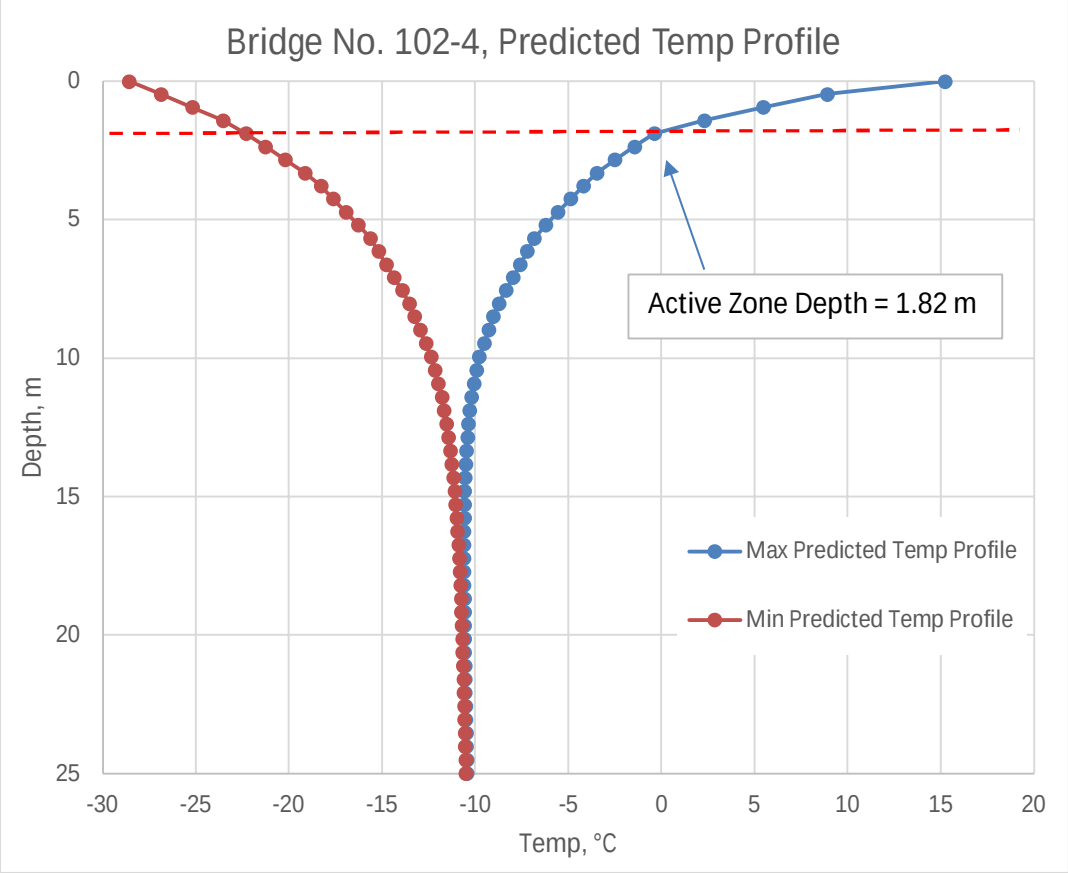


Figure A-4: Predicted Ground Temperature Profile at Bridge No. 102-4

A.3 References

- Andersland, B.A., Ladanyi, B., 2004, "Frozen Ground Engineering", Second Edition, ASCE, John Wiley and Sons, Inc.
- H353004-10000-229-230-0005, Rev. 2, 2016-2017-2018 Rail Geotechnical Investigation Factual Data Report.
- H353004-00000-229-210-0001, Rev. 0, Geotechnical Design Basis.
- GEO-SLOPE International Inc., 2014, “Thermal Modelling with TEMP/W – An Engineering Methodology”.

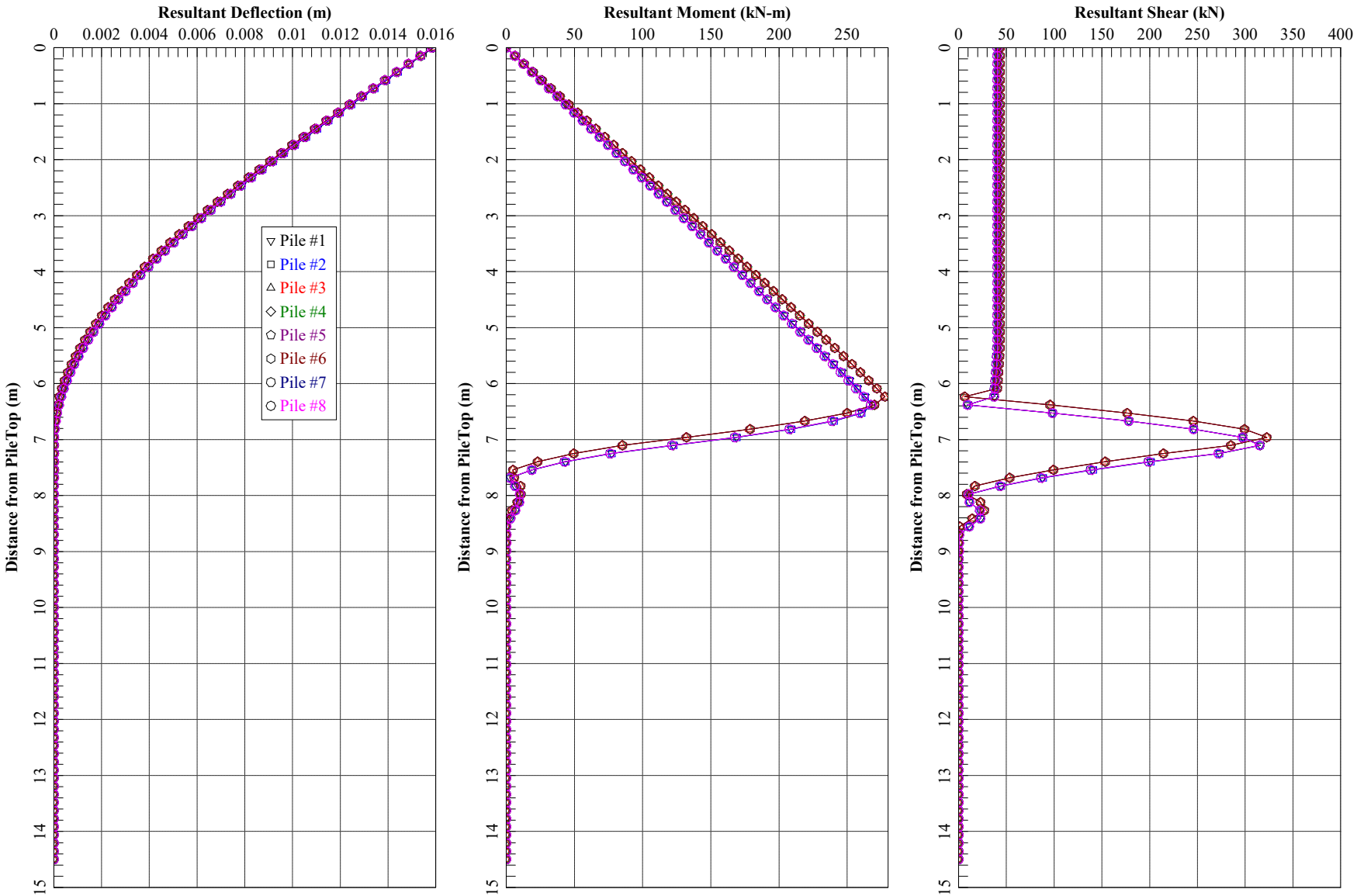
Appendix B
Lateral Pile Analysis

Case Number	1.1	1.2	1.3	1.4
Bridge	15-1	15-1	15-1	15-1
Structural Element	Regular Bent	Regular Bent_High Load	Super Bent	Abutment
Pile Connection Type	Pinned	Pinned	Pinned	Fixed-y
Inputs				
Ground Surface Elevation (m)	73.8	73.8	73.2	78.0
Ground Water Elevation (m)	78.5	78.5	78.5	78.5
Top of Pile Elevation (m)	79.0	79.0	79.0	79.0
Pile Tip Elevation (m)	64.5	64.5	64.5	64.5
Ground Clearence (m)	5.2	5.2	5.8	1.0
Soil Stratigraphy				
Layer 1				
Description	Active Zone_Silt-Sand	Active Zone_Silt-Sand	Active Zone_Silt-Sand	Active Zone_Rock Fill
Top Elevation (m)	73.8	73.8	73.2	78.0
Thickness (m)	1.0	1.0	1.0	3.0
Unit Weight (kN/m^3)	19	19	19	19
Saturated Unit Weight (kN/m^3)	19	19	19	19
P-Y Model	*API Sand*	*API Sand*	*API Sand*	*API Sand*
Friction Angle (deg)	30	30	30	38
Initial Modulus of Subgrade Reaction (kPa/m)	12000	12000	12000	30000
Layer 2				
Description	Permafrost_Sand-Silt	Permafrost_Sand-Silt	Permafrost_Sand-Silt	Permafrost_Sand-Silt
Top Elevation (m)	72.8	72.8	72.2	75.0
Thickness (m)	6.8	6.8	6.2	9.0
Unit Weight (kN/m^3)	19	19	19	19
Saturated Unit Weight (kN/m^3)	19	19	19	19
P-Y Model	*Stiff Clay without Free Water*	*Stiff Clay without Free Water*	*Stiff Clay without Free Water*	*Stiff Clay without Free Water*
Strain Factor	0.001875	0.001875	0.001875	0.001875
Undrained Shear Strength (kPa)	1800	1800	1800	1800
Layer 3				
Description	Bedrock_Gneiss	Bedrock_Gneiss	Bedrock_Gneiss	Bedrock_Gneiss
Top Elevation (m)	66.0	66.0	66.0	66.0
Thickness (m)	20.0	20.0	20.0	20.0
Unit Weight (kN/m^3)	25	25	25	25
Saturated Unit Weight (kN/m^3)	25	25	25	25
P-Y Model	*Strong Rock (Vuggy Limestone)*	*Strong Rock (Vuggy Limestone)*	*Strong Rock (Vuggy Limestone)*	*Strong Rock (Vuggy Limestone)*
Uniaxial Compressive Strength (kPa)	40000	40000	40000	40000
Outputs				
Pile Cap Displacements				
Lat-max (mm)	2.9	2.9	2.9	0.3
Long-max (mm)	11.7	15.6	12.7	5.8
Vert-max (mm)	0.8	0.8	0.7	0.1
Idividual Pile Loads				
Bending Moment-max (kN-m)	212.9	277.8	194.5	221.5
Shear Force-max (kN)	279.3	322.7	268.1	252.4
Axial Force-max (kN)	841.5	859.6	797.6	1150.1

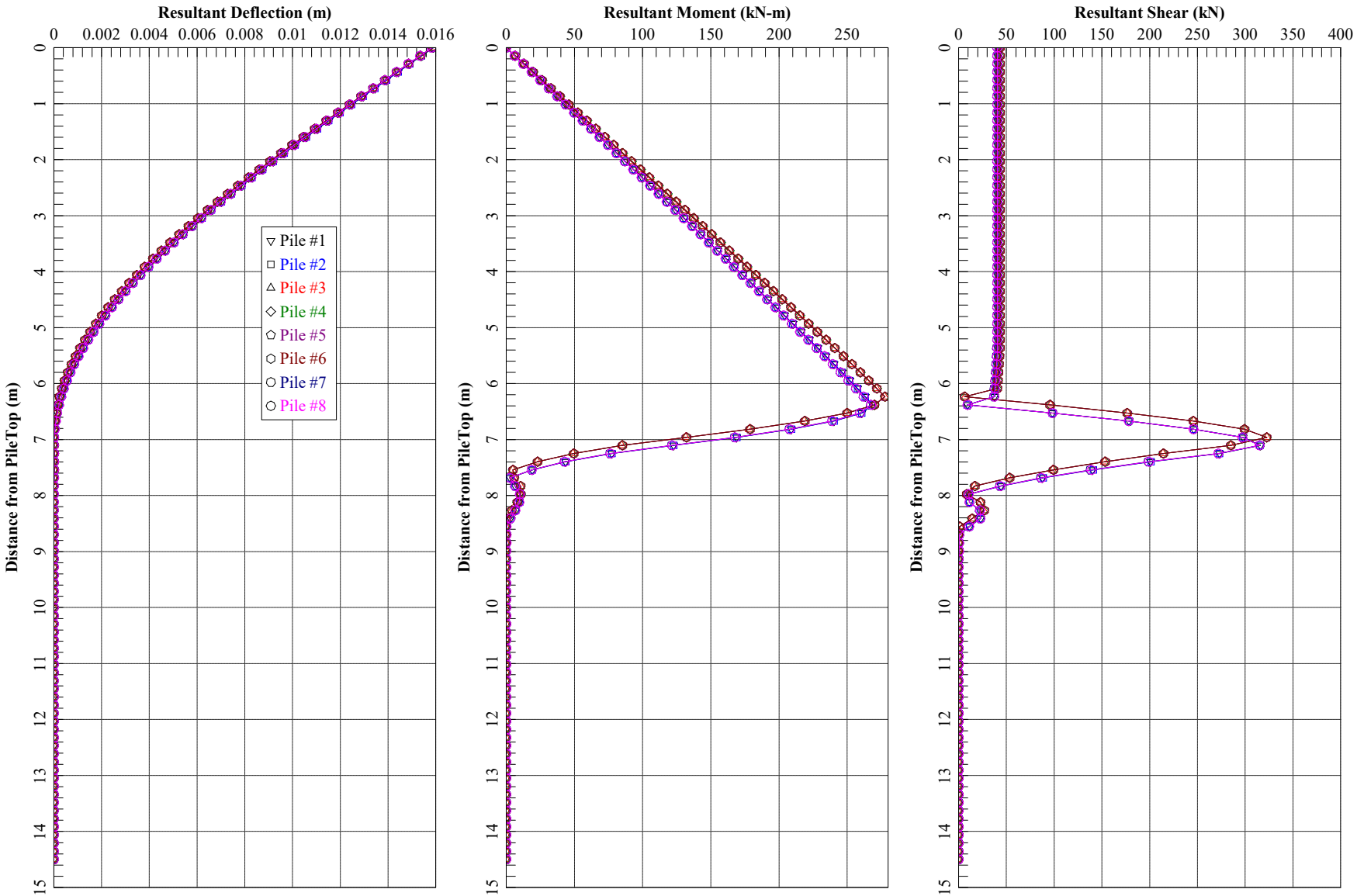
Case Number	2.1	2.2	2.3	2.4
Bridge	70-2	70-2	70-2	70-2
Structural Element	Regular Bent	Regular Bent_High Load	Super Bent	Abutment
Pile Connection Type	Pinned	Pinned	Pinned	Fixed-y
Inputs				
Ground Surface Elevation (m)	119.9	119.9	119.6	125.3
Ground Water Elevation (m)	126.0	126.0	126.0	126.0
Top of Pile Elevation (m)	126.3	126.3	126.3	126.3
Pile Tip Elevation (m)	99.0	99.0	99.0	99.0
Ground Clearence (m)	6.4	6.4	6.7	1.0
Soil Stratigraphy				
Layer 1				
Description	Active Zone_Silt-Sand	Active Zone_Silt-Sand	Active Zone_Silt-Sand	Active Zone_Rock Fill
Top Elevation (m)	119.9	119.9	119.6	125.3
Thickness (m)	1.0	1.0	1.0	3.0
Unit Weight (kN/m^3)	19	19	19	19
Saturated Unit Weight (kN/m^3)	19	19	19	19
P-Y Model	*API Sand*	*API Sand*	*API Sand*	*API Sand*
Friction Angle (deg)	30	30	30	38
Initial Modulus of Subgrade Reaction (kPa/m)	12000	12000	12000	30000
Layer 2				
Description	Permafrost_Sand-Silt	Permafrost_Sand-Silt	Permafrost_Sand-Silt	Permafrost_Sand-Silt
Top Elevation (m)	118.9	118.9	118.6	122.3
Thickness (m)	18.4	18.4	18.1	21.8
Unit Weight (kN/m^3)	19	19	19	19
Saturated Unit Weight (kN/m^3)	19	19	19	19
P-Y Model	*Stiff Clay without Free Water*	*Stiff Clay without Free Water*	*Stiff Clay without Free Water*	*Stiff Clay without Free Water*
Strain Factor	0.001875	0.001875	0.001875	0.001875
Undrained Shear Strength (kPa)	1200	1200	1200	1200
Layer 3				
Description	Bedrock_Limestone	Bedrock_Limestone	Bedrock_Limestone	Bedrock_Limestone
Top Elevation (m)	100.5	100.5	100.5	100.5
Thickness (m)	20.0	20.0	20.0	20.0
Unit Weight (kN/m^3)	25	25	25	25
Saturated Unit Weight (kN/m^3)	25	25	25	25
P-Y Model	*Weak Rock*	*Weak Rock*	*Weak Rock*	*Weak Rock*
Uniaxial Compressive Strength (kPa)	15000	15000	15000	15000
Initial Modulus (kPa)	1000000	1000000	1000000	1000000
Strain Factor	0.0005	0.0005	0.0005	0.0005
RQD (5)	70	70	70	70
Outputs				
Pile Cap Displacements				
Lat-max (mm)	4.4	4.4	3.9	0.3
Long-max (mm)	20.8	27.8	18.8	6.6
Vert-max (mm)	1.0	1.0	0.8	0.3
Idividual Pile Loads				
Bending Moment-max (kN-m)	255.5	334.2	221.8	242.8
Shear Force-max (kN)	230.7	299.7	207.9	192.4
Axial Force-max (kN)	867.9	886.9	807.9	941.3

Case Number	3.1	3.2
Bridge	86-3	86-3
Structural Element	Regular Bent	Abutment
Pile Connection Type	Pinned	Fixed-y
Inputs		
Ground Surface Elevation (m)	139.2	144.4
Ground Water Elevation (m)	144.5	144.5
Top of Pile Elevation (m)	145.4	145.4
Pile Tip Elevation (m)	118.0	118.0
Ground Clearance (m)	6.2	1.0
Soil Stratigraphy		
Layer 1		
Description	Active Zone_Sand	Active Zone_Rock Fill
Top Elevation (m)	139.2	144.4
Thickness (m)	1.0	3.0
Unit Weight (kN/m^3)	19	19
Saturated Unit Weight (kN/m^3)	19	19
P-Y Model	*API Sand*	*API Sand*
Friction Angle (deg)	32	38
Initial Modulus of Subgrade Reaction (kPa/m)	18000	30000
Layer 2		
Description	Permafrost_Sand	Permafrost_Sand
Top Elevation (m)	138.2	141.4
Thickness (m)	30.0	30.0
Unit Weight (kN/m^3)	19	19
Saturated Unit Weight (kN/m^3)	19	19
P-Y Model	*Stiff Clay without Free Water*	*Stiff Clay without Free Water*
Strain Factor	0.001875	0.001875
Undrained Shear Strength (kPa)	1800	1800
Outputs		
Pile Cap Displacements		
Lat-max (mm)	4.2	0.2
Long-max (mm)	33.0	7.2
Vert-max (mm)	1.0	0.3
Idividual Pile Loads		
Bending Moment-max (kN-m)	427.1	251.8
Shear Force-max (kN)	405.4	218.7
Axial Force-max (kN)	906.8	1011.6

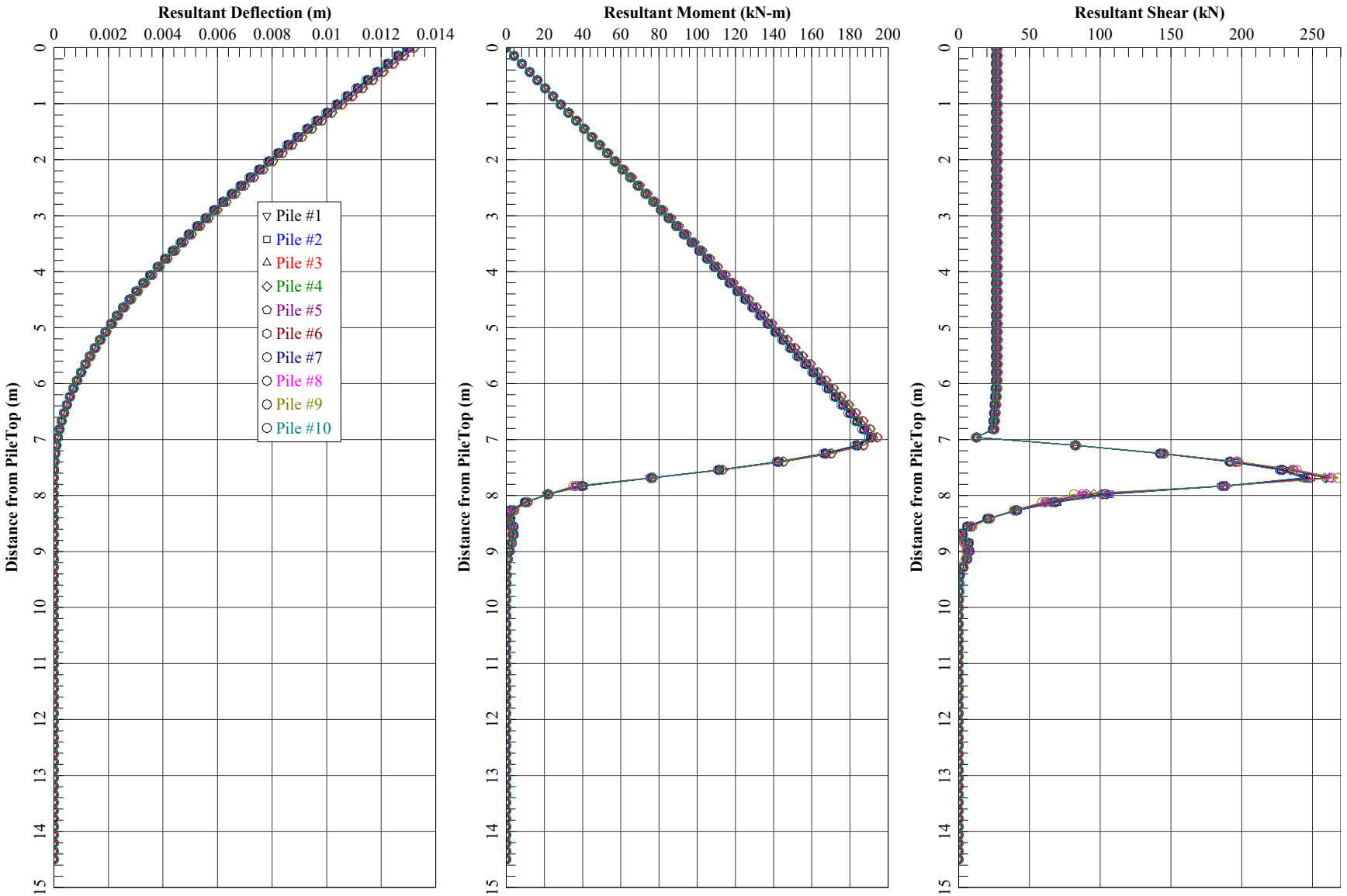
Case Number	4.1	4.2
Bridge	102-4	102-4
Structural Element	Regular Bent	Abutment
Pile Connection Type	Pinned	Fixed-y
Inputs		
Ground Surface Elevation (m)	157.7	167.9
Ground Water Elevation (m)	163.5	163.5
Top of Pile Elevation (m)	168.9	168.9
Pile Tip Elevation (m)	153.5	153.5
Ground Clearence (m)	11.2	1.0
Soil Stratigraphy		
Layer 1		
Description	Active Zone_Sand-Gravel	Active Zone_Rock Fill
Top Elevation (m)	157.7	167.9
Thickness (m)	1.0	3.0
Unit Weight (kN/m^3)	19	20
Saturated Unit Weight (kN/m^3)	19	20
P-Y Model	*API Sand*	*API Sand*
Friction Angle (deg)	32	38
Initial Modulus of Subgrade Reaction (kPa/m)	18000	30000
Layer 2		
Description	Permafrost_Sand-Gravel	Permafrost_Sand-Gravel
Top Elevation (m)	156.7	164.9
Thickness (m)	0.2	8.4
Unit Weight (kN/m^3)	19	19
Saturated Unit Weight (kN/m^3)	19	19
P-Y Model	*Stiff Clay without Free Water*	*Stiff Clay without Free Water*
Strain Factor	0.001875	0.001875
Undrained Shear Strength (kPa)	1800	1800
Layer 3		
Description	Bedrock_Gneiss	Bedrock_Gneiss
Top Elevation (m)	156.5	156.5
Thickness (m)	20.0	20.0
Unit Weight (kN/m^3)	25	25
Saturated Unit Weight (kN/m^3)	25	25
P-Y Model	*Strong Rock (Vuggy Limestone)*	*Strong Rock (Vuggy Limestone)*
Uniaxial Compressive Strength (kPa)	40000	40000
Outputs		
Pile Cap Displacements		
Lat-max (mm)	8.0	0.3
Long-max (mm)	147.3	6.6
Vert-max (mm)	1.2	0.1
Idividual Pile Loads		
Bending Moment-max (kN-m)	788.5	250.9
Shear Force-max (kN)	1168.9	227.4
Axial Force-max (kN)	1005.2	1211.6


Resultant Deflection (m)
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
Distance from PileTop (m)
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Pile #7
Pile #8
Resultant Moment (kN-m)
0
50
100
150
200
250
Distance from PileTop (m)
Resultant Shear (kN)
0
50
100
150
200
250
300
350
400
Distance from PileTop (m)

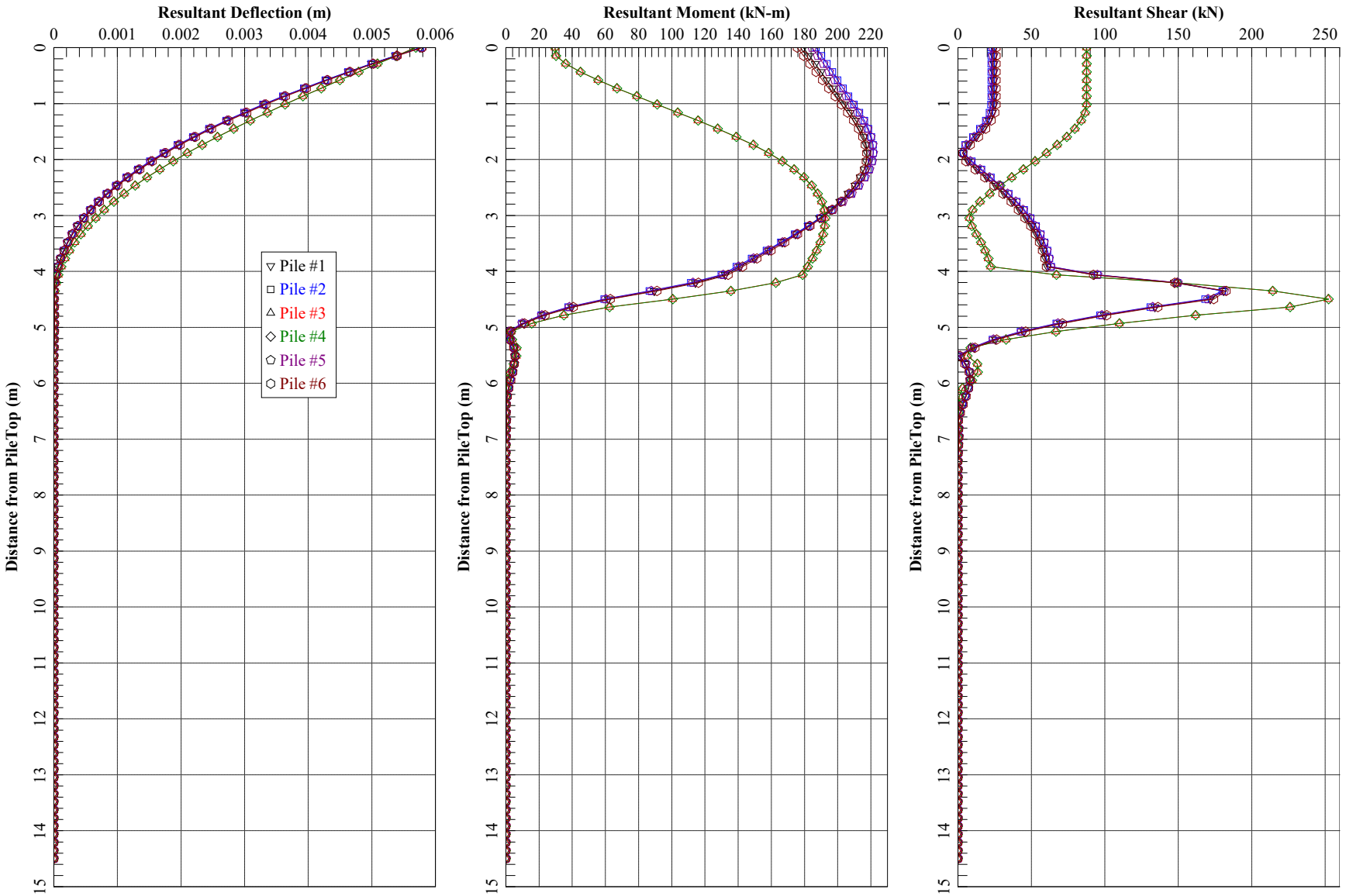
15-1_1.1


Resultant Deflection (m)
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
Distance from PileTop (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Pile #7
Pile #8
Resultant Moment (kN-m)
0
50
100
150
200
250
Distance from PileTop (m)
Resultant Shear (kN)
0
50
100
150
200
250
300
350
400
Distance from PileTop (m)

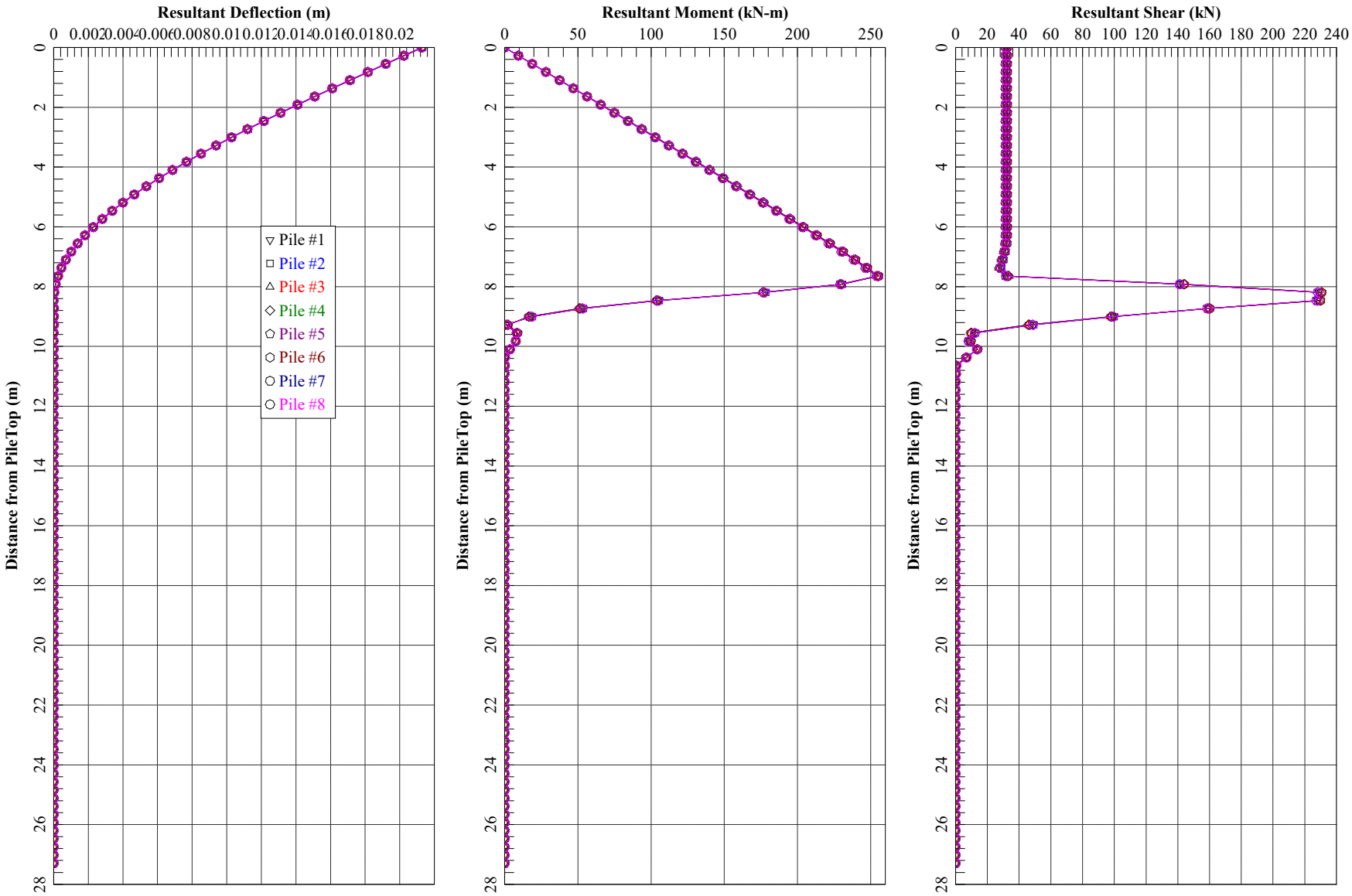
15-1_1.2


Resultant Deflection (m)
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
Distance from PileTop (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Pile #7
Pile #8
Pile #9
Pile #10
Resultant Moment (kN-m)
0
20
40
60
80
100
120
140
160
180
200
Distance from PileTop (m)
Resultant Shear (kN)
0
50
100
150
200
250
Distance from PileTop (m)

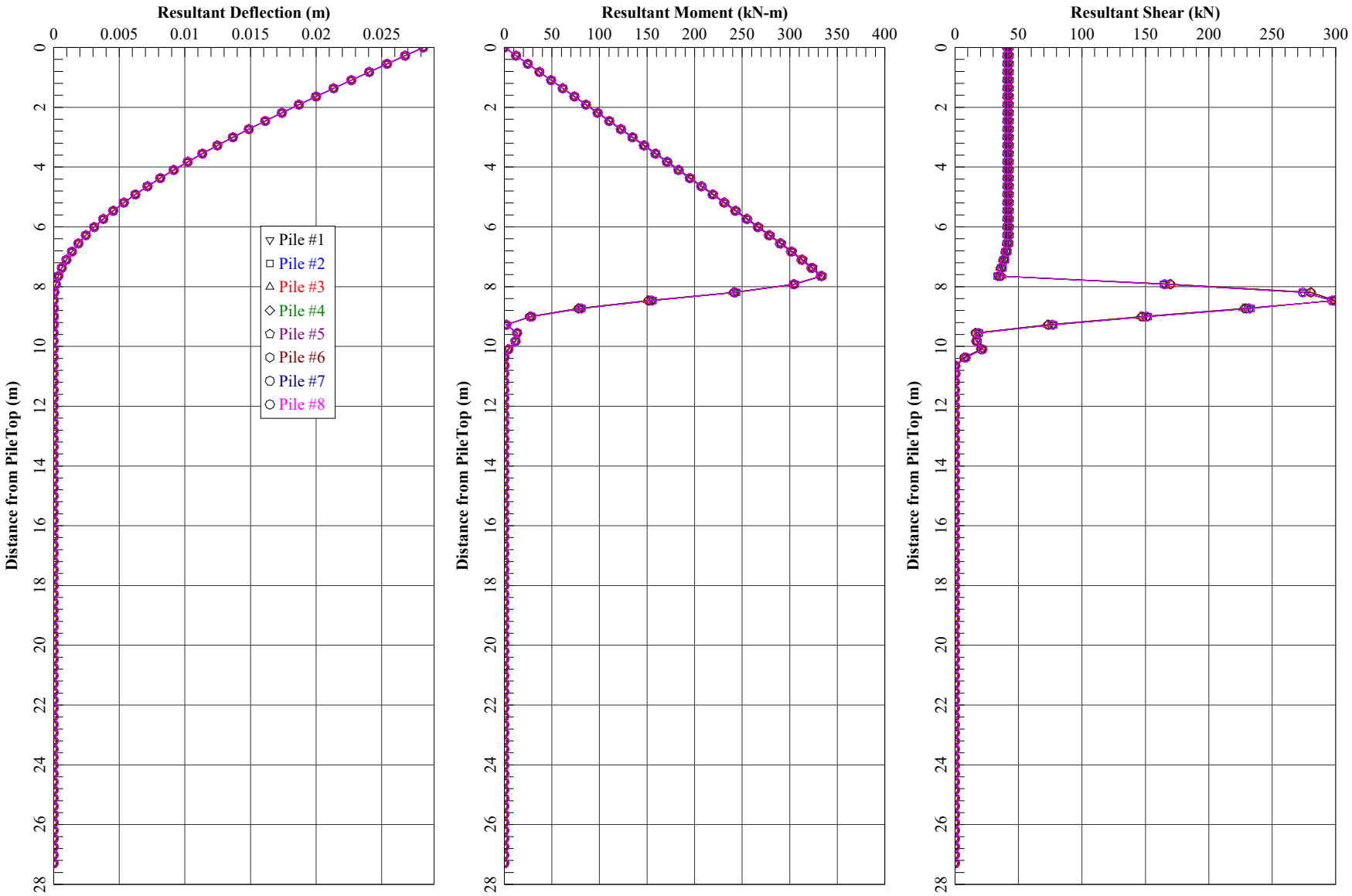
15-1_1.3


Resultant Deflection (m)
0
0.001
0.002
0.003
0.004
0.005
0.006
Distance from PileTop (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Resultant Moment (kN-m)
0
20
40
60
80
100
120
140
160
180
200
220
Distance from PileTop (m)
Resultant Shear (kN)
0
50
100
150
200
250
Distance from PileTop (m)

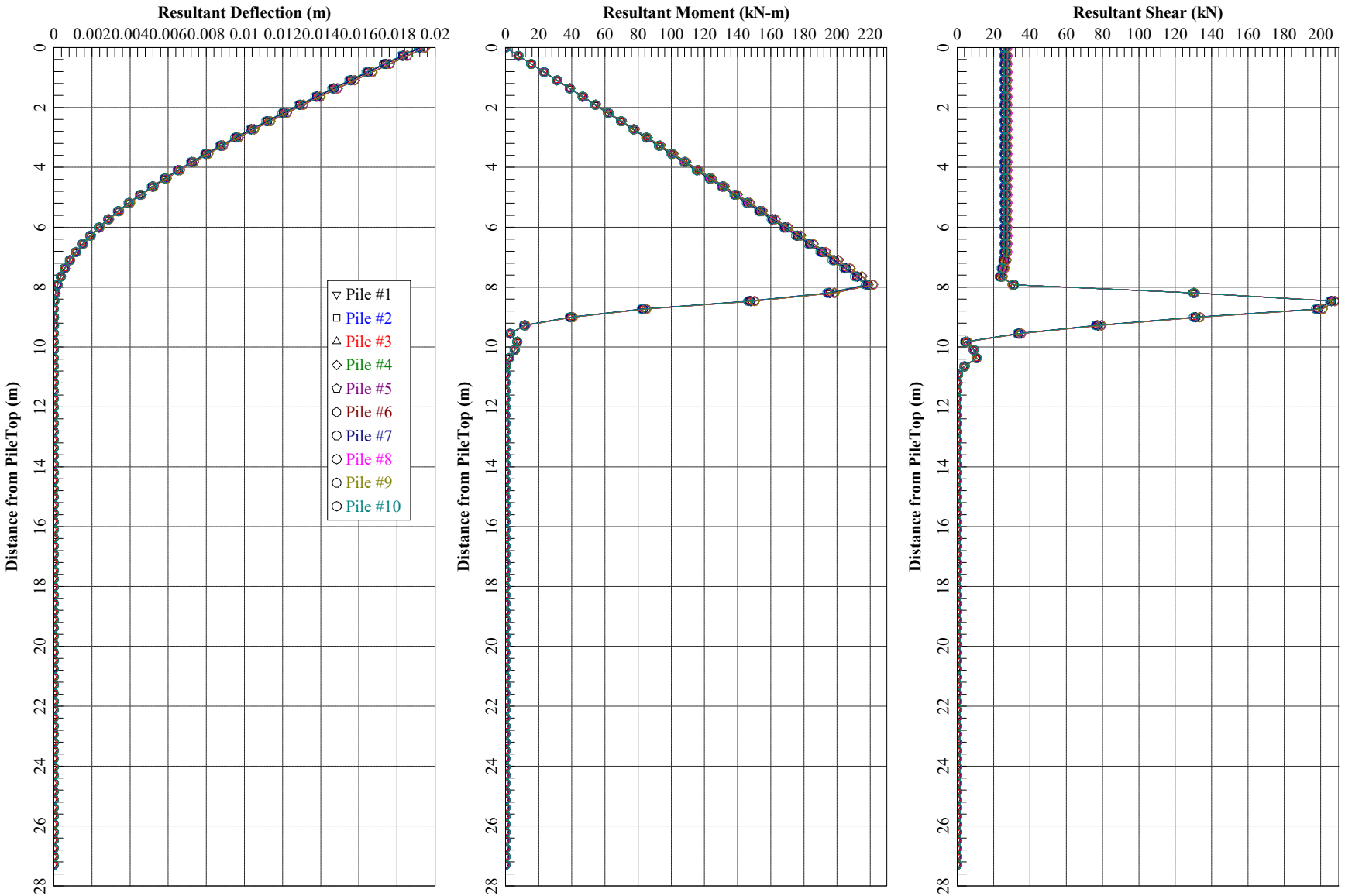
15-1_1.4


Resultant Deflection (m)
0 0.002 0.004 0.006 0.008 0.01 0.012 0.014 0.016 0.018 0.02
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Pile #7
Pile #8
Resultant Moment (kN-m)
0 50 100 150 200 250
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Resultant Shear (kN)
0 20 40 60 80 100 120 140 160 180 200 220 240
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28

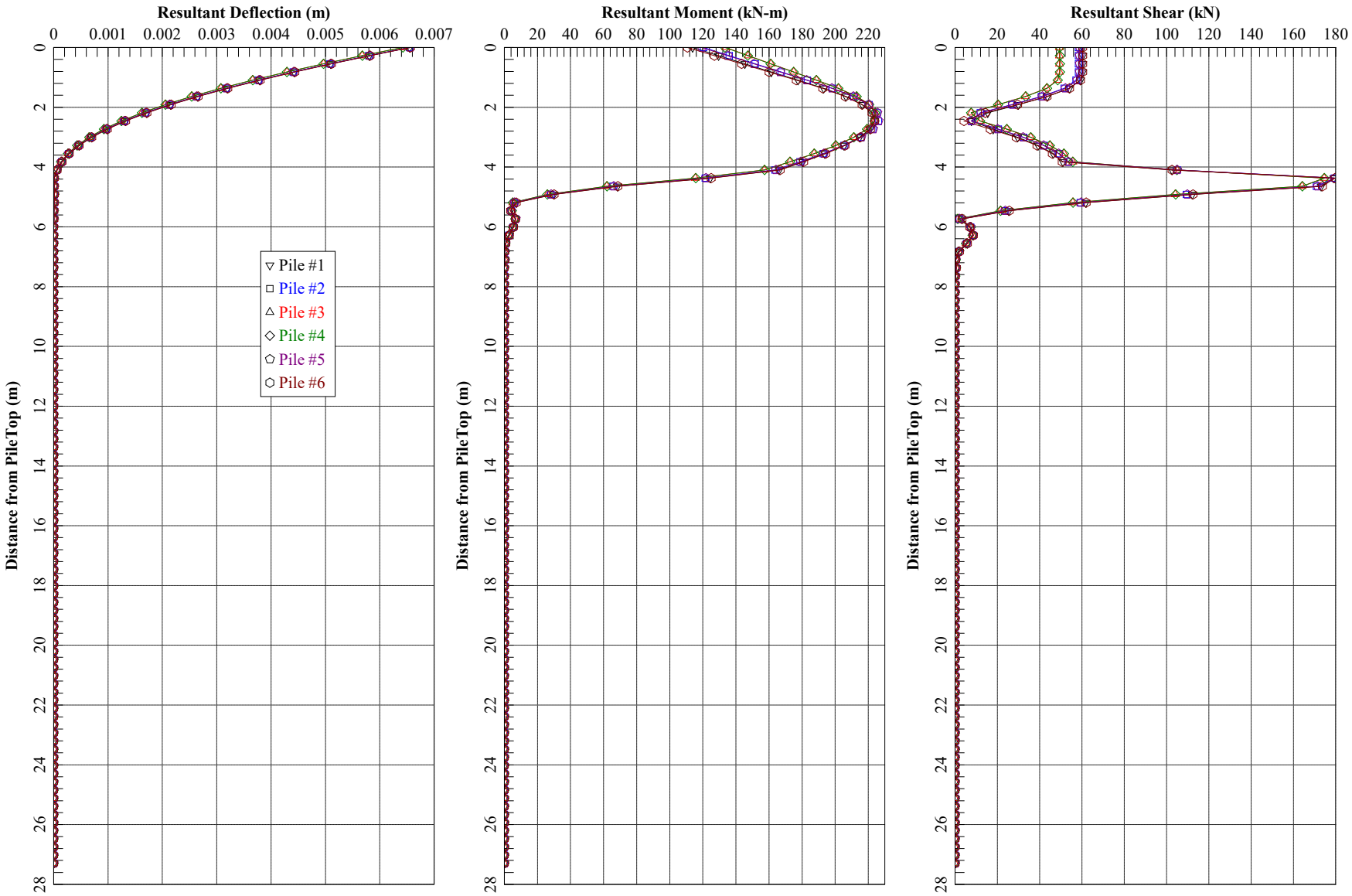
70-2_2.1


Resultant Deflection (m)
0
0.005
0.01
0.015
0.02
0.025
Distance from PileTop (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Pile #7
Pile #8
Resultant Moment (kN-m)
0
50
100
150
200
250
300
350
400
Distance from PileTop (m)
Resultant Shear (kN)
0
50
100
150
200
250
300
Distance from PileTop (m)

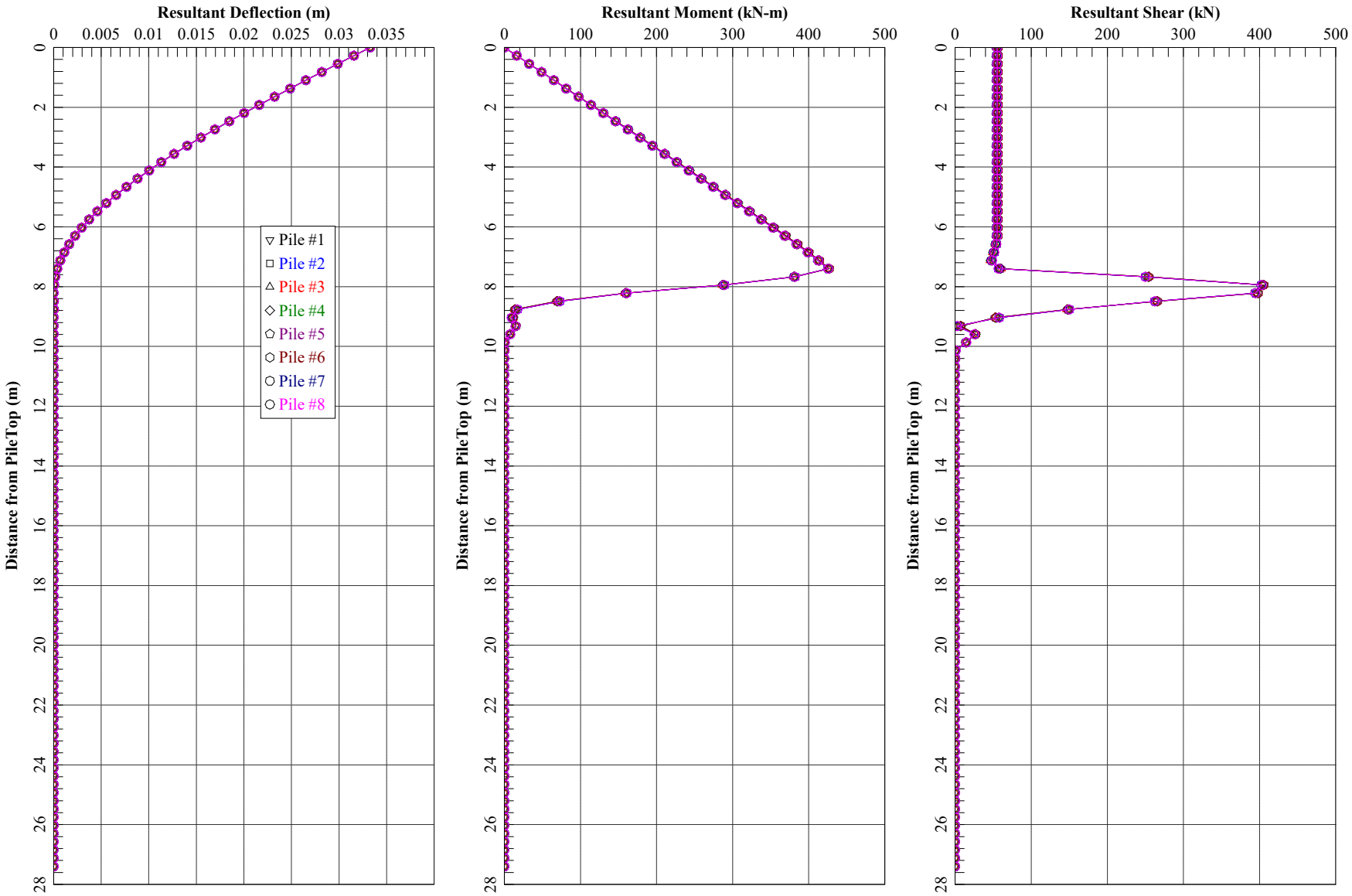
70-2_2.2


Resultant Deflection (m)
0 0.002 0.004 0.006 0.008 0.01 0.012 0.014 0.016 0.018 0.02
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Pile #7
Pile #8
Pile #9
Pile #10
Resultant Moment (kN-m)
0 20 40 60 80 100 120 140 160 180 200 220
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Resultant Shear (kN)
0 20 40 60 80 100 120 140 160 180 200
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28

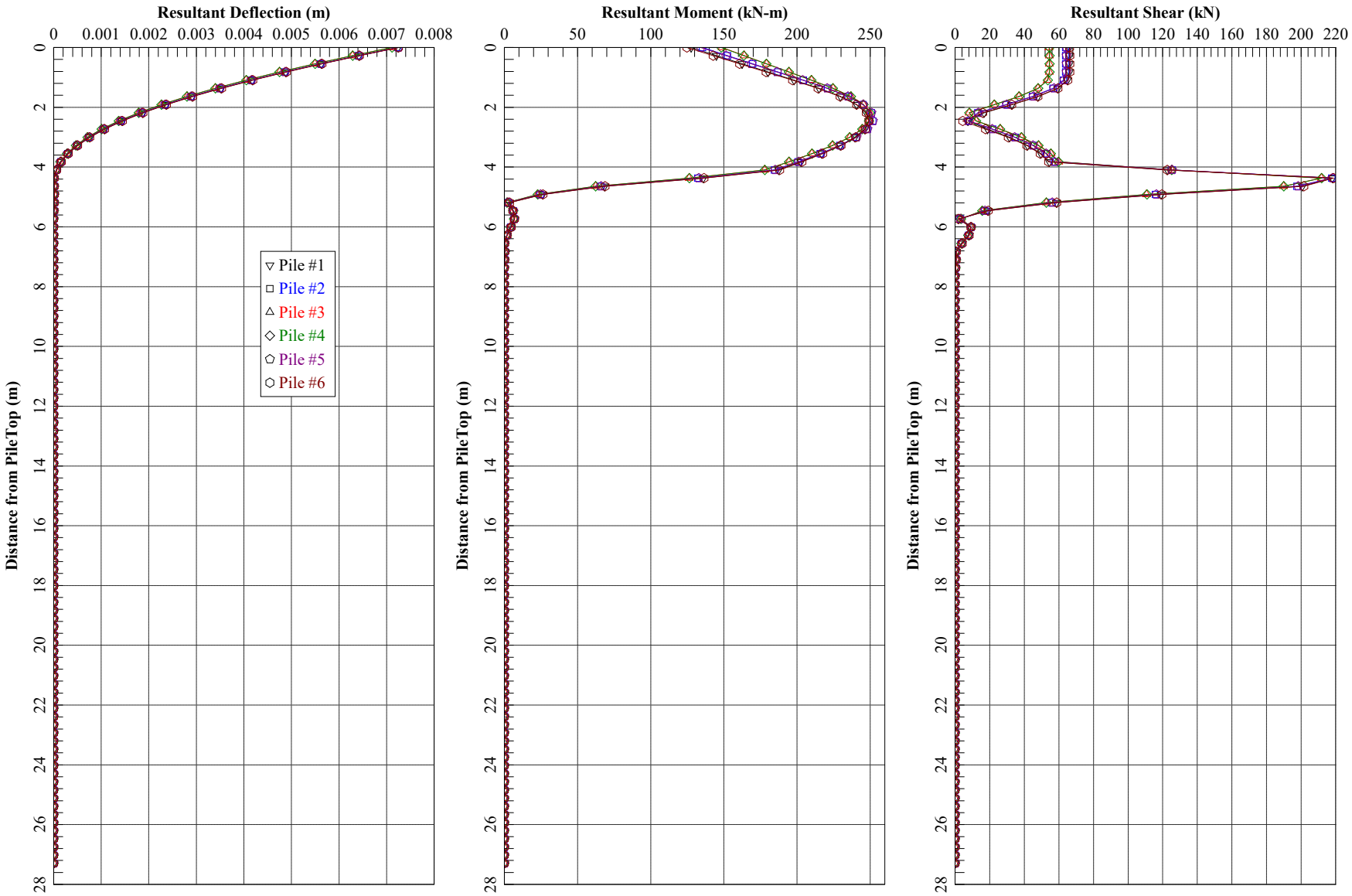
70-2_2.3


Resultant Deflection (m)
0
0.001
0.002
0.003
0.004
0.005
0.006
0.007
Distance from PileTop (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Resultant Moment (kN-m)
0
20
40
60
80
100
120
140
160
180
200
220
Distance from PileTop (m)
Resultant Shear (kN)
0
20
40
60
80
100
120
140
160
180
Distance from PileTop (m)

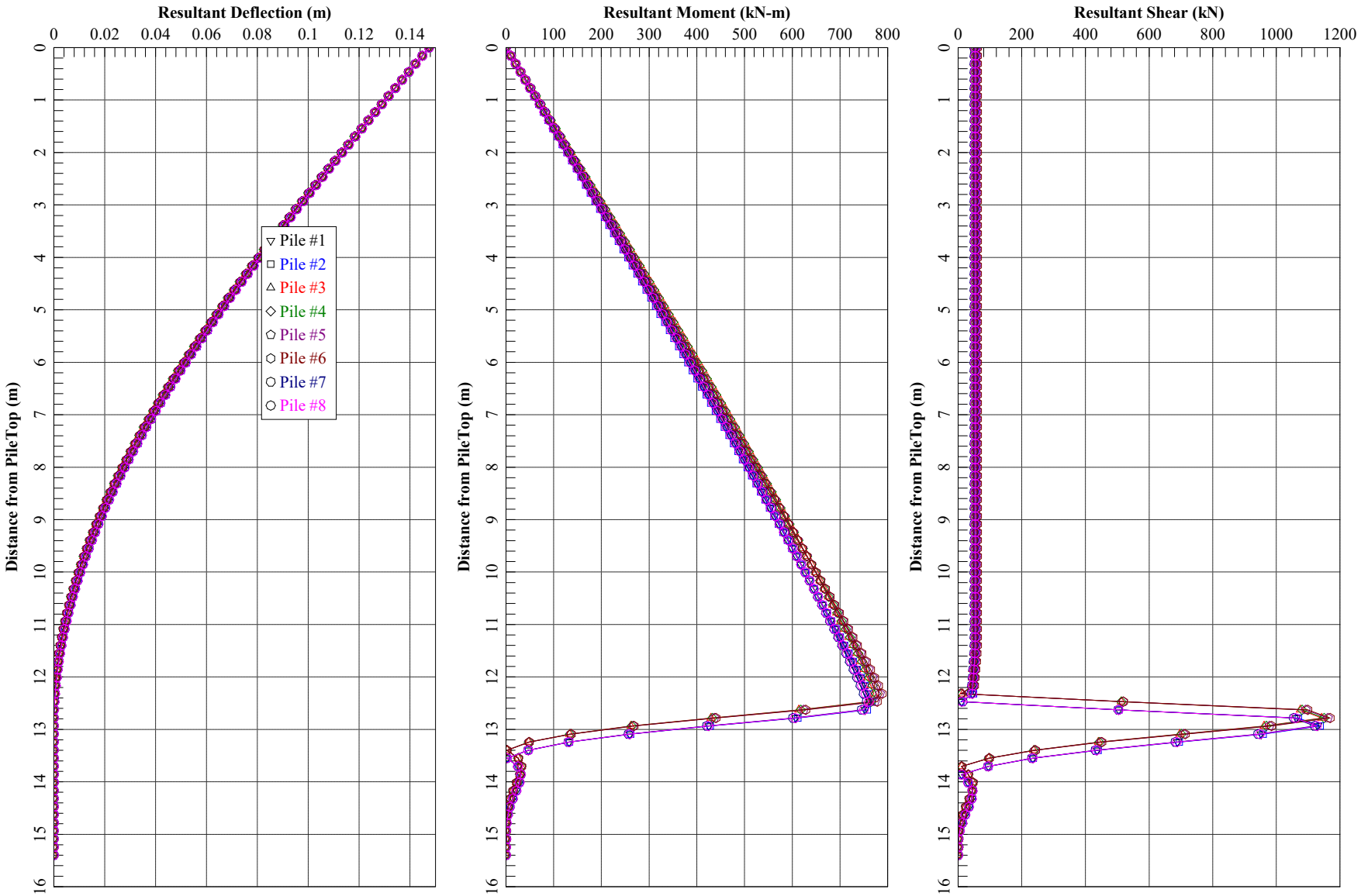
70-2_2.4


Resultant Deflection (m)
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
Distance from PileTop (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Pile #7
Pile #8
Resultant Moment (kN-m)
0
100
200
300
400
500
Distance from PileTop (m)
Resultant Shear (kN)
0
100
200
300
400
500
Distance from PileTop (m)

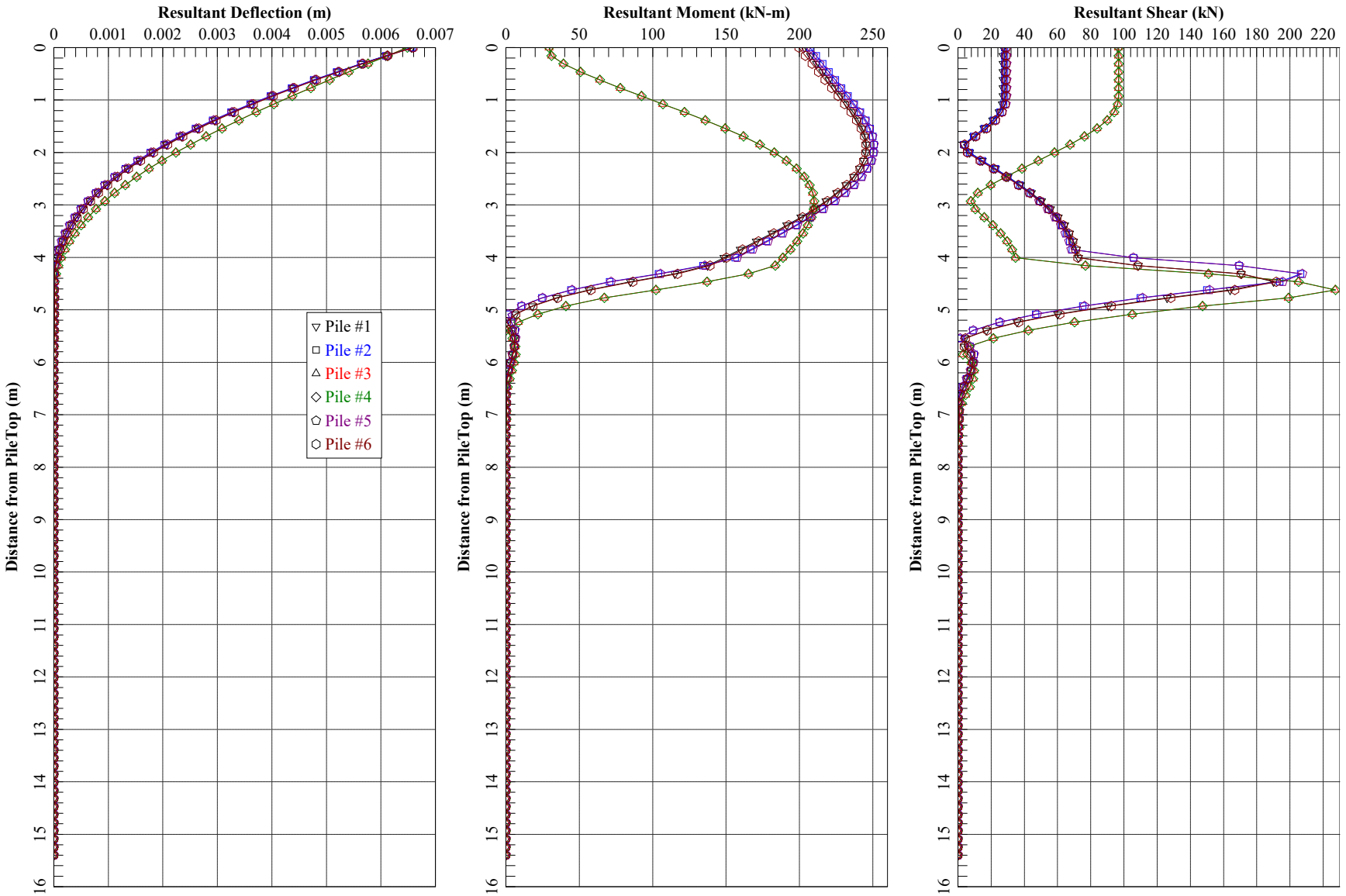
102-3_3.1


Resultant Deflection (m)
0 0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Resultant Moment (kN-m)
0 50 100 150 200 250
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Resultant Shear (kN)
0 20 40 60 80 100 120 140 160 180 200 220
Distance from PileTop (m)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28

86-3_3.2


Resultant Deflection (m)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Distance from PileTop (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Pile #7
Pile #8
Resultant Moment (kN-m)
0
100
200
300
400
500
600
700
800
Distance from PileTop (m)
Resultant Shear (kN)
0
200
400
600
800
1000
1200
Distance from PileTop (m)

102-4_4.1


Resultant Deflection (m)
0
0.001
0.002
0.003
0.004
0.005
0.006
0.007
Distance from PileTop (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Pile #1
Pile #2
Pile #3
Pile #4
Pile #5
Pile #6
Resultant Moment (kN-m)
0
50
100
150
200
250
Distance from PileTop (m)
Resultant Shear (kN)
0
20
40
60
80
100
120
140
160
180
200
220
Distance from PileTop (m)

102-4_4.2

Appendix C
Reference Borehole Logs

HATCH BOREHOLE REPORT

BH18-BR15-1
Sheet 1 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Bridge 15 (Kilometer 18)

Project No.: H353004
Datum: NAD83
Platform:

Easting: 555,758.0 m
Northing: 7,915,441.0 m
Surface Elevation: 78.00 m
Bottom Elevation: 60.63 m
Total Depth: 17.4 m
Logged By: MY/PS
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 3/11/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	77.0	1.0	Mini Sonic Drilling Rig BL100			SNOW	ICE										
						ICE	ICE										
	76.0	2.0				SILTY SAND, some GRAVEL: fine to medium grained sand, brownish grey.	Nf inferred										
	75.0	3.0					Possible ice feature, all melted.				6	34	44	22			
	74.0	4.0				4.20 m - 4.30 m: Boulder inferred with silty sand layer.					11	6	57	37			
	73.0	5.0									7						
	72.0	6.0															
	71.0	7.0															
	70.0	8.0				COBBLES and BOULDERS: Cobble at 7.75 m and 8.90 m.											
	69.0	9.0				MUD SLURRY with GRAVEL to COBBLES: Coarse gravel (26 mm).	Nf inferred										
	68.0	10.0															

Notes:

BOREHOLE REPORT

BH18-BR15-1
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Bridge 15 (Kilometer 18)

Project No.: H353004
Datum: NAD83
Platform:

Easting: 555,758.0 m
Northing: 7,915,441.0 m
Surface Elevation: 78.00 m
Bottom Elevation: 60.63 m
Total Depth: 17.4 m
Logged By: MY/PS
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 3/11/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						ROCK: 60% mafic, 10-15% red mineral, 10% black elongate, reflective. Refusal on hard rock.											
	67.0	11.0				***Start of Coring at 10.7m.***											
						Continued on Rock Core Log sheet.											
	66.0	12.0															
	65.0	13.0															
	64.0	14.0															
	63.0	15.0															
	62.0	16.0															
	61.0	17.0															
	60.0	18.0															
	59.0	19.0															
	58.0	20.0															

Notes:

BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR15-1

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Bridge 15 (Kilometer 18)

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,758.0 m

Northing: 7,915,441.0 m

Surface Elevation: 78.00 m

Bottom Elevation: 60.63 m

Total Depth: 17.4 m

Logged By: MY/PS

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 3/11/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description (ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.)	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description (Inclination, type, infill, amount, aperture, planarity, roughness, frequency) Specific / General
							Resuming in Rock Core Format 10.7m.							
	67.0	11.0		1 / 130			BEDROCK: Granitic gneiss alternating with mafic bands.					52		Fz 3° Jt Pl Sm 5° Jt Pl Sm
	66.0	12.0		2 / 105								76		Dl 40° Jt Pl Sm 10° Jt Pl Sm cg
	65.0	13.0		3 / 96			12.58 m: Mafic matrix with white minerals peppered throughout, medium grain size.					43		90° Jt Pl Sm 85° Jt Pl Sm 90° Jt Pl Ro 90° Jt Pl Sm 75° Jt Pl Sm Fz 0° Jt Pl Sm Soil cg Cz
	64.0	14.0		4 / 154								92		30° Jt Pl Ro Rust staining sn 80° Jt Pl Ro Rust staining sn 90° Jt Pl Sm 45° Jt Pl Ro Rust sn 30° Jt Pl 30° Jt Pl Sm Darker staining 0° Jt Pl Ro
	63.0	15.0		5 / 101			14.80 m - 15.85 m: Dark mafic to ultramafic matrix, black visable minerals.					86		45° Jt Pl Sm 45° Jt Pl Sm 70° Jt Pl Ro Dl Fz Dl
	62.0	16.0		6 / 99			15.85 m - 15.95 m: Granitic gneiss. 15.95 m - 17.22 m: Mafic matrix.					95		45° Jt Pl Sm
	61.0	17.0					17.22 m: Mafic matrix with red banding, granitic gneiss.							45° Jt Pl Sm Some staining, infill cg Dl 40° Jt Pl Sm Staining sn
	60.0	18.0					To Target Depth. **Drillhole BH18-BR15-1 terminated at 17.4m.**							
	59.0	19.0												
	58.0	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

HATCH BOREHOLE REPORT

BH18-BR15-2

Sheet 1 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Bridge 15 (Kilometer 18)

Project No.: H353004
Datum: NAD83
Platform:

Easting: 514,211.0 m
Northing: 7,965,645.0 m
Surface Elevation: 78.00 m
Bottom Elevation: 61.20 m
Total Depth: 16.8 m
Logged By: MY/PS
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 3/12/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	78.0	0.0				ICE	ICE										
	77.0	1.0				BOULDERS to COBBLES: Grey with red viens.	Nf										
						SAND, trace SILT: Fine to medium grained, light brown, red, and black.	Nbn - Vx				14	1	85	14			
	76.0	2.0				SANDY SILT: Grey.	Nbn			>>	63	1	45	54			
						SILTY SAND, trace to some GRAVEL: Fine to medium grained, brownish grey.					9	29	39	32			
	75.0	3.0					Nf										
	74.0	4.0				3.90 m: Trace boulders, sub-rounded to rounded gravel and boulders.					11	14	60	26			
							Nf inferred										
	73.0	5.0				5.20 m: Some gravel, trace boulders.											
	72.0	6.0									5	22	48	30			
	71.0	7.0															
	70.0	8.0	Mini Sonic Drilling Rig BL100			7.80 m: Trace cobbles.											
						8.50 m - 8.70 m: Trace boulders, coarsening downwards, sub-angular to sub-rounded.											
	69.0	9.0															
						9.45 m - 9.80 m: Boulders, dark matrix with granitic crystals.	Nf										
	68.0	10.0															

Notes:

BOREHOLE REPORT

BH18-BR15-2
Sheet 2 of 3

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Bridge 15 (Kilometer 18)

Project No.: H353004
Datum: NAD83
Platform:

Easting: 514,211.0 m
Northing: 7,965,645.0 m
Surface Elevation: 78.00 m
Bottom Elevation: 61.20 m
Total Depth: 16.8 m
Logged By: MY/PS
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 3/12/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						10.00 m - 10.15 m: Boulders, dark matrix with granitic crystals. ***Start of Coring at 10.2m.*** ***Continued on Rock Core Log sheet.***											
	67.0	11.0															
	66.0	12.0															
	65.0	13.0															
	64.0	14.0															
	63.0	15.0															
	62.0	16.0															
	61.0	17.0															
	60.0	18.0															
	59.0	19.0															
	58.0	20.0															

Notes:

BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR15-2

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Bridge 15 (Kilometer 18)

Project No.: H353004

Datum: NAD83

Platform:

Easting: 514,211.0 m

Northing: 7,965,645.0 m

Surface Elevation: 78.00 m

Bottom Elevation: 61.20 m

Total Depth: 16.8 m

Logged By: MY/PS

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 3/12/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description Inclination, type, infill, amount, aperture, planarity, roughness, frequency Specific / General
							Resuming in Rock Core Format 10.2m.							
	67.0	11.0					BEDROCK: Granitic gneiss, grey matrix with red veins. 10.70 m - 11.10 m: mafic matrix with plagioclase and granitic banding (gneissic banding). Crushed rock, up to 30 cm.							
	66.0	12.0												
	65.0	13.0												
	64.0	14.0					13.70 m - 13.85 m: Pulverized rock.							
	63.0	15.0												
	62.0	16.0					15.50 m: Thicker plagioclase beds, thicker clasts (granite)							
	61.0	17.0					To Target Depth. **Drillhole BH18-BR15-2 terminated at 16.8m.**							
	60.0	18.0												
	59.0	19.0												
	58.0	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

BOREHOLE REPORT

BH17-BR86-1

Sheet 1 of 4

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: North West Abutment

Project No.: H353004

Datum: NAD83

Platform: Ground

Easting: 542,257.3 m

Northing: 7,922,181.7 m

Surface Elevation: 142.93 m

Bottom Elevation: 103.33 m

Total Depth: 39.6 m

Logged By: R.S

Reviewed By: H.G

Contractor: Boart Longyear

Driller: Brent McAndrew

Rig Type/ Mounting: MiniSonic Rig

Hole Diameter (mm): 100 mm

Date Logged: 10/1/2017

Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	142.9	0.0				Sandy GRAVEL, trace Silt: Brown.	unfrozen										
	141.9	1.0				SAND, trace Silt: Brown to greyish-brown, medium to fine grained, well graded. Ice poor soil.	Nbn										
	140.9	2.0															
	139.9	3.0															
	138.9	4.0															
	137.9	5.0				ICE	ICE										
	136.9	6.0															
	135.9	7.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine grained. Ice poor soil.	Nbn										
	134.9	8.0															
	133.9	9.0															
	132.9	10.0															
	131.9	11.0															

Notes: Hole not located directly on abutment.

BOREHOLE REPORT

BH17-BR86-1
Sheet 2 of 4

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD83
Location: North West Abutment
Platform: Ground

Easting: 542,257.3 m
Northing: 7,922,181.7 m
Surface Elevation: 142.93 m
Bottom Elevation: 103.33 m
Total Depth: 39.6 m
Logged By: R.S
Reviewed By: H.G

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/1/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	130.9	12.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine grained. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	129.9	13.0															
	128.9	14.0															
	127.9	15.0															
	126.9	16.0															
	125.9	17.0															
	124.9	18.0															
	123.9	19.0															
	122.9	20.0															
	121.9	21.0															
	120.9	22.0															

Notes: Hole not located directly on abutment.

HATCH BOREHOLE REPORT

BH17-BR86-1

Sheet 3 of 4

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD83
Location: North West Abutment
Platform: Ground

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/1/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 2/10/2018

Easting: 542,257.3 m
Northing: 7,922,181.7 m
Surface Elevation: 142.93 m
Bottom Elevation: 103.33 m
Total Depth: 39.6 m
Logged By: R.S
Reviewed By: H.G

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	119.9	23.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine grained. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	118.9	24.0															
	117.9	25.0															
	116.9	26.0															
	115.9	27.0															
	114.9	28.0															
	113.9	29.0				29.30m to 29.4m: Some fine gravel.											
	112.9	30.0															
	111.9	31.0															
	110.9	32.0															
	109.9	33.0															

Notes: Hole not located directly on abutment.

HATCH BOREHOLE REPORT

BH17-BR86-1

Sheet 4 of 4

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD83
Location: North West Abutment
Platform: Ground

Easting: 542,257.3 m
Northing: 7,922,181.7 m
Surface Elevation: 142.93 m
Bottom Elevation: 103.33 m
Total Depth: 39.6 m
Logged By: R.S
Reviewed By: H.G

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/1/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile 0 25 50	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	108.9	34.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine grained. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	107.9	35.0				SAND, with SILT: Brown, fine grained. Ice poor soil.	Nbn										
	106.9	36.0															
	105.9	37.0				35.0m to 37.8m: Dark brownish-grey.											
	104.9	38.0															
	103.9	39.0															
	102.9	40.0				To Target Depth. **Drillhole BH17-BR86-1 terminated at 39.6m.**											
	101.9	41.0															
	100.9	42.0															
	99.9	43.0															
	98.9	44.0															

Notes: Hole not located directly on abutment.

BOREHOLE REPORT

BH17-BR86-2

Sheet 1 of 4

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD83
Location: North West Abutment
Platform: Ground

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/26/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 2/10/2018

Easting: 542,268.6 m
Northing: 7,922,171.3 m
Surface Elevation: 142.97 m
Bottom Elevation: 103.37 m
Total Depth: 39.6 m
Logged By: U.K and R.S
Reviewed By: H.G

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	142.0	1.0				Sandy GRAVEL, trace SILT: Brown.	unfrozen										
	141.0	2.0				SAND, trace SILT: Brown and greysish-brown. Ice poor soil.	Nbn				14	25	72	2			
	140.0	3.0									23	0	93	7			
	139.0	4.0									18	0	91	9			
	138.0	5.0				4.6m to 6.1m: Uniform brown colour, trace multi-coloured fine gravel.					37	4	91	5			
	137.0	6.0															
	136.0	7.0															
	135.0	8.0				SAND, trace to some Silt: Alternating layers of grey sand and brown silty-sand, poorly graded. Ice poor soil.	Nbn										
	134.0	9.0															
	133.0	10.0									22	0	89	11			
	132.0	11.0															

Notes: Hole is directly on North West Abutment.

BOREHOLE REPORT

BH17-BR86-2
Sheet 2 of 4

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: North West Abutment

Project No.: H353004
Datum: NAD83
Platform: Ground

Easting: 542,268.6 m
Northing: 7,922,171.3 m
Surface Elevation: 142.97 m
Bottom Elevation: 103.37 m
Total Depth: 39.6 m
Logged By: U.K and R.S
Reviewed By: H.G

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100 mm
Date Logged: 10/26/2017
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	131.0	12.0				SAND, trace to some Silt: Alternating layers of grey sand and brown silty-sand, poorly graded. Ice poor soil. *(Continued)*	Nbn *(Continued)*				23						
	130.0	13.0															
	129.0	14.0															
	128.0	15.0															
	127.0	16.0															
	126.0	17.0															
	125.0	18.0															
	124.0	19.0															
	123.0	20.0									22	0	90	10			
	122.0	21.0															
	121.0	22.0															

Notes: Hole is directly on North West Abutment.

BOREHOLE REPORT

BH17-BR86-2
Sheet 3 of 4

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD83
Location: North West Abutment
Platform: Ground

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/26/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 2/10/2018

Easting: 542,268.6 m
Northing: 7,922,171.3 m
Surface Elevation: 142.97 m
Bottom Elevation: 103.37 m
Total Depth: 39.6 m
Logged By: U.K and R.S
Reviewed By: H.G

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	120.0	23.0				SAND, trace to some Silt: Alternating layers of grey sand and brown silty-sand, poorly graded. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	119.0	24.0									25						
	118.0	25.0															
	117.0	26.0															
	116.0	27.0															
	115.0	28.0															
	114.0	29.0															
	113.0	30.0									26						
	112.0	31.0															
	111.0	32.0															
	110.0	33.0															

Notes: Hole is directly on North West Abutment.

BOREHOLE REPORT

BH17-BR86-2
Sheet 4 of 4

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: North West Abutment

Project No.: H353004
Datum: NAD83
Platform: Ground

Easting: 542,268.6 m
Northing: 7,922,171.3 m
Surface Elevation: 142.97 m
Bottom Elevation: 103.37 m
Total Depth: 39.6 m
Logged By: U.K and R.S
Reviewed By: H.G

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100 mm
Date Logged: 10/26/2017
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 25 / 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	142.97	0.0				SAND, trace to some Silt: Alternating layers of grey sand and brown silty-sand, poorly graded. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	109.0	34.0															
	108.0	35.0															
	107.0	36.0															
											27						
	106.0	37.0															
						37.4m to 39.3m: Trace Organics, dark brownish-grey to black, thin lenses of organics.											
	105.0	38.0															
	104.0	39.0															
						SAND, and SILT: Brown, fine grained. Ice poor soil.	Nbn				25	0	61	39			
	103.0	40.0				To Target Depth. **Drillhole BH17-BR86-2 terminated at 39.6m.**											
	102.0	41.0															
	101.0	42.0															
	100.0	43.0															
	99.0	44.0															

Notes: Hole is directly on North West Abutment.

HATCH BOREHOLE REPORT

BH17-BR86-3

Sheet 1 of 4

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: South East Abutment

Project No.: H353004
Datum: NAD83
Platform: Ground

Easting: 542,304.8 m
Northing: 7,922,141.4 m
Surface Elevation: 143.38 m
Bottom Elevation: 103.78 m
Total Depth: 39.6 m
Logged By: U.K
Reviewed By: H.G

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100 mm
Date Logged: 10/22/2017
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	142.4	1.0				SAND with Gravel, trace Silt: Brown.	unfrozen				14	21	69	10			
	141.4	2.0				SAND, trace to some SILT: Brown and greyish- brown, medium to fine grained. Ice poor soil.	Nbn				23	0	93	7			
	140.4	3.0									24	0	94	6			
	139.4	4.0															
	138.4	5.0									25	0	89	11			
	137.4	6.0				6.1m to 9.0m: Colour changes to uniform dark brown.											
	136.4	7.0															
	135.4	8.0									26	0	78	22			
	134.4	9.0															
	133.4	10.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine. Ice poor soil.	Nbn										
	132.4	11.0															

Notes: Hole is directly on South East Abutment

BOREHOLE REPORT

BH17-BR86-3
Sheet 2 of 4

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD83
Location: South East Abutment
Platform: Ground

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/22/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 2/10/2018

Easting: 542,304.8 m
Northing: 7,922,141.4 m
Surface Elevation: 143.38 m
Bottom Elevation: 103.78 m
Total Depth: 39.6 m
Logged By: U.K
Reviewed By: H.G

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	131.4	12.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine. Ice poor soil. *(Continued)*	Nbn *(Continued)*				26	0	93	7			
	130.4	13.0															
	129.4	14.0															
	128.4	15.0															
	127.4	16.0				15.2m to 16.8m: Silty sand layers are dark brown.											
	126.4	17.0															
	125.4	18.0															
	124.4	19.0															
	123.4	20.0															
	122.4	21.0															
	121.4	22.0															

Notes: Hole is directly on South East Abutment

BOREHOLE REPORT

BH17-BR86-3
Sheet 3 of 4

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: South East Abutment

Project No.: H353004
Datum: NAD83
Platform: Ground

Easting: 542,304.8 m
Northing: 7,922,141.4 m
Surface Elevation: 143.38 m
Bottom Elevation: 103.78 m
Total Depth: 39.6 m
Logged By: U.K
Reviewed By: H.G

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: MiniSonic Rig
Hole Diameter (mm): 100 mm
Date Logged: 10/22/2017
Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 25 / 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	120.4	23.0				SAND, trace Silt: Alternating layers of grey sand and brown silty sand, poorly graded, medium to fine. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	119.4	24.0				23.0m to 24.5m: Colour changes to dark brown, layers are now brown and dark brown.											
	118.4	25.0															
	117.4	26.0															
	116.4	27.0															
	115.4	28.0				27.4m to 30.5m: Colour changes to grey, layers are now light and dark grey.											
	114.4	29.0															
	113.4	30.0									25	0	92	8			
	112.4	31.0				SAND, trace SILT: Brown to grey. Ice poor soil.	Nbn										
	111.4	32.0															
	110.4	33.0															

Notes: Hole is directly on South East Abutment

BOREHOLE REPORT

BH17-BR86-3

Sheet 4 of 4

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: South East Abutment

Project No.: H353004

Datum: NAD83

Platform: Ground

Easting: 542,304.8 m

Northing: 7,922,141.4 m

Surface Elevation: 143.38 m

Bottom Elevation: 103.78 m

Total Depth: 39.6 m

Logged By: U.K

Reviewed By: H.G

Contractor: Boart Longyear

Rig Type/ Mounting: MiniSonic Rig

Date Logged: 10/22/2017

Driller: Brent McAndrew

Hole Diameter (mm): 100 mm

Date Reviewed: 2/10/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	109.4	34.0				SAND, trace SILT: Brown to grey. Ice poor soil. *(Continued)*	Nbn *(Continued)*										
	108.4	35.0															
	107.4	36.0															
	106.4	37.0															
	105.4	38.0															
	104.4	39.0															
	103.4	40.0				To Target Depth. **Drillhole BH17-BR86-3 terminated at 39.6m.**											
	102.4	41.0															
	101.4	42.0															
	100.4	43.0															
	99.4	44.0															

Notes: Hole is directly on South East Abutment

BOREHOLE REPORT

BH18-BR70-1
Sheet 1 of 5

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Proposed Bridge 70 Abutment

Project No.: H353004
Datum: NAD83
Platform:

Easting: 529,138.0 m
Northing: 7,916,667.0 m
Surface Elevation: 124.00 m
Bottom Elevation: 91.50 m
Total Depth: 32.5 m
Logged By: YF/MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 4/13/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	123.0	1.0				SILTY SAND: Greyish brown, fine to medium grained.	Nbn										
	122.0	2.0															
	121.0	3.0				3.00 m: Saline smelling dark organic layer. 3.30 m: Banding of silt. 3.70 m: Organic layer.	Nbn to Vx				22	0	97	3			
	120.0	4.0				4.20 m: Micaceous minerals, organics.	Vs										
	119.0	5.0															
	118.0	6.0					Nbn										
	117.0	7.0									28	0	80	20			
	116.0	8.0				7.60 m: Interbedded silt and organic layers, pungent organics.	Vr to Vx										
	115.0	9.0				ICE and SOIL: Silt, trace sand, grey.	I+S				36	0	3	97			
	114.0	10.0															

Notes:

BOREHOLE REPORT

BH18-BR70-1
Sheet 2 of 5

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Proposed Bridge 70 Abutment

Project No.: H353004
Datum: NAD83
Platform:

Easting: 529,138.0 m
Northing: 7,916,667.0 m
Surface Elevation: 124.00 m
Bottom Elevation: 91.50 m
Total Depth: 32.5 m
Logged By: YF/MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 4/13/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						ICE and SOIL: Silt, trace sand, grey. *(Continued)*	I+S *(Continued)*										
	113.0	11.0				SILTY SAND: Brownish grey, stratified, possible laminated organics.	Nbn										
						11.30 m - 11.45 m: Clay layers.					19	0	39	61			
	112.0	12.0				11.80 m - 12.00 m: Inferred boulder.											
						12.25 m - 12.30 m: Trace gravel, grey.											
						12.70 m - 13.05 m: Inferred boulder.											
	111.0	13.0				13.30 m: Cobbles.											
	110.0	14.0				SANDY SILT, trace GRAVEL: Grey.	Nbn										
											15	9	51	40			
	109.0	15.0				15.20 m, 16.40 m: Cobbles, greyish brown.											
	108.0	16.0															
											14	19	26	55			
	107.0	17.0															
						17.40 m - 18.00 m: Boulders	Nbn inferred										
	106.0	18.0				SANDY SILT, trace CLAY: Dark grey.	Nbn inferred										
						SILT, trace GRAVEL, trace SAND: Grey, coarse grained sand.	Nbn inferred										
	105.0	19.0															
	104.0	20.0				19.80 m - 21.70 m: Trace to some											

Notes:

BOREHOLE REPORT

BH18-BR70-1
Sheet 3 of 5

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Proposed Bridge 70 Abutment

Project No.: H353004
Datum: NAD83
Platform:

Easting: 529,138.0 m
Northing: 7,916,667.0 m
Surface Elevation: 124.00 m
Bottom Elevation: 91.50 m
Total Depth: 32.5 m
Logged By: YF/MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 4/13/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 / 25 / 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	103.0	21.0				angular fine to medium gravel, trace cobbles. SILT, trace GRAVEL, trace SAND: Grey, coarse grained sand. *(Continued)*	Nbn inferred *(Continued)*										
	102.0	22.0				21.70 m: Angular gravel in a silt matrix. Inferred as rock flour, cobbles, gravel, boulders, white to grey dust.											
	101.0	23.0				BEDROCK (Inferred): Rock dust.											
	100.0	24.0															
	99.0	25.0															
	98.0	26.0				***Start of Coring at 25.9m.*** ***Continued on Rock Core Log sheet.***											
	97.0	27.0															
	96.0	28.0															
	95.0	29.0															
	94.0	30.0															

Notes:

BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR70-1

Sheet 4 of 5

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,138.0 m

Northing: 7,916,667.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 91.50 m

Total Depth: 32.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/13/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
	103.0	21.0												
	102.0	22.0												
	101.0	23.0												
	100.0	24.0												
	99.0	25.0					***Resuming in Rock Core Format 25.9m.***							
	98.0	26.0		18 / 101			BEDROCK: Siltstone to dolomitic limestone, grey with dark grey / black streaks, fine to very fine grained, medium strong rock. 25.98 m - 27.02 m: Silt seams.					64		90° Jt Pl Sm
	97.0	27.0					27.32 m - 27.36 m: Silt seams. 27.40 m - 28.60 m: Irregular black bands, bioturbated with mud seams, strong rock (excepting weak seams). 27.82 m - 27.83 m: Silt seams.							90° Jt Pl Sm Silt, light brown cg Dl 90° Jt Pl Sm 90° Jt Pl Sm Yellowish brown coating cg 90° Jt Pl Sm Silt cg 90° Jt Pl Sm Some silt cg 90° Jt Pl Sm Silt cg 90° Jt Pl Sm Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm
	96.0	28.0		19 / 72								42		Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm Sm
	95.0	29.0		20 / 86			28.60 m - 29.50 m: No visible mud, but some core loss.					83		90° Jt Pl Sm 90° Jt Pl Sm Silt cg 90° Jt Pl Sm Silt cg 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm 80° Jt Pl Sm
	94.0	30.0					29.50 m - 31.00 m: Bioturbated, 5 cm mud seam, strong rock.					58		90° Jt Pl Sm Fz 90° Jt Ir Ro

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR70-1

Sheet 5 of 5

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,138.0 m

Northing: 7,916,667.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 91.50 m

Total Depth: 32.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/13/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description (ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.)	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description (Inclination, type, infill, amount, aperture, planarity, roughness, frequency) Specific / General
	93.0	31.0		21 / 103			BEDROCK: Siltstone to dolomitic limestone, grey with dark grey / black streaks, fine to very fine grained, medium strong rock. *(Continued)*					58		90° Jt Pl Sm Silt cg 90° Jt Pl Sm Sm 90° Jt Ir Ro 90° Jt Pl Sm 90° Jt Pl Sm 90° Jt Pl Sm Silt cg Fz 90° Jt Pl Ro Dl
	92.0	32.0		22 / 103								95		
	91.0	33.0					To Target Depth. **Drillhole BH18-BR70-1 terminated at 32.5m.**							
	90.0	34.0												
	89.0	35.0												
	88.0	36.0												
	87.0	37.0												
	86.0	38.0												
	85.0	39.0												
	84.0	40.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

BOREHOLE REPORT

BH18-BR70-2

Sheet 1 of 4

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,107.0 m

Northing: 7,916,700.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 95.50 m

Total Depth: 28.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: Sonic Drill Rig

Date Logged: 4/17/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	124.0	0.0				SAND, trace to some SILT: Light brown, fine to medium grained.	Nbn										
	123.0	1.0									1	38	47	15			
											20	0	86	14			
							Nbe										
	122.0	2.0															
	121.0	3.0															
											15	0	91	9			
	120.0	4.0															
	119.0	5.0															
	118.0	6.0				6.10 m: With fine black organic layers.											
	117.0	7.0				7.00 m - 7.10 m: Silt, some sand.											
						SAND interbedded with SILT.	Nbe										
	116.0	8.0				8.30 m: Becoming finer with depth.	Vr										
	115.0	9.0				ICE: 40% soil	ICE										
						SILT, some CLAY: Dark brown.	Vr - Vs										
											23	0	2	98			
	114.0	10.0				9.70 m - 10.10 m: Ice lenses, snow like.											

Notes:

BOREHOLE REPORT

BH18-BR70-2
Sheet 2 of 4

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Proposed Bridge 70 Abutment

Project No.: H353004
Datum: NAD83
Platform:

Easting: 529,107.0 m
Northing: 7,916,700.0 m
Surface Elevation: 124.00 m
Bottom Elevation: 95.50 m
Total Depth: 28.5 m
Logged By: YF/MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 4/17/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	113.0	11.0				SILT, some CLAY: Dark brown. *(Continued)* 10.50 m - 10.70 m: Fine to medium sand, trace silt. 10.70 m - 10.75 m: Ice, snow like. 10.75 m: Fine sand, interbedded with darker brown silt.	Vr - Vs *(Continued)* Nbn Vr										
	112.0	12.0				SILTY SAND, trace GRAVEL: Dark brown with layers of yellow, angular gravel. 12.70 m - 12.90 m: White to grey limestone cobbles. 12.90 m: Fine to medium gravel, angular to sub-rounded. 13.60 m - 13.70 m: Becoming darker brown.											
	110.0	14.0				COBBLES: Limestone in possible rock floor. 14.90 m - 15.20 m: Highly disturbed, dark grey wilt wirh angular gravel, inferred rock. 15.20 m - 16.80 m: Potential bedrock surface, grey angular gravel size pieces in majority crushed grey silt sized matrix. 17.10 m: Fractured rock, weathered top layer, 5 mm pockets of silt with 10 cm silt pocket below, very fine grained, laminated to fractured to full of holes. 18.30 m - 18.75 m: Loss of fines. 18.75 m - 19.30 m: Laminated, very fine grained. 19.35 m - 19.60 m: Silt, grey, pieces of rock, likely bedrock, thin horizontal laminations, smooth, horizontal	Nf inferred					0	2	98			
	104.0	20.0															

Notes:

BOREHOLE REPORT

BH18-BR70-2

Sheet 3 of 4

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,107.0 m

Northing: 7,916,700.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 95.50 m

Total Depth: 28.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: Sonic Drill Rig

Date Logged: 4/17/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
						fractures, silt seams present. COBBLES: Limestone in possible rock floor. *(Continued)*											
	103.0	21.0				~~21.20~~ m - 22.10 m: Fractured zone, fresh, strong.											
						Start of Coring at 21.3m. ***Continued on Rock Core Log sheet.***											
	102.0	22.0															
	101.0	23.0															
	100.0	24.0															
	99.0	25.0															
	98.0	26.0															
	97.0	27.0															
	96.0	28.0															
	95.0	29.0															
	94.0	30.0															

Notes:

BOREHOLE LOG

ROCK CORE FORMAT

BH18-BR70-2

Sheet 4 of 4

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 70 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 529,107.0 m

Northing: 7,916,700.0 m

Surface Elevation: 124.00 m

Bottom Elevation: 95.50 m

Total Depth: 28.5 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/17/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
	103.0	21.0					***Resuming in Rock Core Format 21.3m.***							
	102.0	22.0					BEDROCK: Siltstone to dolomitic limestone. 22.10 m - 24.00 m: Fractured, crystal filled (white, medium grade) voids from 23.30 m, fresh, strong.							
	101.0	23.0												
	100.0	24.0					24.00 m - 25.50 m: Void to 24.40 m, becoming beige 24.50 m - 24.70 m, mottled.							
	99.0	25.0												
	98.0	26.0					25.50 m - 27.00 m: Beige mottled from 25.60 m - 26.00 m, decreasing in beige concentrate after, fresh.							
	97.0	27.0					27.00 m - 28.50 m: Beige mottled grey mudstone, becoming more banded, strong, fresh, one vein at 28.00 m.							
	96.0	28.0												
	95.0	29.0					To Target Depth. **Drillhole BH18-BR70-2 terminated at 28.5m.**							
	94.0	30.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

BOREHOLE REPORT

BH18-102-1
Sheet 1 of 2

Client: Baffinland Iron Mine
Project: Mary River Expansion Study
Location: Proposed Bridge 102 Abutment

Project No.: H353004
Datum: NAD83
Platform:

Easting: 555,763.0 m
Northing: 7,915,435.0 m
Surface Elevation: 168.00 m
Bottom Elevation: 158.35 m
Total Depth: 9.7 m
Logged By: YF/MY
Reviewed By:

Contractor: Boart Longyear
Driller: Brent McAndrew
Rig Type/ Mounting: Sonic Drill Rig
Hole Diameter (mm): 100
Date Logged: 4/7/2018
Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 25 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	168.0	0.0				PEAT: Frozen with roots.	Nf										
						GRAVEL: Two boulders.											
	167.0	1.0				GRAVELLY SAND with COBBLES: Brown.											
						Start of Coring at 1.3m. ***Continued on Rock Core Log sheet.***											
	166.0	2.0															
	165.0	3.0															
	164.0	4.0															
	163.0	5.0															
	162.0	6.0															
	161.0	7.0															
	160.0	8.0															
	159.0	9.0															
	158.0	10.0															

Notes:

BOREHOLE LOG

ROCK CORE FORMAT

BH18-102-1

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,763.0 m

Northing: 7,915,435.0 m

Surface Elevation: 168.00 m

Bottom Elevation: 158.35 m

Total Depth: 9.7 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/7/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
	167.0	1.0					***Resuming in Rock Core Format 1.3m.***							
	166.0	2.0					BEDROCK: Gneiss, red plagioclase feldspar, coarse to very coarse grained, strong to very strong rock, fresh. 1.73 m: One discontinuity angled approx. 30 deg, black coated, 8 mm black alteration zone. 2.09 m - 2.31 m: Fractured area. 2.31 m - 2.91 m: Becoming coarser grained. 3.00 m: Becoming grey with pink (7 mm) veins, medium grained, strong to very strong. 3.53 m - 3.74 m: Black biotite mica, fractured zone, irregularly oriented 0.5 mm - 5 mm crystals. 3.74 m - 4.54 m: Quartzo feldspathic gneiss, grey to pink, very strong to strong. 4.54 m - 4.85 m: Potassium feldspar rich, pink, fractured zone. 4.85 m - 4.96 m: Possibly chloritized, 2 mm vein, medium grained, medium strong. 4.91 m - 4.93 m: Clay vein, weak. 4.96 m - 5.06 m: Some gneissic banding, red/black fine grained, strong. 5.06 m - 5.26 m: Broken core, clay rich vein, fine to medium grained, red/black, chlorite infilled joints. 5.26 m - 6.01 m: Trace potassium feldspar banding, quartz rich, strong grey, fine. 6.06 m - 6.36 m: Quartzo feldspar with black biotite banding, potassium feldspar rich, red, chlorite infilled joints. 6.36 m - 6.59 m: Quartz and feldspar, grey. 8.12 m - 8.26 m: Gneiss, grey pink, strong. 8.26 m - 8.30 m: Possible clay zone,							
	165.0	3.0												
	164.0	4.0												
	163.0	5.0												
	162.0	6.0												
	161.0	7.0												
	160.0	8.0												
	159.0	9.0												
	158.0	10.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

BOREHOLE LOG

ROCK CORE FORMAT

BH18-102-1

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,763.0 m

Northing: 7,915,435.0 m

Surface Elevation: 168.00 m

Bottom Elevation: 158.35 m

Total Depth: 9.7 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/7/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description Inclination, type, infill, amount, aperture, planarity, roughness, frequency Specific / General
	157.0	11.0					possibly chloritized, weak. 8.30 m - 8.61 m: Fine to medium grained, grey. 8.61 m - 8.87 m: Band of quartz to potasium feldspar, coarse grained, pink. Remainder fine to medium grained, grey, possible possible chlorite veins, trace pyrite, black biotite veins.							
	156.0	12.0					To Target Depth. **Drillhole BH18-102-1 terminated at 9.7m.**							
	155.0	13.0												
	154.0	14.0												
	153.0	15.0												
	152.0	16.0												
	151.0	17.0												
	150.0	18.0												
	149.0	19.0												
	148.0	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

BOREHOLE REPORT

BH18-102-2

Sheet 1 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,674.0 m

Northing: 7,915,409.0 m

Surface Elevation: 166.00 m

Bottom Elevation: 149.10 m

Total Depth: 16.9 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear

Rig Type/ Mounting: Sonic Drill Rig

Date Logged: 4/8/2018

Driller: Brent McAndrew

Hole Diameter (mm): 100

Date Reviewed:

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 25 – 50)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	165.0	1.0				SAND and GRAVEL: Medium grained sand, brown, slightly moist.	Nf inferred										
						GRAVELLY SAND, trace BOULDERS: Fine sand, possible boulder dust.	Nf inferred										
	164.0	2.0				GRAVELLY SAND, trace SILT: Medium to coarse grained, brownish grey to brown, subrounded to subangular.	Nf inferred										
	163.0	3.0										31	69	0			
						3.40 m and 3.70 m: Cobbles											
	162.0	4.0				SAND, some GRAVEL, trace SILT: Medium to fine grained, brownish grey.	Nf inferred										
	161.0	5.0				4.70 m: Inferred boulder.											
						5.00 m and 5.30 m: Cobble.											
	160.0	6.0				GRAVEL to COBBLES: Mixed igneous / metamorphic, washed.											
						5.6m: Organic / sulfur layer.											
	159.0	7.0															
	158.0	8.0															
	157.0	9.0				***Start of Coring at 8.7m.*** ***Continued on Rock Core Log sheet.***											
	156.0	10.0															

Notes:

BOREHOLE LOG

ROCK CORE FORMAT

BH18-102-2

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,674.0 m

Northing: 7,915,409.0 m

Surface Elevation: 166.00 m

Bottom Elevation: 149.10 m

Total Depth: 16.9 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/8/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description: Inclination, type, infill, amount, aperture, planarity, roughness, frequency (Specific / General)
	165.0	1.0												
	164.0	2.0												
	163.0	3.0												
	162.0	4.0												
	161.0	5.0												
	160.0	6.0												
	159.0	7.0												
	158.0	8.0					***Resuming in Rock Core Format 8.7m.***							
	157.0	9.0		9 / 135			BEDROCK: Gneiss, visible medium to coarse grains, red, black, and grey, strong to very strong.					77		Fz
														DI
														DI
														10° Jt Pl Sm
														20° Jt Pl Sm Red stains sn
	156.0	10.0										22		Fz

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	DI	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

BOREHOLE LOG

ROCK CORE FORMAT

BH18-102-2

Sheet 3 of 3

Client: Baffinland Iron Mine

Project: Mary River Expansion Study

Location: Proposed Bridge 102 Abutment

Project No.: H353004

Datum: NAD83

Platform:

Easting: 555,674.0 m

Northing: 7,915,409.0 m

Surface Elevation: 166.00 m

Bottom Elevation: 149.10 m

Total Depth: 16.9 m

Logged By: YF/MY

Reviewed By:

Contractor: Boart Longyear **Rig Type/ Mounting:** Sonic Drill Rig **Bearing:** N/A° **Date Logged:** 4/8/2018

Driller: Brent McAndrew **Hole Diameter (mm):** 100 **Plunge:** ° **Date Checked:**

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description (ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.)	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description (Inclination, type, infill, amount, aperture, planarity, roughness, frequency) Specific / General
	155.0	11.0		10 / 98			BEDROCK: Gneiss, visible medium to coarse grains, red, black, and grey, strong to very strong. *(Continued)*					22		Cz 90° Jt Pl Sm 40° Jt Cu Sm
				11 / 76			10.90 m: Possible porphyriticm, no gneissic banding.					43		70° Jt Pl Sm Orange stains sn Dl 75° Jt Pl Sm Fz
	154.0	12.0		12 / 115								87		45° Jt Pl Sm Rust staining sn Fz
	153.0	13.0		13 / 115			12.50 m: Two weathered / soft zones / seams at 13.00 m and 13.30 m, 4 mm, one visible joint, non stained.					66		Dl 30° Jt Pl Sm sn 80° Jt Pl Ro cg 50° Jt Pl Sm cg Fz
	152.0	14.0		14 / 91			13.70 m: Minor gneissic banding, becoming iron stained, black, weak.					49		20° Jt Pl Sm 75° Jt Cu Ro Rust stain, silt infill sn Dl 70° Jt Cu Sm Rusty infill sn Fz 80° Jt Pl Sm Rust infill sn
	151.0	15.0		15 / 117								40		Dl 5° Jt Pl Ro Black silty infill cg 75° Jt 80° Jt Pl Sm infill cg 90° Jt Cu Sm 20° Jt Cu Sm Black silt sn Fz
	150.0	16.0		16 / 106			15.70 m: Potassium felspar and quartz rich core, medium grained, red. 16.40 m: Quartz vein, very stained.					24		45° Jt Cu Sm Rusty sn Cz 45° Jt Cu Sm sn 45° Jt Pl Sm infill cg 80° Jt Pl Sm Rusty sn Dl 50° Jt Cu Sm
	149.0	17.0					To Target Depth. **Drillhole BH18-102-2 terminated at 16.9m.**							
	148.0	18.0												
	147.0	19.0												
	146.0	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						