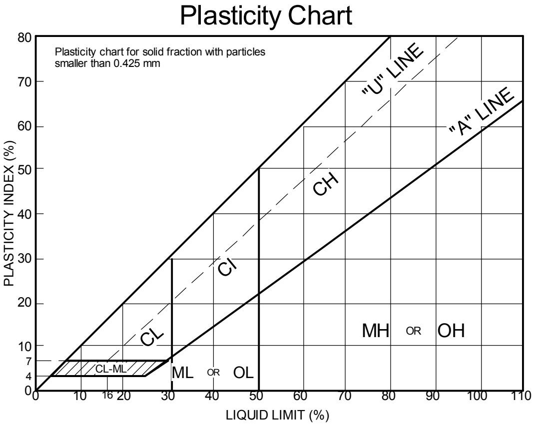
APPENDIX ‘A’

BACKGROUND REPORTS

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classification	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	●	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent....... GW, GP, SW, SP More than 12 percent....... GM, GC, SM, SC 6 to 12 percent....... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	○	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	▥	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▨	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	⁘	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	⁚	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▥	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▨	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			CL	▨	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	▤	Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit greater than 50)		MH	▮	Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts			
			CH	▨	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⁂	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material	Particle Size	
	mm	ASTM Sieve sizes
Sand		
Coarse	2.00 to 4.75	#10 to #4
Medium	0.425 to 2.00	#40 to #10
Fine	0.075 to 0.425	#200 to #40
Silt or Clay	< 0.075	< #200

Material	Particle Size	
	mm	ASTM Sieve Sizes
Boulders	> 300	> 12 in.
Cobbles	75 to 300	3 in. to 12 in.
Gravel		
Coarse	19 to 75	3/4 in. to 3 in.
Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	○	Cobbles
⁘	Concrete	▦	Limestone Bedrock	●	Boulders and Cobbles
▩	Fill	▤	Cemented Shale	▥	Silt Till
		▨	Non-Cemented Shale	▨	Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

⧩ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

The undrained shear strength (Su) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-01

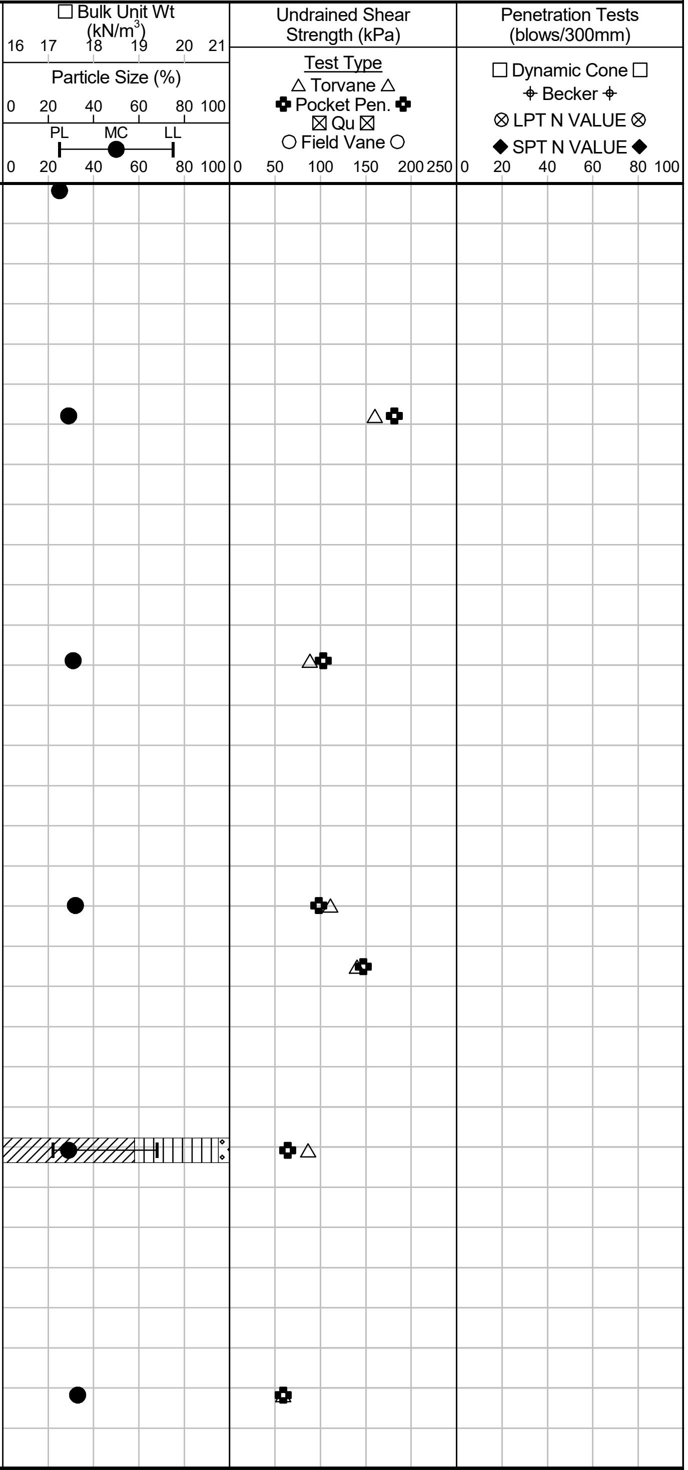
1 of 2

Client: City of Winnipeg, Planning Property and Development
Project Number: 0015-046-00
Project Name: Lyndale Drive Highfield to Birchdale
Location: UTM 14N 5525969 m N, 634329.4 m E
Contractor: Paddock Drilling Ltd.
Ground Elevation: 230.27 m
Method: 125 mm Solid Stem Auger, Acker MP5 Track Mount
Date Drilled: September 9, 2022

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ⧗ Split Barrel (SB) / LPT ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand Gravel Cobbles Boulders

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)
230.2			TOPSOIL (ORGANIC CLAY) - silty, trace sand, trace gravel (<10 mm diam.), trace rootlets - black, moist, firm, intermediate plasticity	◢	G1	
	0.5		CLAY (ALLUVIAL) - silty, trace sand - dark brown - moist, very stiff, intermediate to high plasticity			
	1.0					
	1.5			◢	G2	
	2.0					
			- trace silt inclusions (<10 mm diam.), brown below 2.1 m			
	2.5					
	3.0			◢	G3	
	3.5					
	4.0					
	4.5			◢	G4	
				▮	T5	
	5.0					
	5.5					
	6.0			◢	G6	
	6.5					
	7.0					
	7.5			◢	G7	

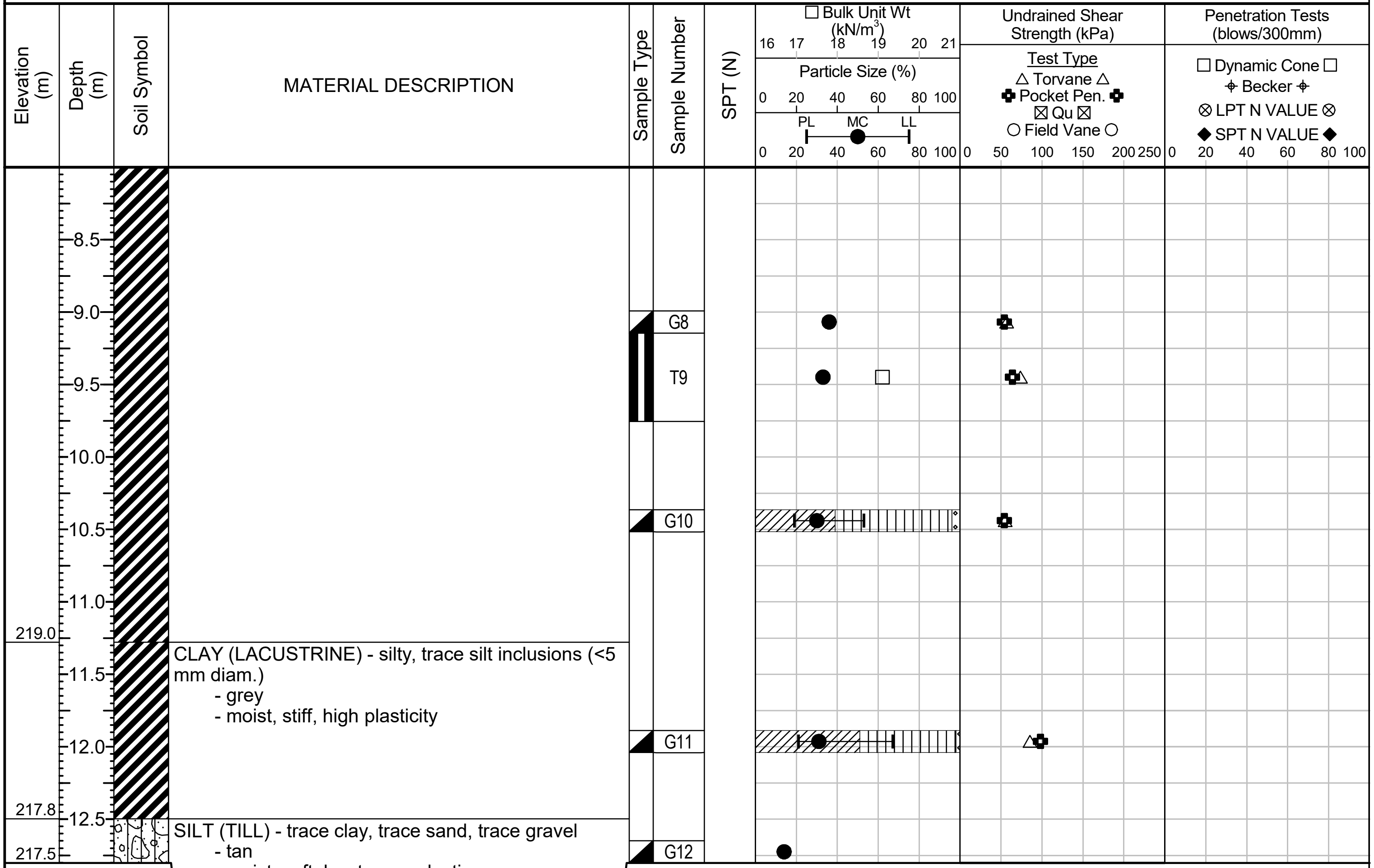


Logged By: Kate Franklin **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

Sub-Surface Log

Test Hole TH22-01

2 of 2



CLAY (LACUSTRINE) - silty, trace silt inclusions (<5 mm diam.)
- grey
- moist, stiff, high plasticity

SILT (TILL) - trace clay, trace sand, trace gravel
- tan
- moist, soft, low to non-plastic

END OF TEST HOLE AT 12.8 m IN SILT (TILL).

Notes:

1) Power auger refusal at 12.8 m depth.
2) Seepage observed at 7.6 m depth. No sloughing obeserved.
3) Water level at 6.1 m below grade immediately after drilling.
4) Test hole open to 12.6 m immediately after drilling.
5) Test hole backfilled with bentonite to ground surface.

Logged By: Kate Franklin **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-02

Client: City of Winnipeg, Planning Property and Development
Project Name: Lyndale Drive Highfield to Birchdale
Contractor: Paddock Drilling Ltd.
Method: 125 mm Solid Stem Auger, Acker MP5 Track Mount

Project Number: 0015-046-00
Location: UTM 14N 5526127 m N, 633941 m E
Ground Elevation: 228.00 m
Date Drilled: September 9, 2022

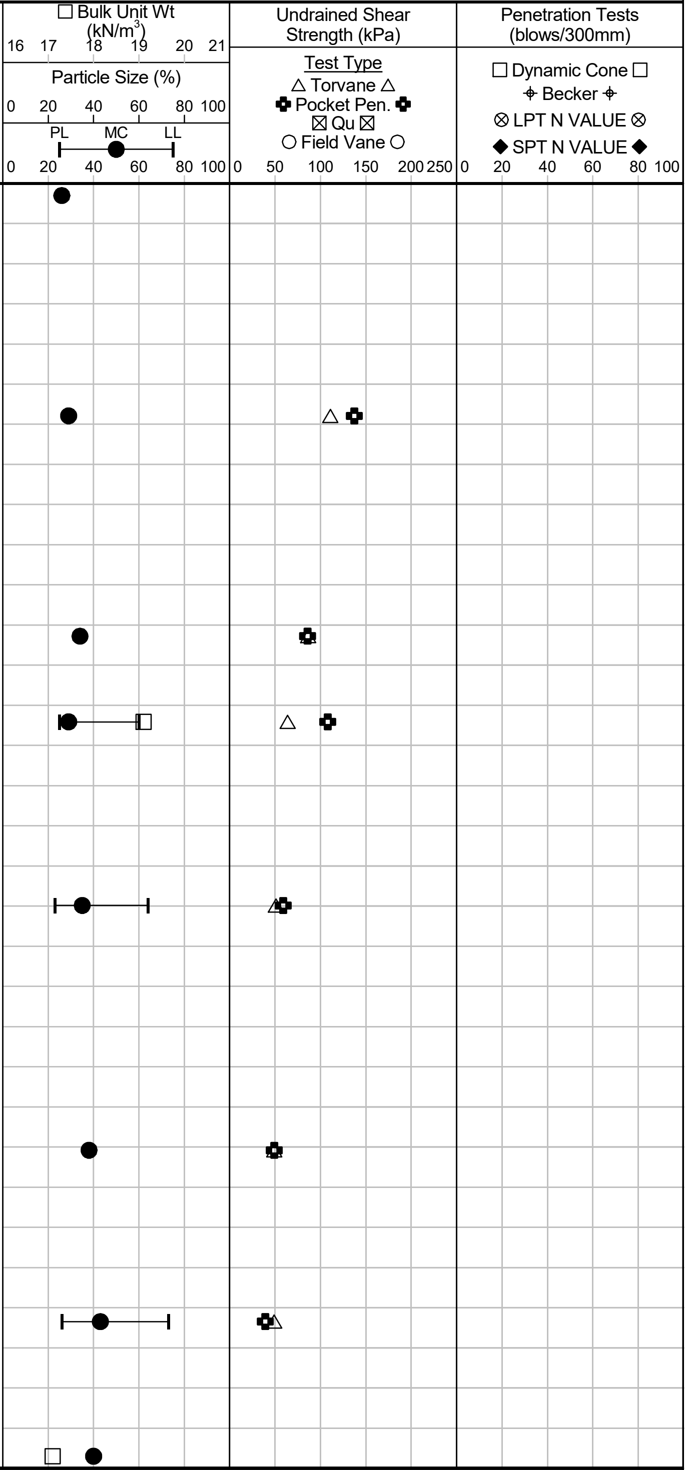
Sample Type: ◩ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ⧓ Split Barrel (SB) / LPT ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand Gravel Cobbles Boulders

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION
227.9		TOPSOIL (ORGANIC CLAY) - silty, trace sand, trace gravel (<10 mm diam.), trace rootlets - black, moist, firm, intermediate plasticity
		CLAY (ALLUVIAL) - silty, trace sand - dark brown - moist, very stiff, intermediate to high plasticity
	6.5	- grey, firm below 6.4 m

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5

Sample Type	Sample Number	SPT (N)
Grab	G23	
Grab	G24	
Grab	G25	
Shelby Tube	T26	
Grab	G27	
Grab	G28	
Grab	G29	
Shelby Tube	T30	

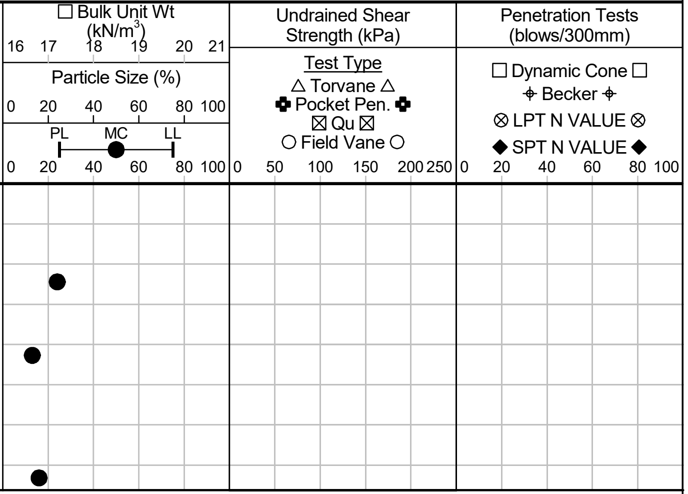


Logged By: Kate Franklin **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

Sub-Surface Log

Test Hole TH22-02

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)
219.8		▨		▮		
	8.5		SAND - trace shells, trace clay - black - moist, loose - poorly graded, medium grained, angular	◢	G31	
219.2	9.0 9.5		SILT (TILL) - trace clay, trace sand, trace gravel - tan - moist, firm, low plasticity	◢	G32	
218.1				◢	G33	



END OF TEST HOLE AT 9.9 m IN SILT (TILL).
Notes:
1) Power auger refusal at 9.9 m depth.
2) Seepage and sloughing observed at 7.6 m depth.
3) Water level at 3.6 m below grade immediately after drilling.
4) Test hole open to 7.3 m immediately after drilling.
5) Test hole backfilled with bentonite to ground surface.

Logged By: Kate Franklin **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

Sub-Surface Log

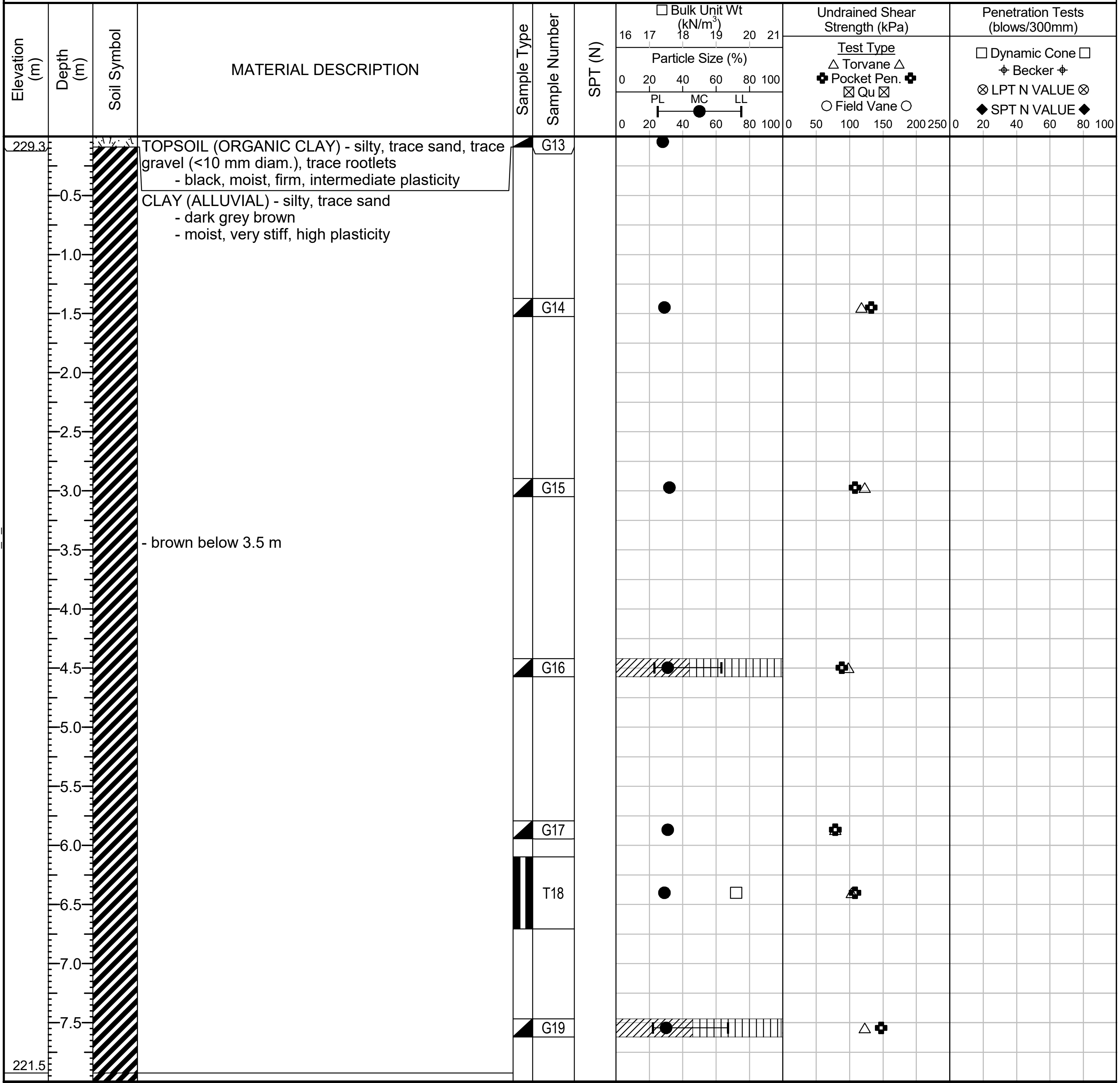
Test Hole TH22-03

1 of 2

Client: City of Winnipeg, Planning Property and Development
Project Name: Lyndale Drive Highfield to Birchdale
Contractor: Paddock Drilling Ltd.
Method: 125 mm Solid Stem Auger, Acker MP5 Track Mount
Project Number: 0015-046-00
Location: UTM 14N 5525950 m N, 634244 m E
Ground Elevation: 229.40 m
Date Drilled: September 9, 2022

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ⧓ Split Barrel (SB) / LPT ▯ Core (C)

Particle Size Legend: ▩ Fines ▨ Clay ▥ Silt ⁘ Sand Gravel Cobbles Boulders

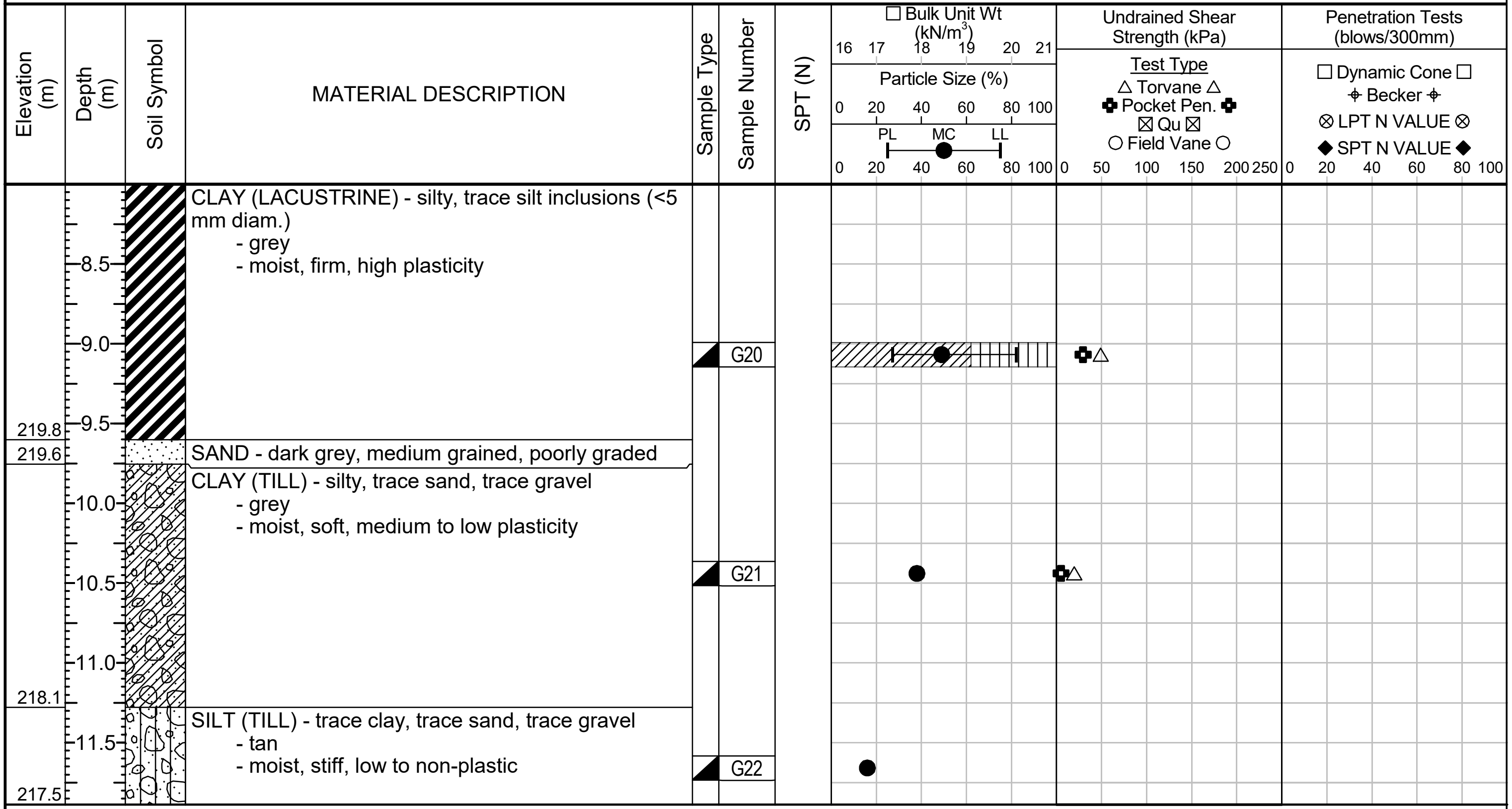


TOPSOIL (ORGANIC CLAY) - silty, trace sand, trace gravel (<10 mm diam.), trace rootlets
- black, moist, firm, intermediate plasticity

CLAY (ALLUVIAL) - silty, trace sand
- dark grey brown
- moist, very stiff, high plasticity

- brown below 3.5 m

Logged By: Kate Franklin **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden



CLAY (LACUSTRINE) - silty, trace silt inclusions (<5 mm diam.)
- grey
- moist, firm, high plasticity

SAND - dark grey, medium grained, poorly graded

CLAY (TILL) - silty, trace sand, trace gravel
- grey
- moist, soft, medium to low plasticity

SILT (TILL) - trace clay, trace sand, trace gravel
- tan
- moist, stiff, low to non-plastic

END OF TEST HOLE AT 11.9 m IN SILT (TILL).
Notes:
1) Power auger refusal at 11.9 m depth.
2) Seepage observed below 7.6 m depth.
3) Sloughing observed below 7.6 m depth.
4) Water level at 4.9 m below grade immediately after drilling.
5) Test hole open to 7.6 m immediately after drilling.
6) Test hole backfilled with bentonite to ground surface.

Logged By: Kate Franklin **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

Sub-Surface Log

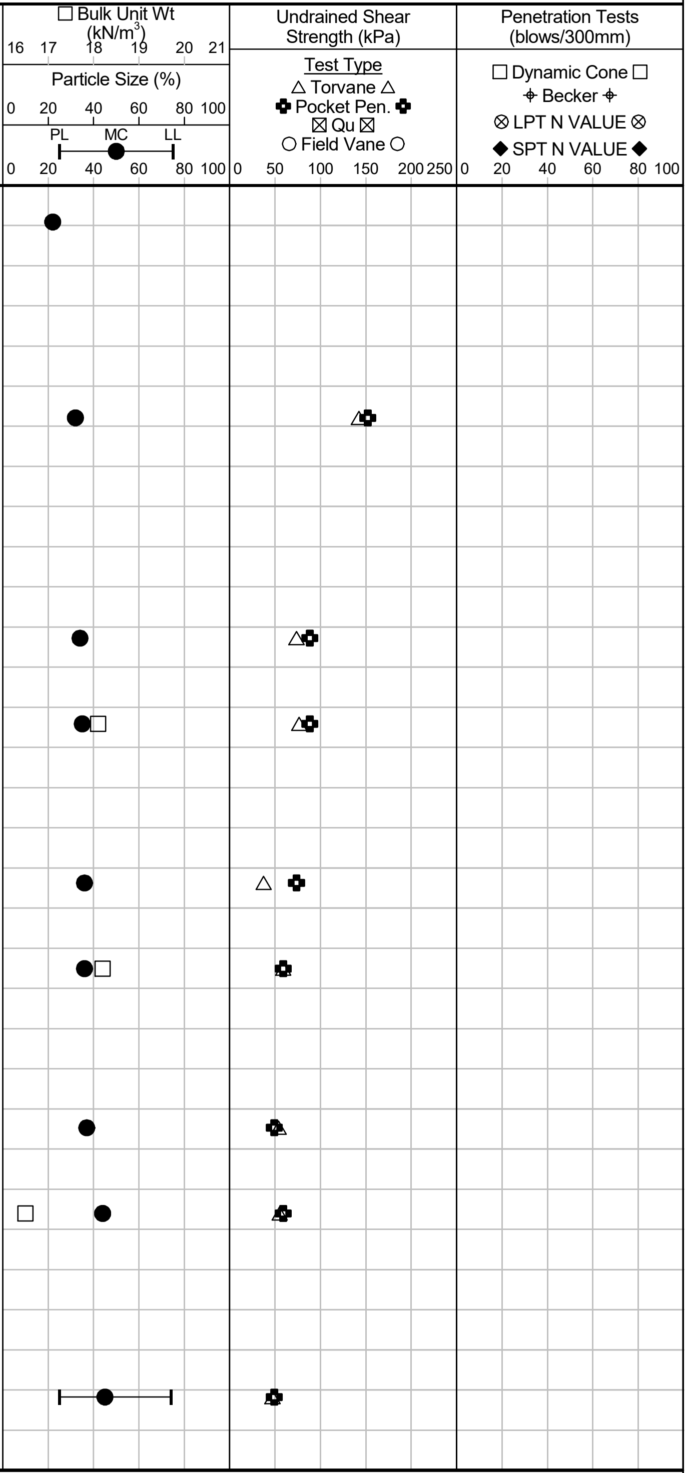
Test Hole TH22-04
1 of 2

Client: City of Winnipeg, Planning Property and Development
Project Name: Lyndale Drive Highfield to Birchdale
Contractor: Paddock Drilling Ltd.
Method: 125 mm Solid Stem Auger, Acker MP5 Track Mount
Project Number: 0015-046-00
Location: UTM 14N 5526371 m N, 633933.1 m E
Ground Elevation: 227.91 m
Date Drilled: September 9, 2022

Sample Type: ◩ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ⧓ Split Barrel (SB) / LPT ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ◌ Cobbles ■ Boulders

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)
227.8			TOPSOIL (ORGANIC CLAY) - silty, trace sand, trace gravel (<10 mm diam.), trace rootlets - black, moist, firm, intermediate plasticity	◩	G34	
	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5	▨	CLAY (ALLUVIAL) - silty, trace sand - dark brown - moist, very stiff, high plasticity	◩ ◩ ▮ ◩ ▮ ◩ ▮	G35 G36 T37 G38 T39 G40 T41	
221.2	7.0 7.5	▨	CLAY (LACUSTRINE) - silty - grey - moist, firm, high plasticity	◩	G42	

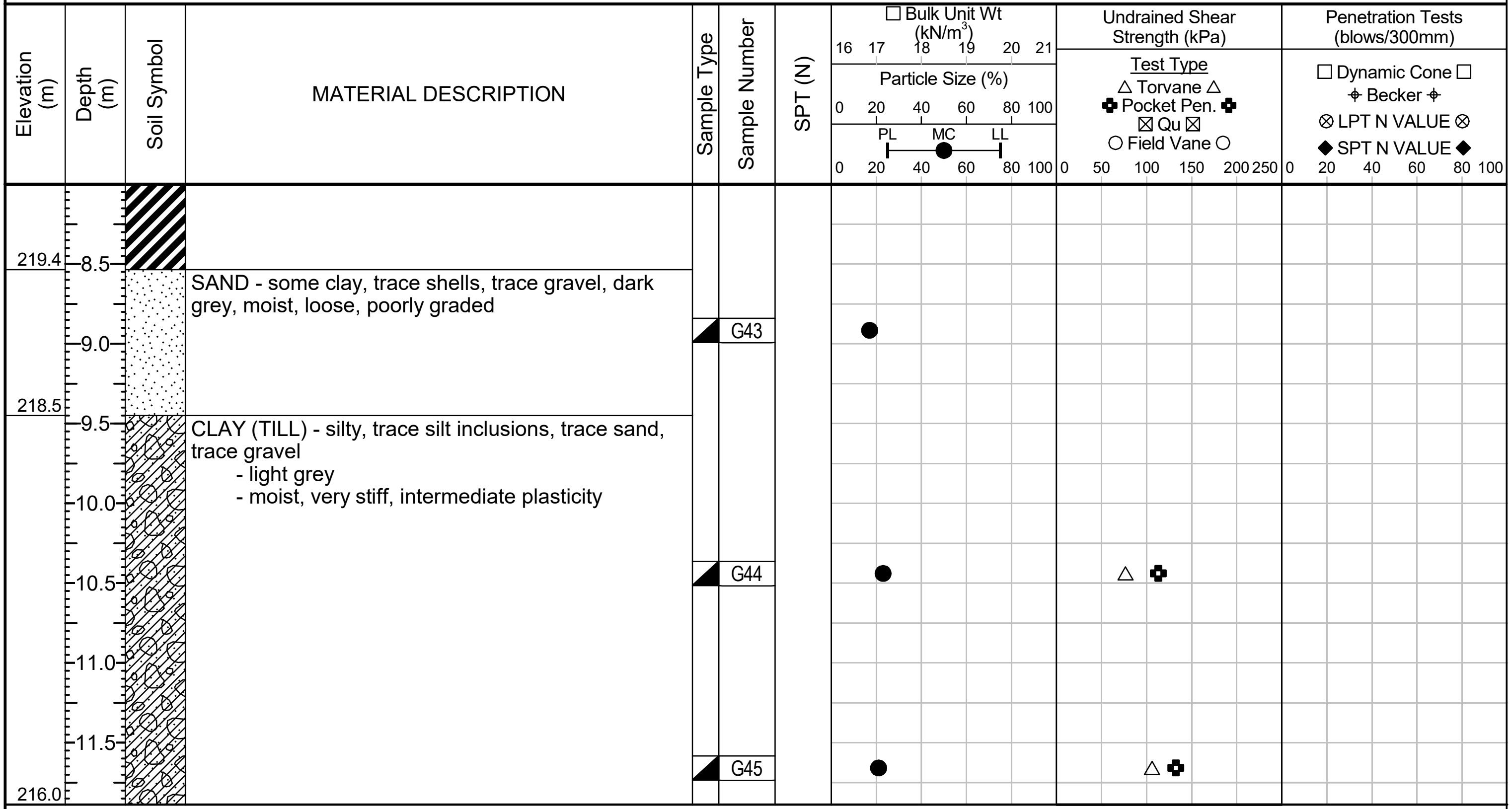


Logged By: Kate Franklin **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

Sub-Surface Log

Test Hole TH22-04

2 of 2



SAND - some clay, trace shells, trace gravel, dark grey, moist, loose, poorly graded

CLAY (TILL) - silty, trace silt inclusions, trace sand, trace gravel
- light grey
- moist, very stiff, intermediate plasticity

END OF TEST HOLE AT 11.9 m IN CLAY (TILL).

Notes:
1) Power auger refusal observed at 11.9 m depth.
2) Seepage observed below 6.1 m depth.
3) Test hole squeezed in at 5.5 m depth.
4) Test hole dry and open to 5.5 m depth immediately after drilling.
5) Test hole backfilled with bentonite to ground surface.

Logged By: Kate Franklin **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

October 18, 2022 Our File No. 0015-046-00

Dr. Kendall Thiessen
Riverbank Management Engineer
City of Winnipeg - Planning, Property and Development Department
Unit 15 - 30 Fort Street
Winnipeg, Manitoba
R3C 4X5

RE: Lyndale Drive Riverbank Stabilization
Hydrologic and Hydraulic Assessment

This letter report summarizes the results of our hydraulic assessment of the Red River at the proposed riverbank stabilization site along Lyndale Drive between Birchdale Avenue and Highfield Street. The proposed riverbank stabilization measures are to include the placement and subcut of additional rock riprap erosion protection along the riverbank. The location of the site is indicated on Figure 1.

Pertinent features of the site are as follows:

- Jurisdiction - City of Winnipeg
- Watercourse - Red River
- UTM Coordinates - 633900E, 5526030N (Zone 14)
- City of Winnipeg River Stationing - 349+70 to 339+51

Additional details with respect to the hydraulic assessment of the proposed erosion protection are summarized in the following sections.

Red River Hydrology

The hydrology for the Red River is complicated by the operation of the Floodway, which diverts flow around the City of Winnipeg during times of a flood within the Red River Valley. Additionally, the Saint Andrews Lock and Dam, located downstream of Winnipeg, controls river levels through the City of Winnipeg including the Lyndale Drive reach during the open water period. The project site is located upstream of the confluence with the Assiniboine River, however the backwater influence from the combined flows of the two rivers does influence this reach of the Red River.

Manitoba Water Stewardship has developed flood hydrology for the Red River within the City of Winnipeg taking into account recent upgrades to the Floodway. The hydrology derived by Manitoba Water Stewardship is based on a detailed and comprehensive assessment of recorded flows in addition to the incorporation of estimates of extreme historical events. The table from Manitoba Water Stewardship summarizing their assessment is appended for reference. The assessment from Manitoba Water Stewardship has flood hydrology derived for the Red River downstream of the Floodway Inlet and at James Avenue which would be indicative of flood conditions within the Red River throughout the City of Winnipeg. Table 1 summarizes the flood hydrology for the Red River taking into account the flows diverted to the Floodway.

The backwater analyses of the Red River for the project area requires a discharge for the downstream boundary condition. The discharge required reflects conditions downstream of the Saint Andrews Lock and Dam at the Floodway outlet. The discharge would be approximately equal to the discharge within the Red River downstream of the Assiniboine River confluence when the Floodway is not operating, however this cannot be assumed under flood conditions when total flows are greater than approximately 1100 m^3/s. The discharge has been estimated from the Manitoba Water Stewardship updated hydrology table by summing the Red River at James Avenue discharge and the Floodway discharge. Table 1 summarizes the estimated discharge downstream of the Saint Andrews Lock and Dam.

The hydrology to estimate seasonal flows outside of the spring period, were estimated using hydrologic records available from Water Survey of Canada (WSC) for the Red River near Lockport (05OJ010) gauge and WSC gauge Assiniboine River near Headingley (05MJ001). The records were sorted into 2 distinct seasons - Summer (July 1 to September 30th) and Winter (December 1st to February 28th) - with frequency analysis on the annual peaks within those seasons. It has been assumed that the flows recorded at Lockport would reflect flows at James Avenue, except in cases where the Floodway is in operation with total flows exceeding approximately 1100 m^3/s. Table 1 summarizes the hydrologic estimates.

Table 1 – Red River Flood Hydrology

Discharge Event	Red River at Lyndale Drive* (m^3/s)	Red River at James Avenue** (m^3/s)	Red River Downstream of St. Andrews Lock and Dam*** (m^3/s)
Annual Flood Hydrology			
0.625% (160 Year)	2195	2331	4775
1%	2168	2292	4225
2%	1688	1810	3452
5%	1334	1453	2597
10%	1283	1401	2033
20%	1179	1361	1597
50%	824	1005	1005
Seasonal Flood Hydrology****			
50% Summer (July 1 to Sept 30)	316	396	396
50% Winter (Dec 1 to Feb 28)	44	68	68
Average Winter Flow (Dec 1 to Feb 28)	35	54	54

* Red River downstream of Flood Inlet plus LaSalle River contribution, Manitoba Water Stewardship, Updated Red River Hydrology - February 2010

** Red River at James Ave, Manitoba Water Stewardship, Updated Red River Hydrology - February 2010

*** Sum of Red River at James Ave discharge and Floodway discharge, Manitoba Water Stewardship, Updated Red River Hydrology - February 2010

**** - Based on seasonal frequency analysis for streamflow records at WSC gauge Red River near Lockport - 05OJ010 and WSC gauge Assiniboine River near Headingley (05MJ001).

The Red River is controlled by the Saint Andrews Lock and Dam through the City of Winnipeg during the open water period typically between May and October. The target control level is approximately 223.7 m at James Avenue and the water levels are maintained at this level independent of flows in the Red River except under flood conditions. Normal flows during this period are approximately 316 m^3/s at the Lyndale Drive site and 396 m^3/s

downstream of the confluence with the Assiniboine River.

Hydraulic Assessment – Existing Conditions

The hydraulic conditions within the Red River were assessed to establish the baseline hydraulic regime. A detailed backwater analysis was undertaken to assess the hydraulics of the proposed riverbank erosion protection and re-grading design. The steady state hydraulic analysis was undertaken using the US Army Corps of Engineers River Analysis System HEC-RAS model. The HEC-RAS model is a one-dimensional backwater model, which is considered to be the universal standard for computing steady-state water surface profiles. The backwater model was developed from cross sectional information available from an existing comprehensive calibrated hydraulic model developed as part of the January 2015 Red River Hydraulic Assessment prepared for the City of Winnipeg[1]..

The project site (Highfield to Birchdale) is located along a predominantly inside bend of the river. The assessment reach would be approximately Sta 349+70 to 339+51 as per City of Winnipeg river stationing. A plan of the study area is shown on Figure 1. All banks within the project site are erosion controlled, with the upstream limit tying into a transition to failure-controlled banks that have been previously stabilized. The downstream limit of the site (the downstream limit of the park at 202 Lyndale Drive) is near the downstream end of the inside bend. The lower riverbank slope is generally bare, with slump blocks throughout, and relatively steep (2H:1V above the normal river level). The river cross sections within the original comprehensive backwater model were developed from topographic and bathymetric surveys undertaken by GDS Surveys in September 2013 and as part of the January 2015 Red River Hydraulic Assessment. Additional topographic and bathymetric surveys within the Lyndale Driver area were undertaken by GDS Surveys in the winter of 2015/2016, in September 2020 and in August 2022 to provide further detail within the hydraulic model in the study reach. Previously completed works along Lyndale Drive downstream of the project area were included in the model, to ensure that existing hydraulic conditions are accurately represented.

The estimated water surface profiles for the Red River for existing conditions are shown on Figure 2. A hydraulic summary of the existing conditions for the 50% Q (2-year) flood event is provided in Table 2 while Table 3 presents a hydraulic summary for the average winter flow event. The summary is provided for select river sections noted on Figure 1.

Table 2 – Red River Hydraulic Summary Along Lyndale Drive – 50% (2 Year) Flood Event

Existing Conditions			
River Station	**Discharge (m^3/s)**	**Water Level (m)**	**Channel Velocity (m/s)**
XS 1 (STA 348+07)	824	226.25	0.81
XS 2 (STA 345+55)	824	226.24	0.83
XS 3 (STA 343+28)	824	226.23	0.92
XS 4 (STA 340+81)	824	226.22	0.85
XS 5 (STA 339+51)	824	226.21	0.84

Table 3 – Red River Hydraulic Summary Along Lyndale Drive – Average Winter Flow (Dec 1 to Feb 28)

Existing Conditions				
River Station	**Discharge (m^3/s)**	**Water Level (m)**	**Bottom of Ice Level (m)**	**Channel Velocity (m/s)**
XS 1 (STA 348+07)	35	222.07	221.52	0.12
XS 2 (STA 345+55)	35	222.07	221.52	0.11
XS 3 (STA 343+28)	35	222.07	221.52	0.13
XS 4 (STA 340+81)	35	222.07	221.52	0.14
XS 5 (STA 339+51)	35	222.07	221.52	0.13

* - Normal winter flow assumed to be the average between December 1 and February 28 with a 0.6 m ice cover.

Proposed Bank Stabilization

In general, the slope failures have resulted in localized depressions and over-steepened banks. The proposed design includes a combination of subcutting and infill of the riverbank with rock riprap. The proposed infill geometry fills the depressions and provides a flattened, more stable slope, resulting in a bank geometry which is more consistent with the upstream and downstream river sections. As such, the fill does not necessarily encroach the river in a way which reduces its conveyance in these areas. The proposed slope stabilization measures would be within the designated Floodway and Floodway Fringe (regulations appended); thus it is important to minimize any hydraulic impact on water levels or velocities.

The proposed layout of the erosion protection measures is presented on Figure 9, while typical sections are shown on Figures 10. The HEC-RAS model of the existing conditions was modified to include the fill area and riprap apron geometry. The change to river velocity is negligible, with less than a 0.01 m/s increase locally at the 160

Year flood event. Figure 3 shows existing and proposed velocity profiles for the study reach. Changes to the water surface profile would be imperceptible (less than 1 cm).

A hydraulic summary of the existing and proposed conditions for the 160-year flood event is provided in Table 4. The summary is provided for select river sections noted on Figure 1.

Table 4 – Red River Hydraulic Summary Along Lyndale Drive – 160 Year Flood Event

River Station	Discharge (m^3/s)	Water Surface Elevation (m asl)			Channel Velocity (m/s)		
		Existing Conditions	Proposed Conditions *	Change *	Existing Conditions	Proposed Conditions *	Change *
XS 1 (STA 348+07)	2195	230.04	230.04	0.00	1.36	1.36	0.00
XS 2 (STA 345+55)	2195	230.01	230.01	0.00	1.42	1.43	+0.01
XS 3 (STA 343+28)	2195	229.98	229.98	0.00	1.55	1.55	0.00
XS 4 (STA 340+81)	2195	229.97	229.97	0.00	1.40	1.40	0.00
XS 5 (STA 339+51)	2195	229.96	229.96	0.00	1.40	1.40	0.00

Closure

The hydrotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice).

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work or standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

If you have any questions regarding the findings or recommendations presented, please contact the undersigned at your earliest convenience.

TREK Geotechnical Inc.
Per:

Reviewed By:

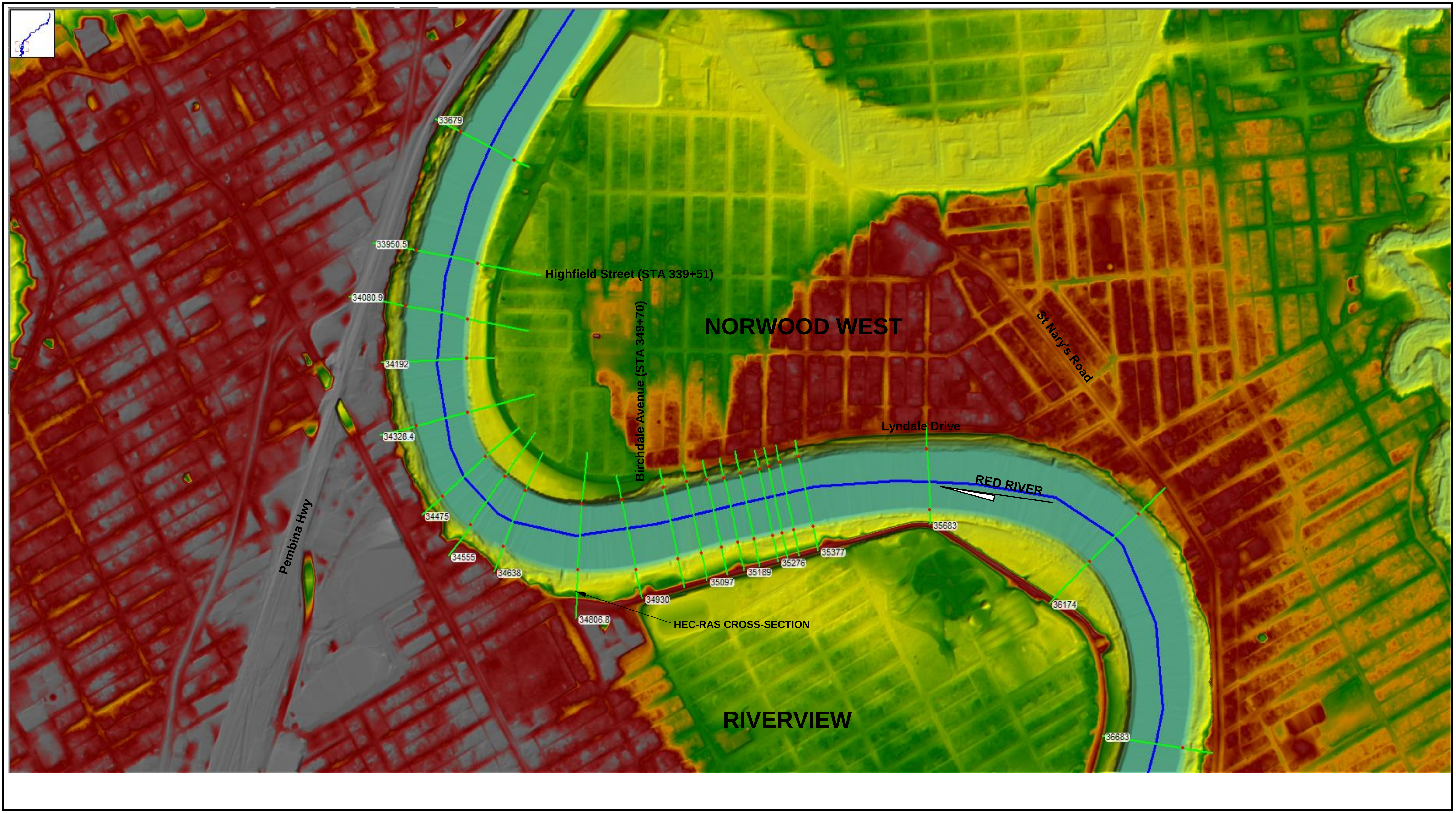
M.E.
ROEMER
Member
42357
Oct 18, 2022

Micha Roemer, M.Sc., P.Eng.
Water Resources Engineer

Bruce Harding, P.Eng.
Senior Water Resources Engineer

ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: 2022/10/18

0015 046 00
City of Winnipeg
Lyndale Drive Riverbank Stabilization



Z:\Projects\0015 City of Winnipeg\0015 046 00 Highfield to Birchdale Erosin Protection\2 Design\2.9 Analysis and Design Notes\WR\[Fig 2022-09-09 WSP Lyndale - Highfield to Birchdale MR0015 046 00.xlsx]Fig2

NOTES:

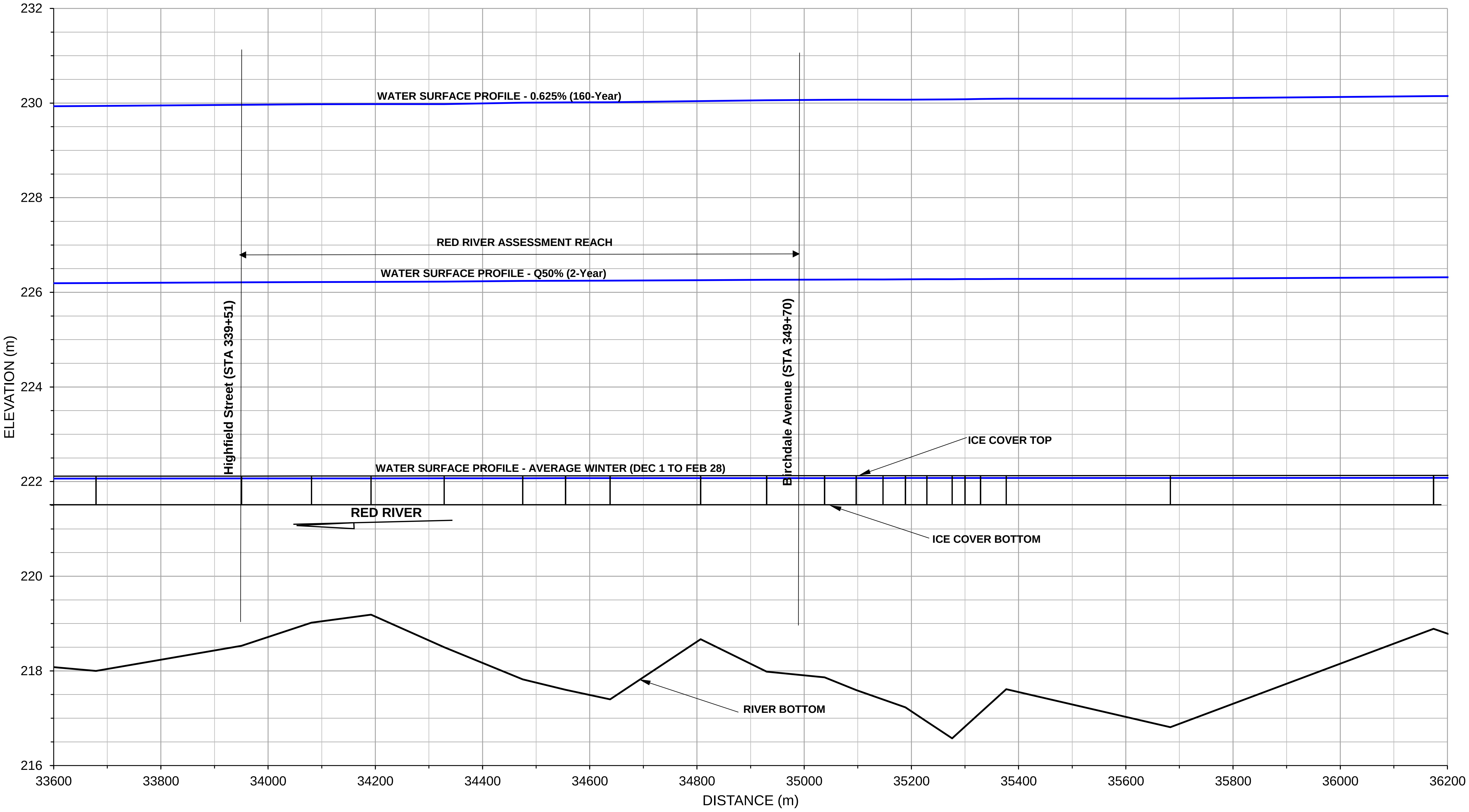
1. BACKGROUND IMAGE BASED ON 2020 RED RIVER VALLEY LIDAR FROM THE MANITOBA LAND INITIATIVE WEBSITE.

FIGURE 1

Red River at Lyndale Drive

Location Plan

0015 046 00
City of Winnipeg
Lyndale Drive Riverbank Stabilization



Z:\Projects\0015 City of Winnipeg\0015 046 00 Highfield to Birchdale Erosin Protection\2 Design\2.9 Analysis and Design Notes\WR\[Fig 2022-09-09 WSP Lyndale - Highfield to Birchdale MR0015 046 00.xlsx]Fig3

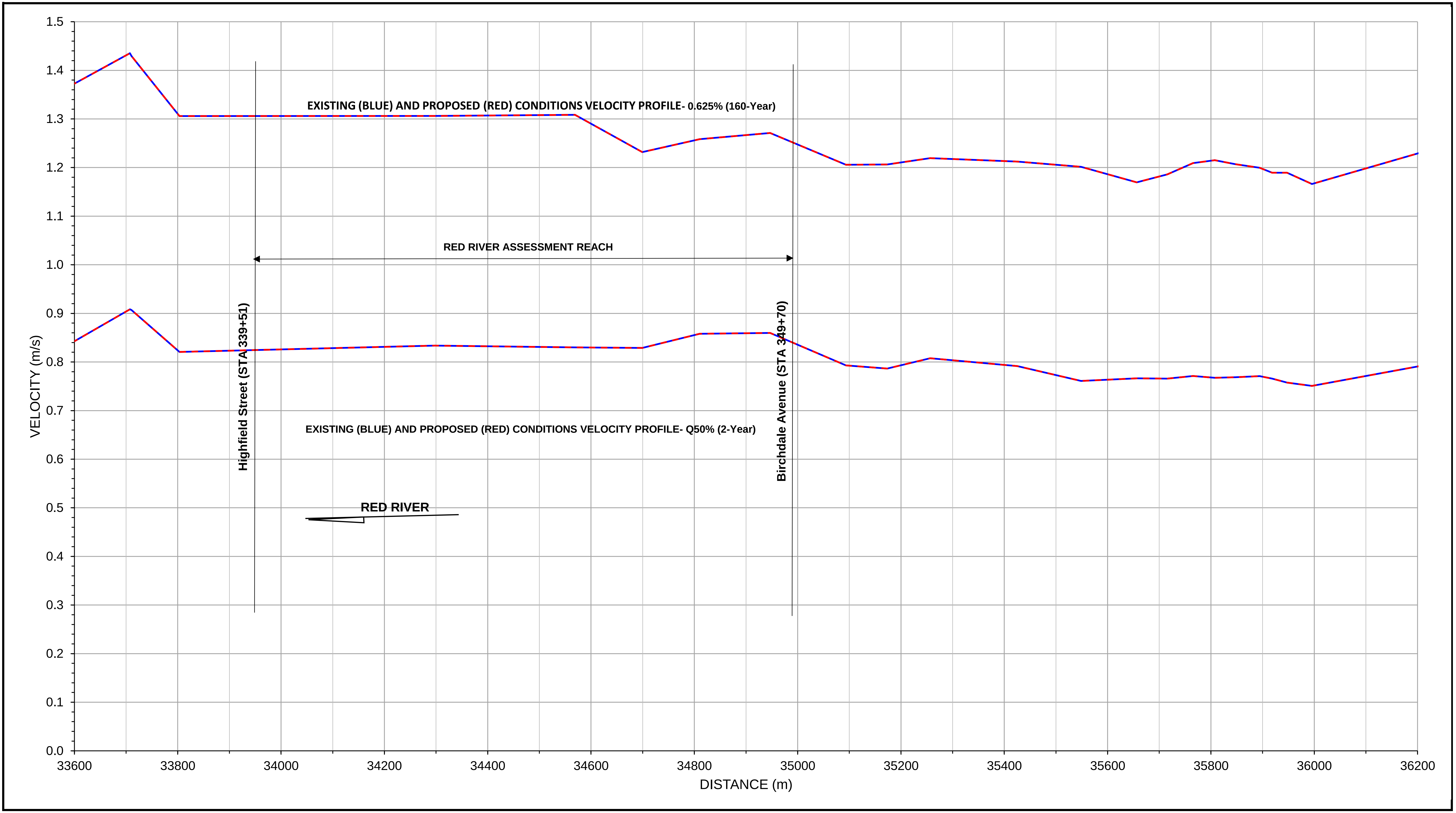
NOTES:

1. HEC-RAS MODEL DEVELOPED FROM AUGUST 2022, SEPTEMBER 2020, SEPTEMBER 2013, AND DECEMBER 2015/JANUARY 2016 SURVEY DATA.

FIGURE 2

Existing Conditions - Red River
Water Surface Profiles

0015 046 00
City of Winnipeg
Lyndale Drive Riverbank Stabilization



Z:\Projects\0015 City of Winnipeg\0015 046 00 Highfield to Birchdale Erosin Protection\2 Design\2.9 Analysis and Design Notes\WR\[Fig 2022-09-09 WSP Lyndale - Highfield to Birchdale MR0015 046 00.xlsx]proposed_vel

NOTES:

1. HEC-RAS MODEL DEVELOPED FROM AUGUST 2022, SEPTEMBER 2020, SEPTEMBER 2013, AND DECEMBER 2015/JANUARY 2016 SURVEY DATA.

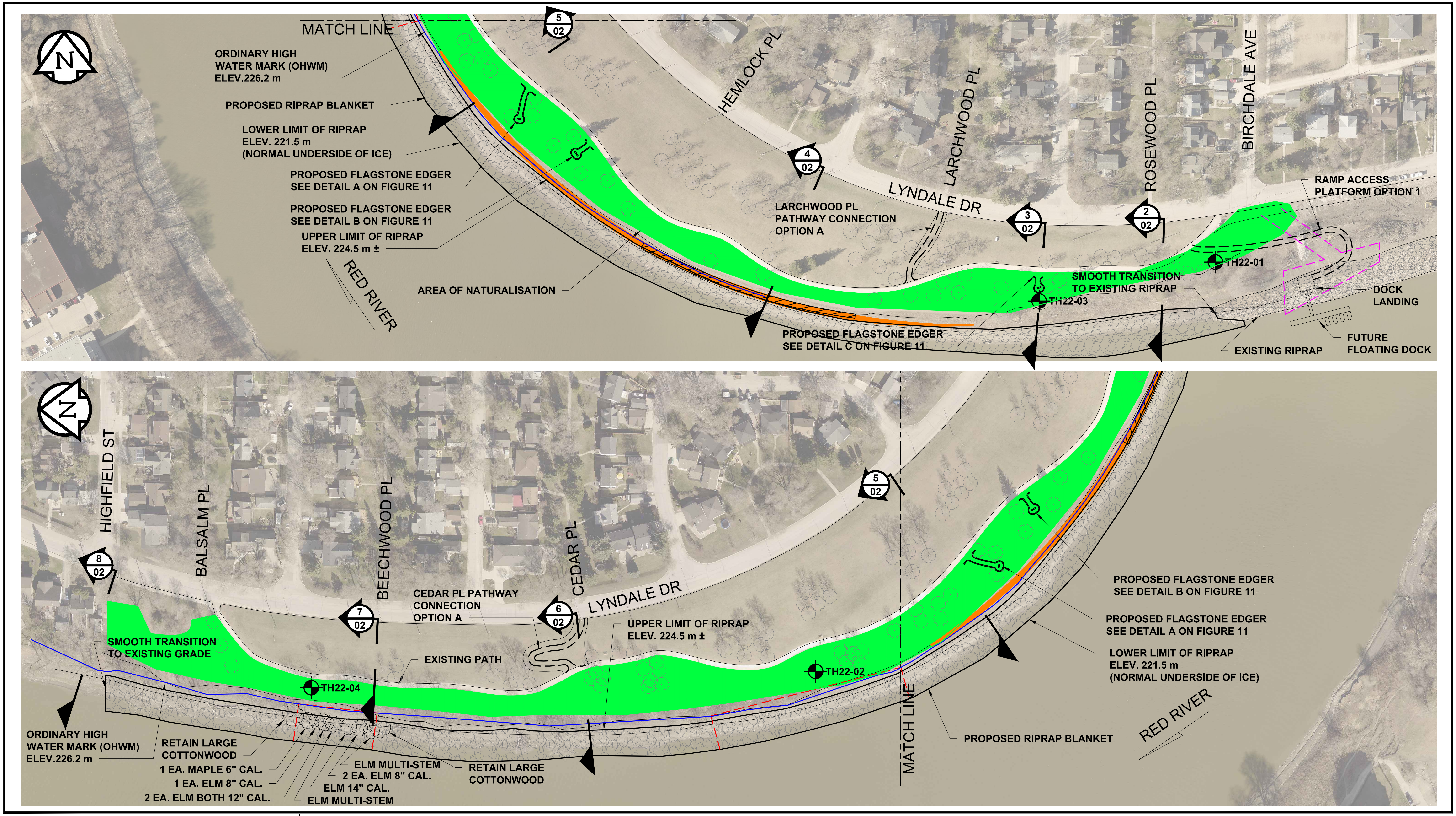
FIGURE 3

Existing and Proposed Conditions - Red River

Velocity Profiles

0015 046 00
City of Winnipeg
Lyndale Drive: Highfield Street to Birchdale Avenue Erosion Protection and Pathway Construction

Z:\Projects\0015 City of Winnipeg\0015 046 00 Highfield to Birchdale Erosin Protection\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 09 2022-10-04 Lyndale - Highfield to Birchdale 0_B 0015-046-00.dwg, 2022-10-06 1:04:44 PM



0 25 50 75 m
SCALE = 1 : 1 500 (279 mm x 432 mm)

LEGEND:

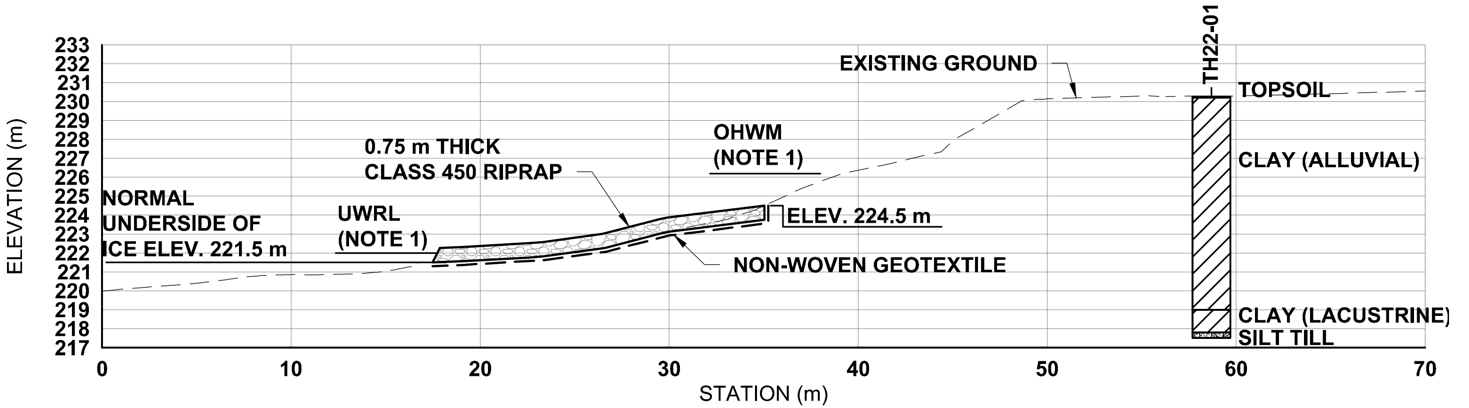
⌖	TEST HOLE (TREK, 2022)
○	TREE
🟧	BANK SWALLOW HABITAT TO BE PROTECTED
▨	BANK SWALLOW NESTING AREA
- - -	RE-USE PREVIOUS TEMPORARY CONSTRUCTION ACCESS (NO EXCAVATION)
- - -	TEMPORARY CONSTRUCTION ACCESS (REQUIRES EXCAVATION)

NOTES:

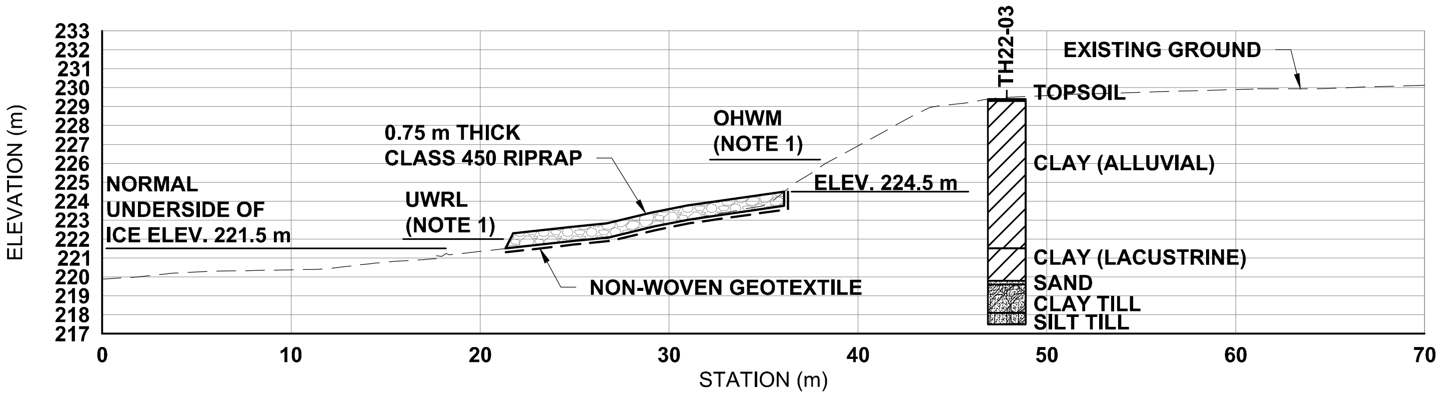
1. AERIAL IMAGERY FROM CITY OF WINNIPEG (2021).

Figure 09
Recommended Erosion Protection and Pathway Upgrades Plan View

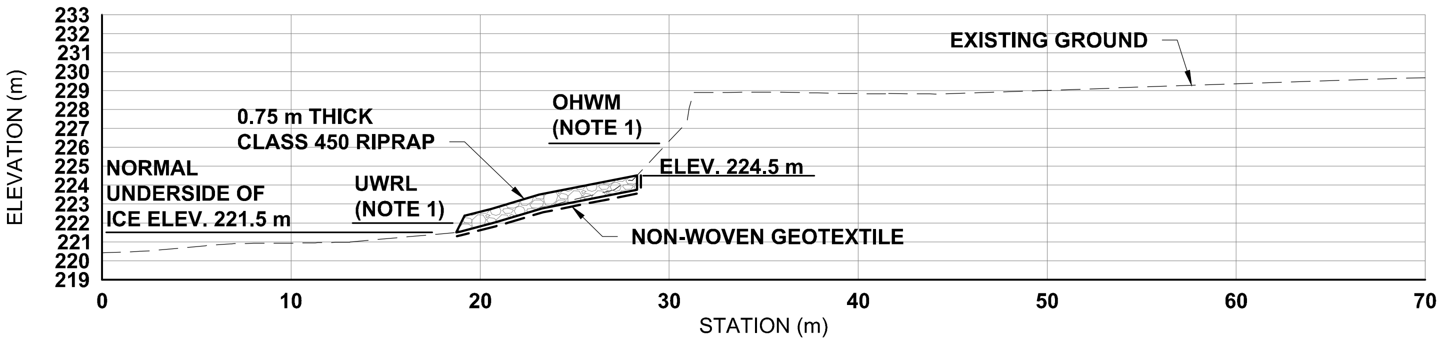
Z:\Projects\0015 City of Winnipeg\0015 046 00 Highfield to Birchdale Erosin Protection\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 10 2022-10-04 Lyndale - Highfield to Birchdale 0_B 0015-046-00.dwg, 2022-10-05 9:17:41 AM



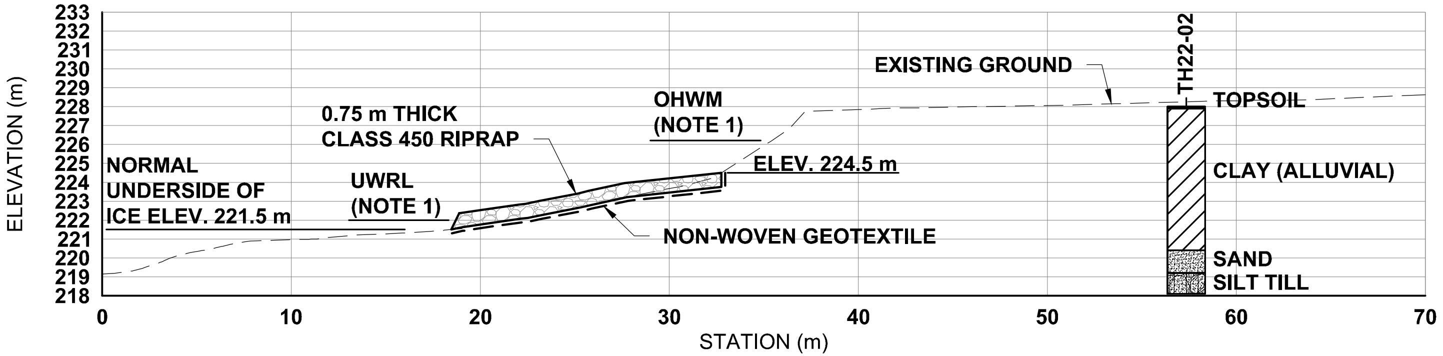
CROSS SECTION 2



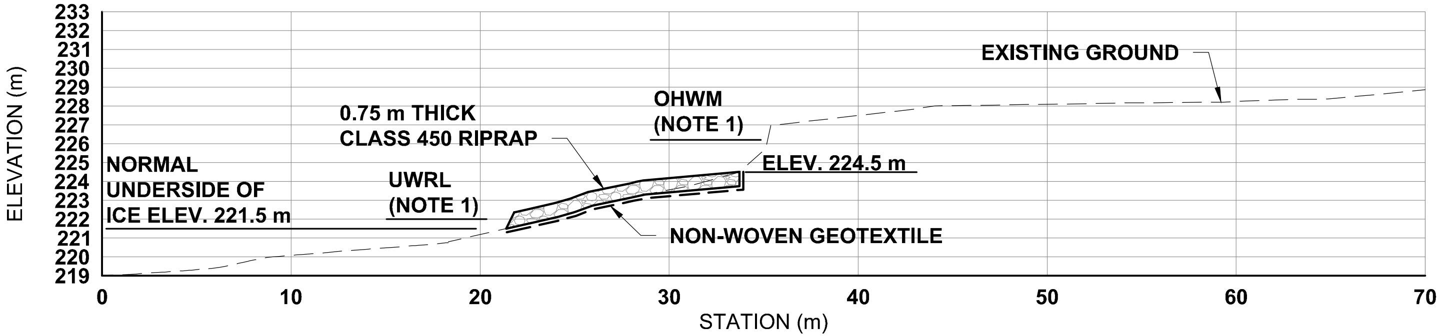
CROSS SECTION 3



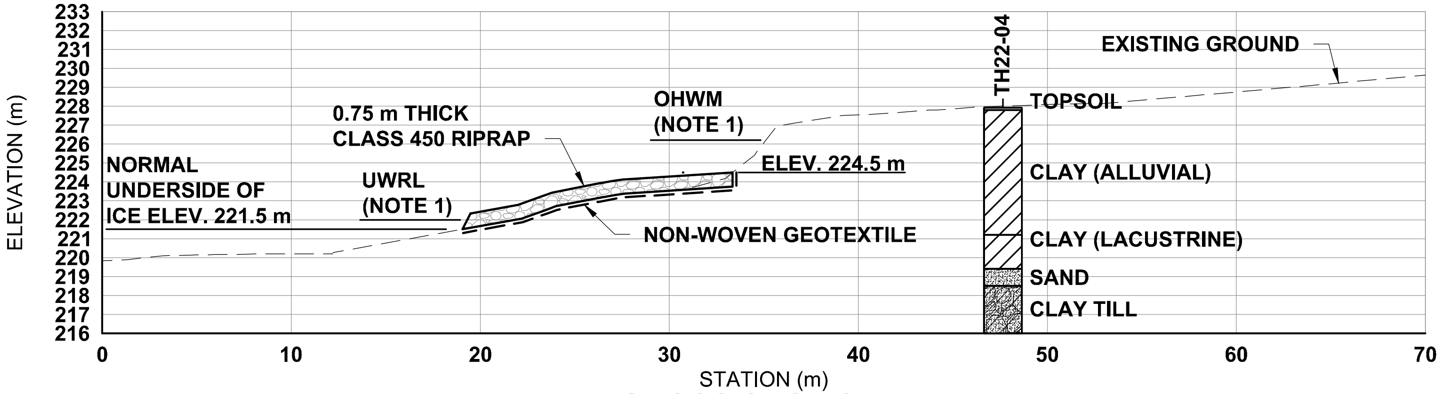
CROSS SECTION 4



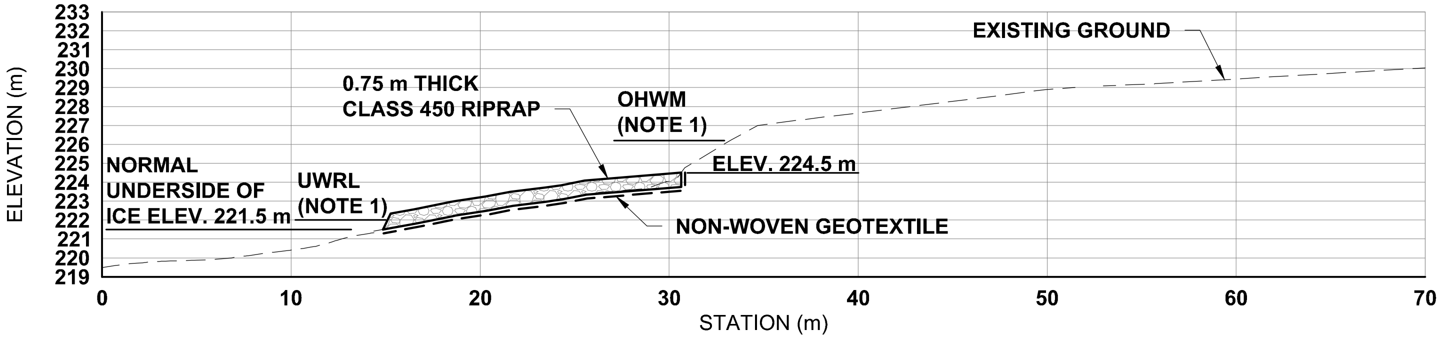
CROSS SECTION 5



CROSS SECTION 6



CROSS SECTION 7



CROSS SECTION 8

0 5 10 15 20 m

SCALE = 1 : 400 (279 mm x 432 mm)

NOTES:

1. UWRL = UNREGULATED WINTER RIVER LEVEL, ELEV. 222.0 m;
   OHWM = ORDINARY HIGH WATER MARK, ELEV. 226.2 m.

Figure 10

Proposed Erosion Protection
Cross Sections Option 1