APPENDIX A

ENVIRONMENT ACT LICENCE PROPOSAL FORM

Environment Act Proposal Form

Manitoba
Conservation and Water Stewardship

Name of the development: Remediation of Omand's Creek between Dublin and Saskatchewan Avenues
Type of development per Classes of Development Regulation (Manitoba Regulation 164/88): Class 2 - 8. Water Development and Control
Legal name of the proponent of the development: City of Winnipeg
Location (street address, city, town, municipality, legal description) of the development: 1460 Dublin Avenue
Name of proponent contact person for purposes of the environmental assessment: Tracy Stople

Phone: 204.986.2221 Fax: 204.986.7311	Mailing address: 4th Floor, 185 King St, Winnipeg, MB R3B 1J1
Email address: TStople@winnipeg.ca	
Webpage address: www.winnipeg.ca	
Date: Nov 29/2013	Signature of proponent, or corporate principal of corporate proponent: Printed name: ROB LOUDFOOT

A complete **Environment Act Proposal (EAP)** consists of the following components:

- **Cover letter**
- **Environment Act Proposal Form**
- **Reports/plans supporting the EAP** (see "Information Bulletin - Environment Act Proposal Report Guidelines" for required information and number of copies)
- **Application fee** (Cheque, payable to Minister of Finance, for the appropriate fee)

Per Environment Act Fees Regulation (Manitoba Regulation 168/96):

Class 1 Developments	$500
Class 2 Developments	$5,000
Class 3 Developments:	
Transportation and Transmission Lines	$5,000
Water Developments	$50,000
Energy and Mining	$100,000

Submit the complete EAP to:

Director
Environmental Approvals Branch
Manitoba Conservation and Water Stewardship
Suite 160, 123 Main Street
Winnipeg, Manitoba R3C 1A5

For more information:
Phone: (204) 945-8321
Fax: (204) 945-5229
http://www.gov.mb.ca/conservation/eal

APPENDIX B

TREK GEOTECHNICAL FORMER DOMINION BRIDGE SITE – GEOTECHNICAL INPUT FOR OMANDS CREEK REMEDIATION

September 13, 2013 Our File No. 0002 011 00

Mr. Kirby McRae, P.Eng.
Tetra Tech Inc.
400-161 Portage Avenue East
Winnipeg, Manitoba
R3B 0Y4

RE: Former Dominion Bridge Site - Geotechnical Input For Omand's Creek Remediation

Introduction

This letter report summarizes the results of the site inspection and slope stability analysis completed by TREK Geotechnical Inc. (TREK) for the proposed remediation of the Omand's Creek channel at the former Dominion Bridge Site in Winnipeg, Manitoba. TREK was retained by Tetra Tech Inc. to provide geotechnical input relative to the excavation of contaminated soil within the channel, removal of the existing retaining wall along a portion of the east bank and restoration of the creek channel.

Background

The former Dominion Bridge site is located between Dublin Ave and Saskatchewan Ave, east of St. James Street. Omand's Creek flows northerly towards the Assiniboine River along what was formerly the western edge of the Dominion Bridge property (Drawing 01). Ownership of the right-of-way (ROW) for the creek channel has since been transferred to the City of Winnipeg. The City also owns the property immediately west of the creek along the McCrossen Street ROW. The Dominion Bridge site was formerly a steel fabricating facility. As a result of previous activities, the soils/sediments surrounding Omand's Creek are contaminated and require removal. The proposed remediation of Omand's creek involves removal of approximately 1.0 m of soils and sediments from the existing channel, replacement of the excavated soil, and channel slope grading. It is our understanding that a clay creek channel bottom is necessary for aquatic habitat although granular fill may be used for the bottom portion of the excavation (*i.e.* blow the clay).

It is our understanding that channel bank regrading is to be confined to City owned property and as such, it may be necessary in some locations to lower the elevation of the existing gravel road located on the former Dominion Bridge property (immediately east of the creek) to keep the top of the channel bank within the City ROW.

Existing Information

The following information was provided to TREK:

- **Drawings for Dominion Bridge Remediation** (The City of Winnipeg, August 2013) - Drawings issued for environmental review which include site plans and associated cross sections, survey information and the proposed construction activities along Omand's Creek.
- **Phase III Environmental Site Assessment** (AECOM, February 2011) – The environmental report detailing the contamination across the site. The report includes testhole logs and groundwater monitoring results.

Site Conditions

A visual inspection of the bank was carried out on August 21st 2013 by Mr. Ken Skaftfeld of TREK, Kirby McRae and Tyler Smeall of Tetra Tech and Kendall Thiessen of the City of Winnipeg. A subsequent inspection was carried out on August 27th by Ken Skaftfeld and Brent Hay of TREK. Photographs were taken during the August 21st inspection and referenced to GPS way points. Selected photographs are referenced in this report.

The east bank is well vegetated with tall grasses and shrubs with the overbank area used as a gravel road along the east edge of the creek ROW as shown on Figure 01. A retaining wall constructed along a significant length of the east bank is in very poor structural condition. The wall was constructed using vertical structural steel members (angles and rails), steel walers and steel plate or timber railway ties as wall facing (Figure 02). It appears that some sections of the wall may be tied back with steel rods and anchors. The wall is up to about 1.5 m high in some areas and gravel backfill is visible in gaps in the wall. There is also fill material and debris visible immediately upslope of the wall. In front (creek side) of the wall, the channel bank slopes at approximately 3.5 horizontal to 1 vertical (3.5H:1V) towards the edge of the water. There were no visible signs of active slope instabilities along the east channel but that wall has a considerable lean towards the creek suggesting insufficient lateral resistance to earth (fill) pressures.

The west bank is heavily vegetated with grasses, shrubs and small trees. A chain link fence runs along the property line between the creek and McCrossen St. right-of-ways and a line of hydro poles and overhead wires extend the entire length of the east bank, approximately 3.0 m onto the McCrossen St. right-of-way. The west bank slopes range from about 1H:1V to as flat as 5H:1V. Four sections of the west bank along the McCrossen St. right-of-way show signs of instabilities in the form of a head scarp, slumping and tension cracking near the top of bank that extend by about 1 m onto the McCrossen St. right-of-way. These sections are from approximately Stations 1+00 to 1+30, 1+95 to 2+40, 2+50 to 2+60, and 2+70 to 3+10 (total of about 125 m) as shown on Drawing 01. These instabilities are evident by the chain link fence within these stretches which has deflected towards the creek and is leaning towards the creek as shown on Figures 03 & 04.

The hydro poles along the west side of the property line adjacent to the zones of movement are in alignment and straight indicating they are beyond any ground movements to date. At the time of the inspection, the channel was at normal summer level or approximately 1.0 m deep and largely filled with reeds.

Figure 01 – Facing north along the east bank

Figure 02 – Facing east at leaning retaining wall from west bank

Figure 03 – Facing south from west bank

Figure 04 – Facing north from west bank

Slope Stability Assessment

Slope stability analysis was conducted to evaluate the stability of the existing channel and develop an excavation plan for the remedial activities. The model geometry is based on the topographic survey provided by Tetra Tech using Cross Section D-D as shown on Drawing 01 which coincides with one of the areas of observed instability. The cross section geometry used for analysis of the existing bank is shown on the GeoStudio model outputs in Appendix A.

Numerical Model Description

The stability analysis was conducted using a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2007 software package (Geo-Slope International Inc.). Static piezometric lines were used to represent groundwater conditions and to calculate factors of safety. The slope stability model used the Morgenstern-Price method of slices to calculate factors of safety. Critical slip surfaces were identified using a grid and radius slip surface method.

Model Parameters

Table 1 lists the soil properties used for the soil units in the slope stability analysis. The soil units used in the model include high plastic clay (large strain, post peak and residual strengths were analyzed), granular fill (east bank only) and rockfill. The post peak and large strain strength properties assumed for the high plastic clay are based on local experience and laboratory testing on other projects. The post peak strengths are representative of an unfailed bank that has not undergone observable movements. Large strain strengths are representative of clay that has undergone some movements but has not failed. The material properties of the residual clay were adjusted for the existing west bank geometry until a factor of safety of 1.0 was observed for slip surfaces consistent with the observed failures. Residual strengths were not used in the east bank analysis as no active failures were observed. The residual strengths properties from the back analysis are considered reasonable for Winnipeg clays that have experienced slope failures.

Table 1 Soil Properties used in Slope Stability Analysis

Soil Description	Bank	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (degrees)
High Plastic Clay (post peak)	East, West	16.5	5	17
High Plastic Clay (large strain)	West	16.5	5	14
High Plastic Clay (residual)	West	16.5	1.5	9
Fill	East	19	0	35
Rockfill	East, West	21	0	45

The groundwater table in the upper bank was set to Elev. 232.5 m, based on monitoring well results from the AECOM report. For the final design grades, the water level in Omand's Creek was set to Elev. 231.4 m, representing 0.6 m (2 feet) below the normal summer level of Elev. 232.0 m, representative of a worst-case condition for stability. For the excavation stages, it was assumed that the Creek would be completely de-watered using cofferdams and pumps.

Design Objectives

The design objectives were to maintain a factor of safety (FS) of 1.30 throughout construction and a long term factor of safety as close to 1.5 as possible given the channel bottom profile, property constraints on the east side of the channel and the existing hydro line on the west side. This may require narrowing the creek channel bottom to achieve adequate channel side slopes.

The approach taken was to assess the stability of the west bank where instabilities have been observed recognizing that similar conditions (previous movements) may be present at other locations on both the east and west banks. In doing so, a final channel geometry can be arrived at that provides an adequate level of long term stability regardless of past performance. The same rationale applies to maintaining an adequate level of stability during construction in the areas of observed or potential movement.

Analysis Results

Preliminary analysis indicated it would be necessary to stage the excavation work such that an adequate level of stability is maintained during construction. The staging sequences necessary to meet the design objectives and the associated factors of safety after each stage are summarized in Table 2 (west bank) and Table 3 (east bank). The stability outputs illustrating the excavation stages for both banks are attached in Appendix A.

Table 2 West Bank Staging

Stage	Factor of Safety	Description
Existing	1.00	Back analysis of existing geometry
Stage 1 - Excavation	2.00	1H:1V cut from 1.0 m E hydro pole to bench at Elev. 231.4 m
Stage 2 - Excavation	1.60	Excavate channel bottom to depth of 1.0 m
Stage 3 – Backfill	1.69	Backfill channel bottom excavation with 0.6 m rockfill
Stage 4 - Backfill	1.92	Backfill remainder of channel bottom excavation with 0.4 m clay. Regrade channel side slopes to 4H:1V

Table 3 East Bank Staging

Stage	Factor of Safety	Description
Existing	1.57	No observed instabilities
Stage 1 - Excavation	1.35	Excavate channel bottom to depth of 1.0 m

Stage 2 - Excavation	1.31	Excavate 1.0 m thick contaminated materials in channel
Stage 3 – Backfill	1.39	Backfill channel bottom excavation with 0.6 m rockfill
Stage 4 - Backfill	2.10	Backfill remainder of channel bottom excavation with 0.4 m clay. Regrade channel side slopes to 4H:1V

Construction Considerations

The following items should be considered during construction in conjunction with the construction stages illustrated on the slope stability outputs.

1. All excavation must be carried out in compliance with the appropriate regulation(s) under the Manitoba Workplace Safety and Health Act.
2. The excavation should be carried out in timely manner, and backfilled immediately, to minimize the time an excavation is left open.
3. The excavation work should be carried out in discrete channel sections (which is expected to be necessary for dewatering).
4. Rock fill on channel bottom should be a 100 or 150 mm down crushed limestone. Place and compact rock fill on woven geotextile.
5. The channel bottom within each section should be backfilled to at least final grade before initiating any adjacent (upstream or downstream) excavation work.
6. The performance of the bank during the channel excavation and reconstruction should be carefully monitored to determine if modifications to the staging are required.
7. Material should not be stockpiled near the top of bank. A minimum set back distance of 5.0 m from the top of bank should be maintained for stockpiled materials.
8. The excavation should be de-watered prior to the start of Stage 1 excavation. The excavation should be kept free of water during all stages until the final design grades are reached.
9. All backfill material should be placed horizontally in controlled lifts and compacted to a minimum of 95% of Standard Proctor Maximum Dry density. Bench subgrade as necessary.
10. The side slopes should be re-vegetated as soon as possible to prevent desiccation and surficial erosion.
11. Inspection by qualified Geotechnical personnel should be carried out during critical stages in construction and in particular, during the initial excavation works.

Closure

The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation, laboratory testing, geometries). Soil conditions are natural deposits that can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

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 or require any additional information regarding the information provided please contact the undersigned at your convenience.

Kind Regards,

TREK Geotechnical

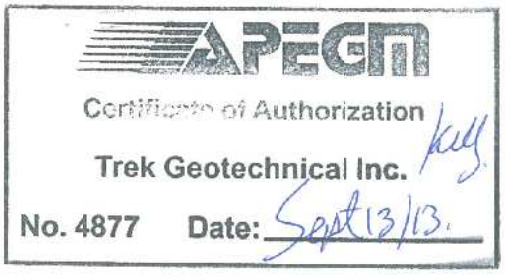
Per:

Reviewed by:

Brent Hay, P.Eng
Geotechnical Engineer

Ken Skaftfeld, P. Eng
Senior Geotechnical Engineer

Attch.



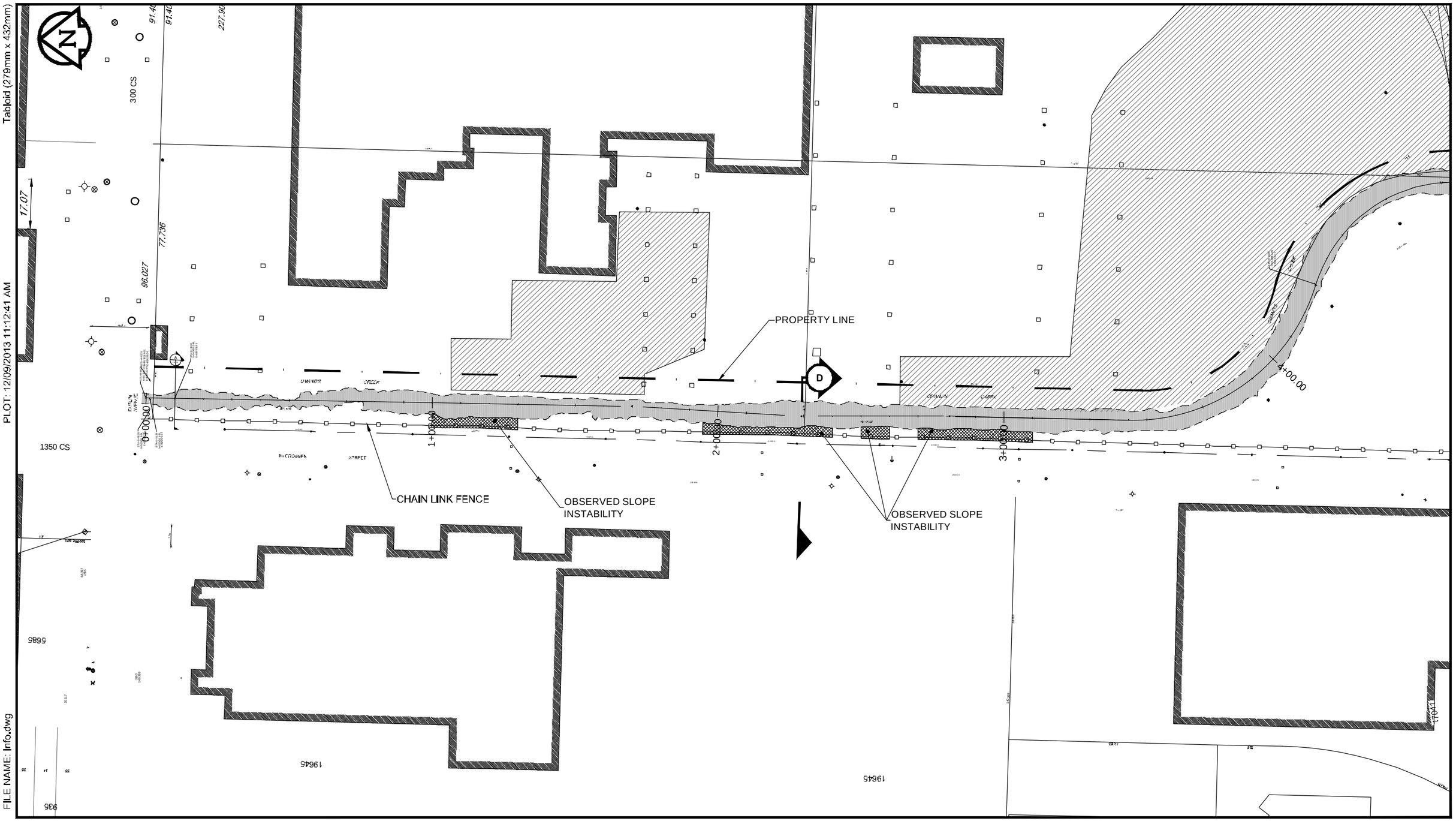
TREK GEOTECHNICAL

0002 001 00
Tetra Tech Inc.
Dominion Bridge Site Remediation

Tabloid (279mm x 432mm)

PLOT: 12/09/2013 11:12:41 AM

FILE NAME: Info.dwg



0 12.5 25 37.5 50m
SCALE : 1:1250 (279mm x 432mm)

Drawing 01
Site Plan

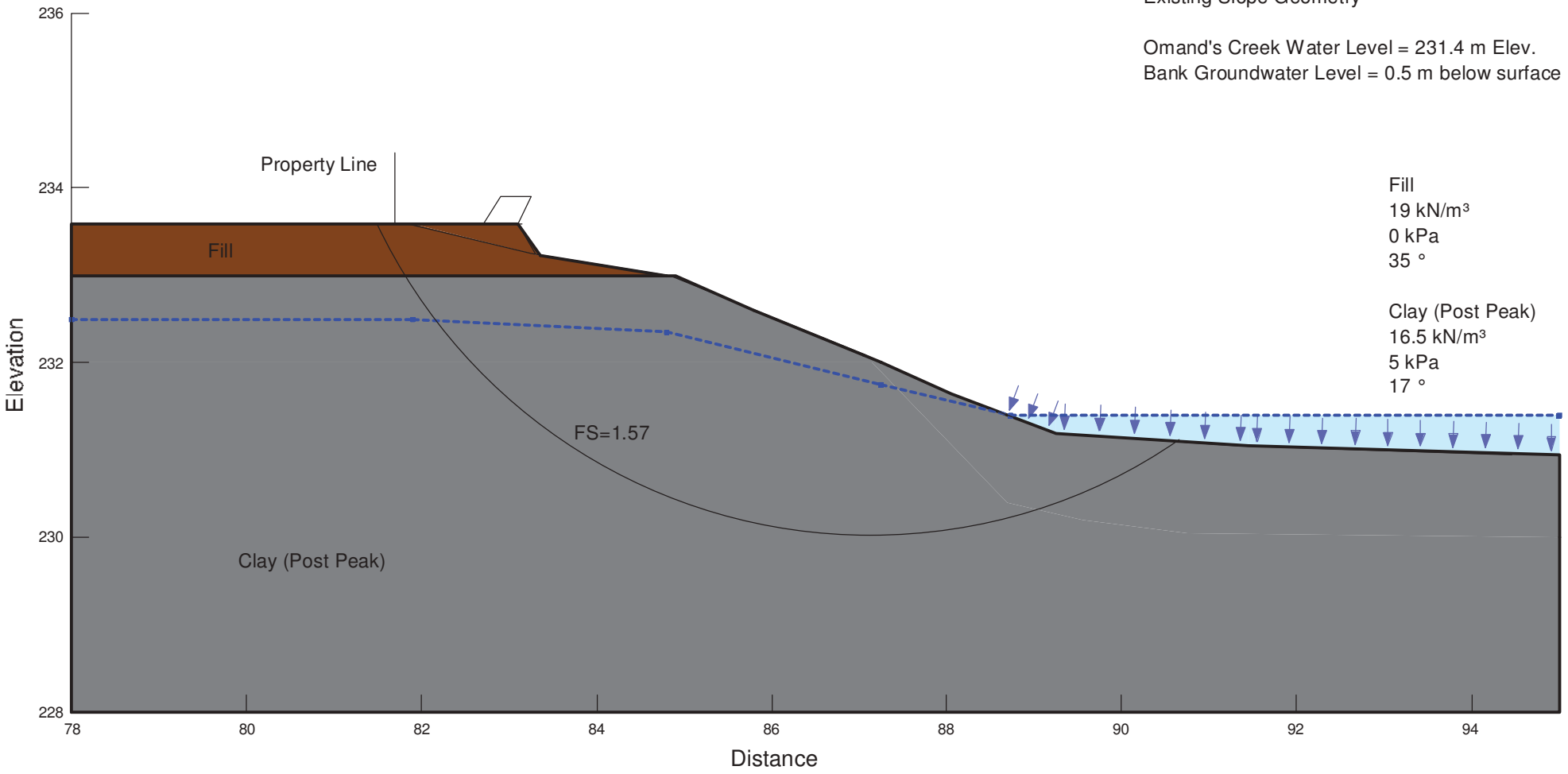
APPENDIX A
Slope Stability Output Files

Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00

East Bank
Analysis of Existing Channel

Cross Section D
Existing Slope Geometry

Omand's Creek Water Level = 231.4 m Elev.
Bank Groundwater Level = 0.5 m below surface



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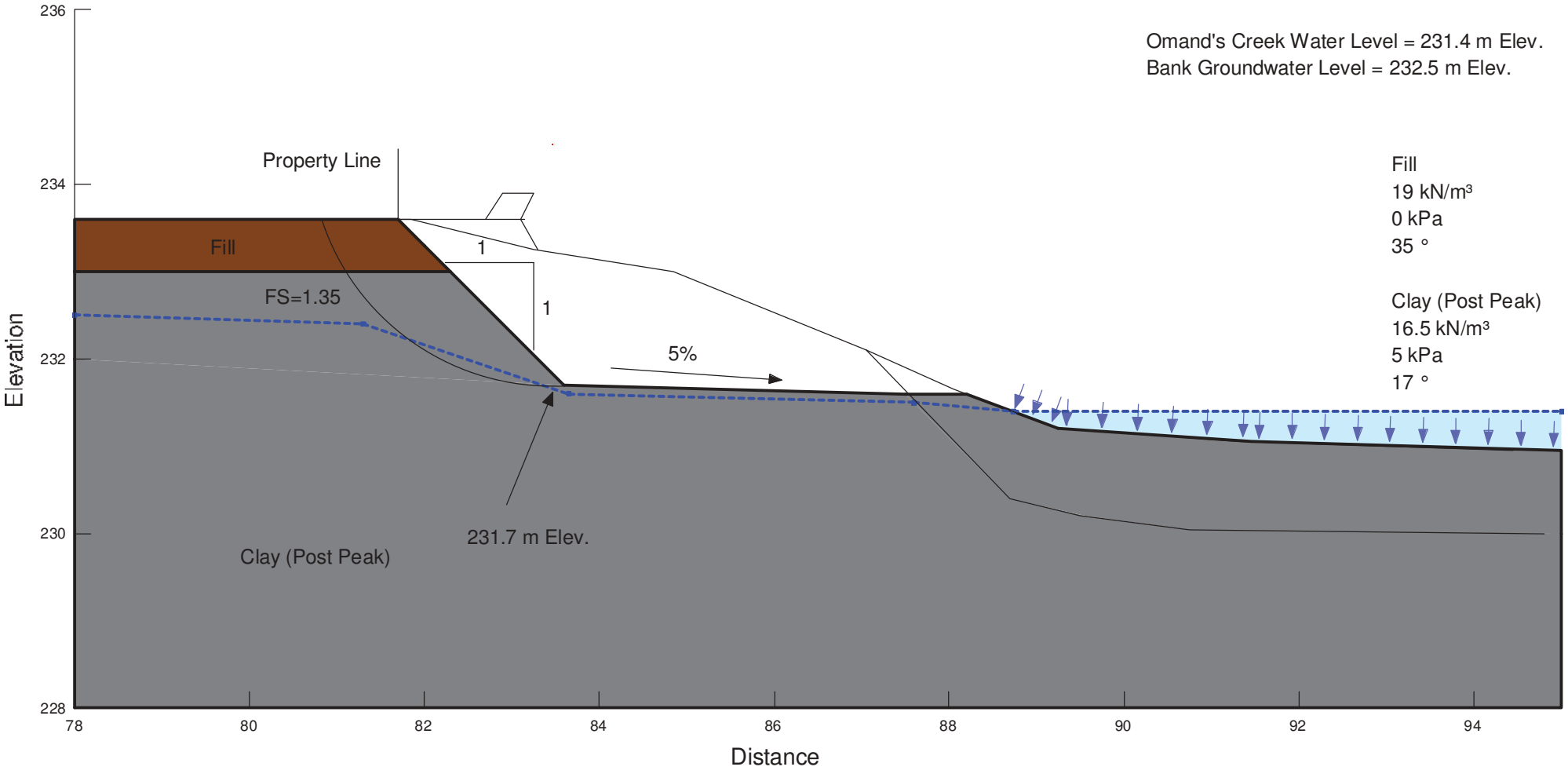
Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00

East Bank
Stage 1 Excavation

Cross Section D
Bench @ 231.7 m elev. with 5% cross slope

Omand's Creek Water Level = 231.4 m Elev.
Bank Groundwater Level = 232.5 m Elev.



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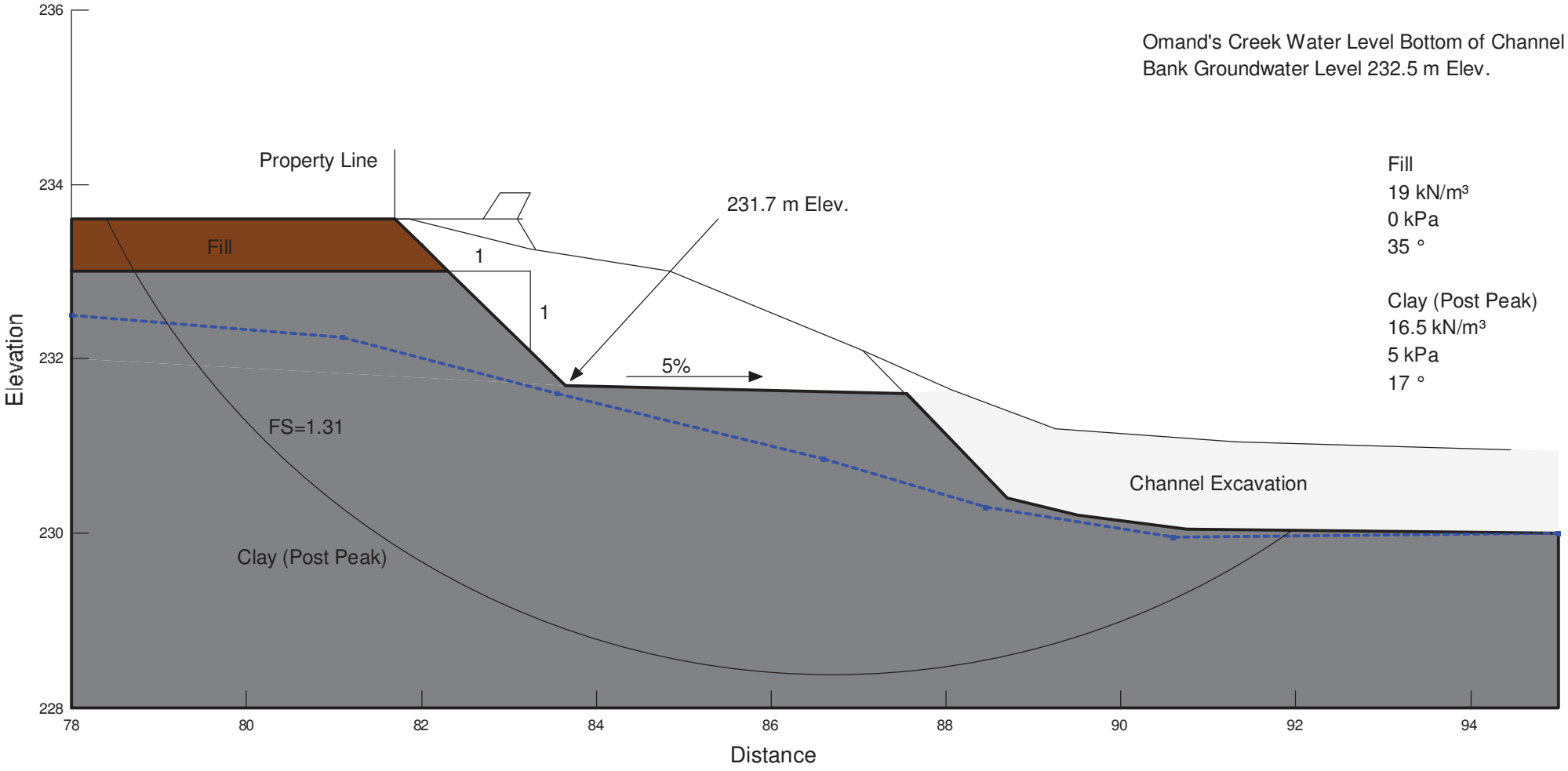
Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00

East Bank
Stage 2 Excavation

Cross Section D
Bench @ 231.7 m and 5% cross slope
with Channel Excavation

Omand's Creek Water Level Bottom of Channel
Bank Groundwater Level 232.5 m Elev.



Fill
19 kN/m³
0 kPa
35 °

Clay (Post Peak)
16.5 kN/m³
5 kPa
17 °

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East Bank
Stage 3 Backfill

Fill
19 kN/m³
0 kPa
35 °

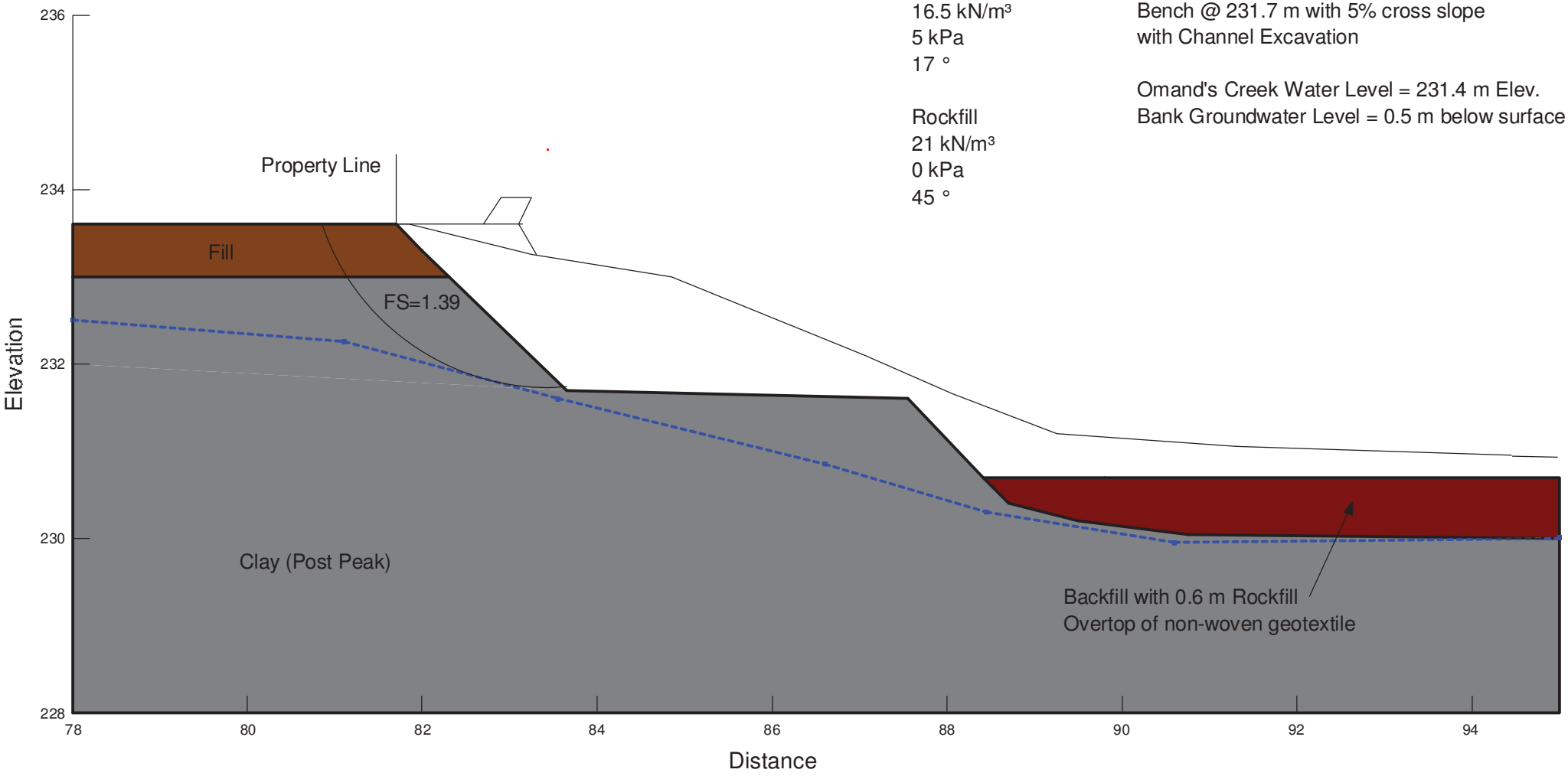
Clay (Post Peak)
16.5 kN/m³
5 kPa
17 °

Rockfill
21 kN/m³
0 kPa
45 °

Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00

Cross Section D
Bench @ 231.7 m with 5% cross slope
with Channel Excavation

Omand's Creek Water Level = 231.4 m Elev.
Bank Groundwater Level = 0.5 m below surface



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East Bank
Stage 4 - Backfill

Fill
19 kN/m³
0 kPa
35 °

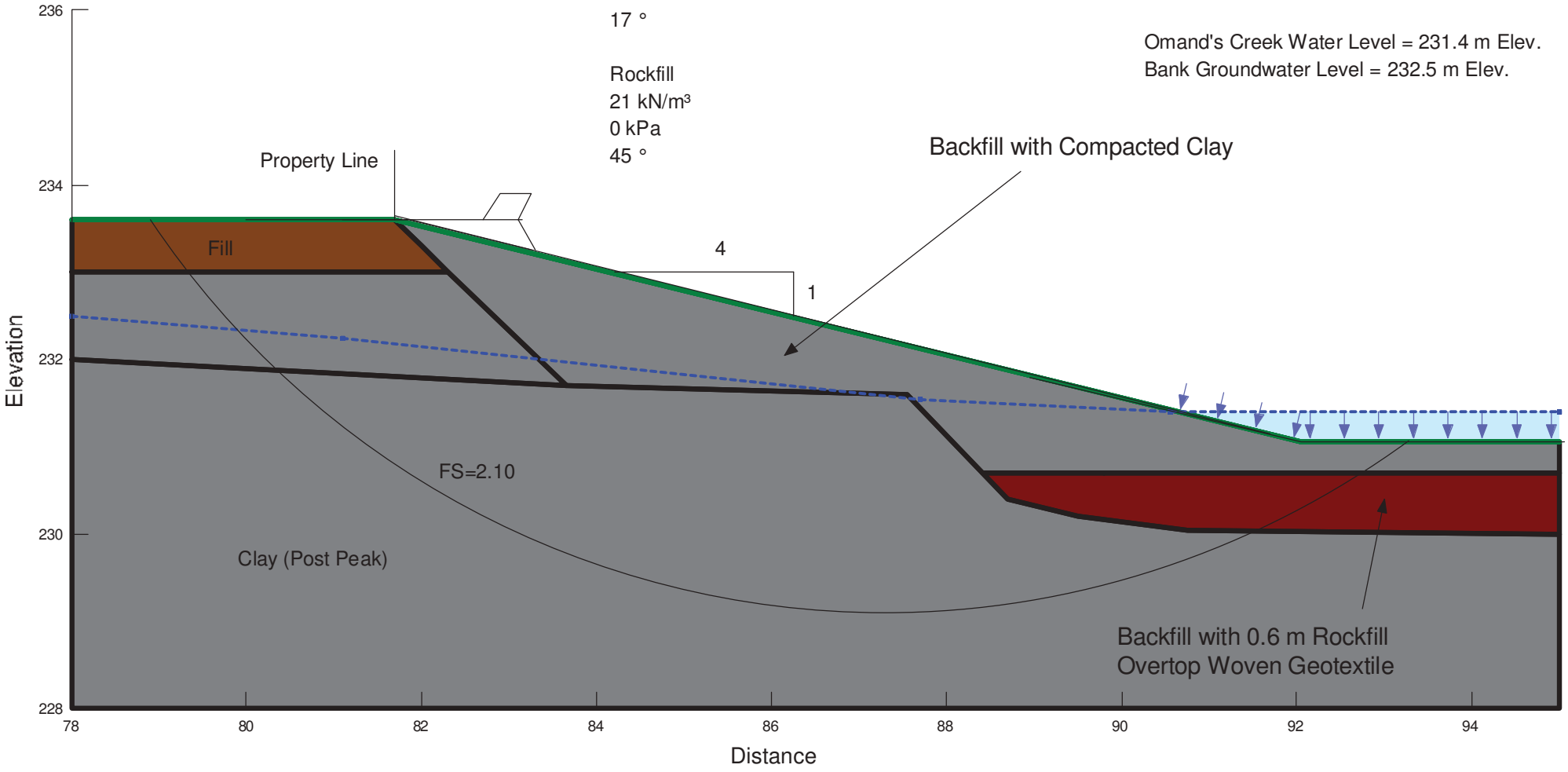
Clay (Post Peak)
16.5 kN/m³
5 kPa
17 °

Rockfill
21 kN/m³
0 kPa
45 °

Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00

Cross Section D
Backfilled Channel

Omand's Creek Water Level = 231.4 m Elev.
Bank Groundwater Level = 232.5 m Elev.



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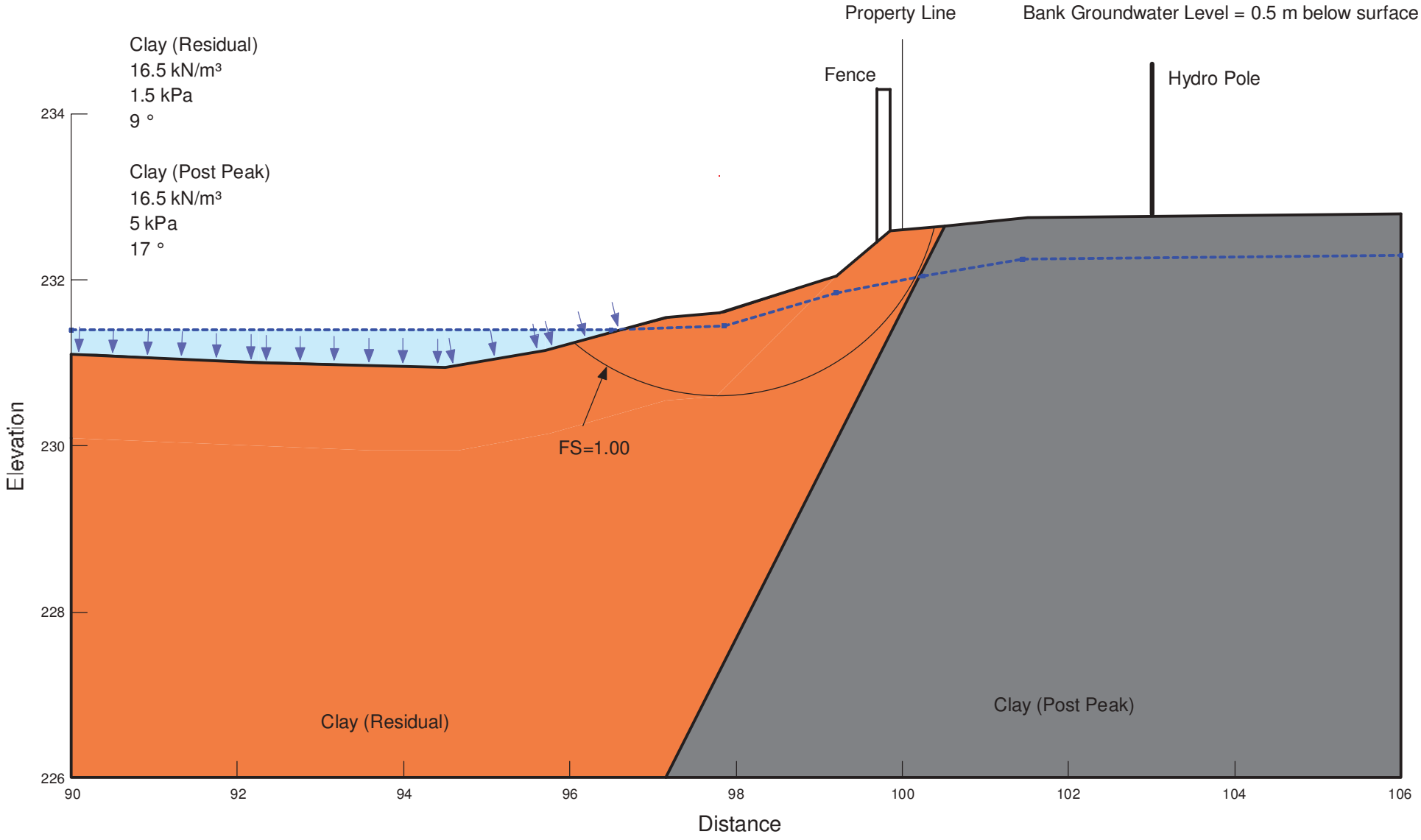
Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00
Cross Section D
Existing Slope Geometry
(Back Analysis)

Omand's Creek Water Level = 231.4 m Elev.
Bank Groundwater Level = 0.5 m below surface

Back Analysis of Existing Channel



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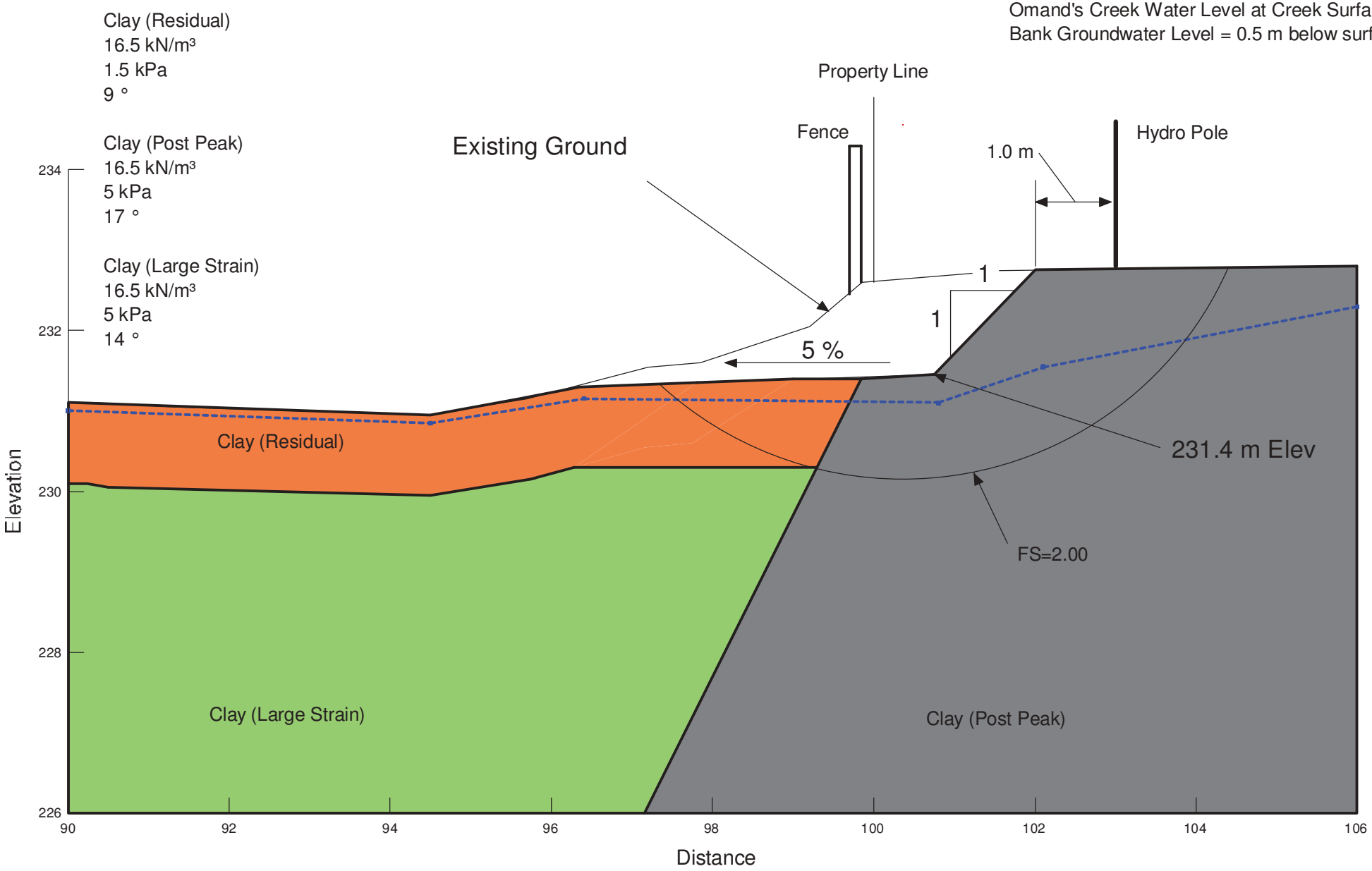
Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00
Cross Section D
Bench @ 231.4 with 5% Cross Slope

Omand's Creek Water Level at Creek Surface
Bank Groundwater Level = 0.5 m below surface

West Bank
Stage 1 - Excavation



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West Bank
Stage 2 - Excavation

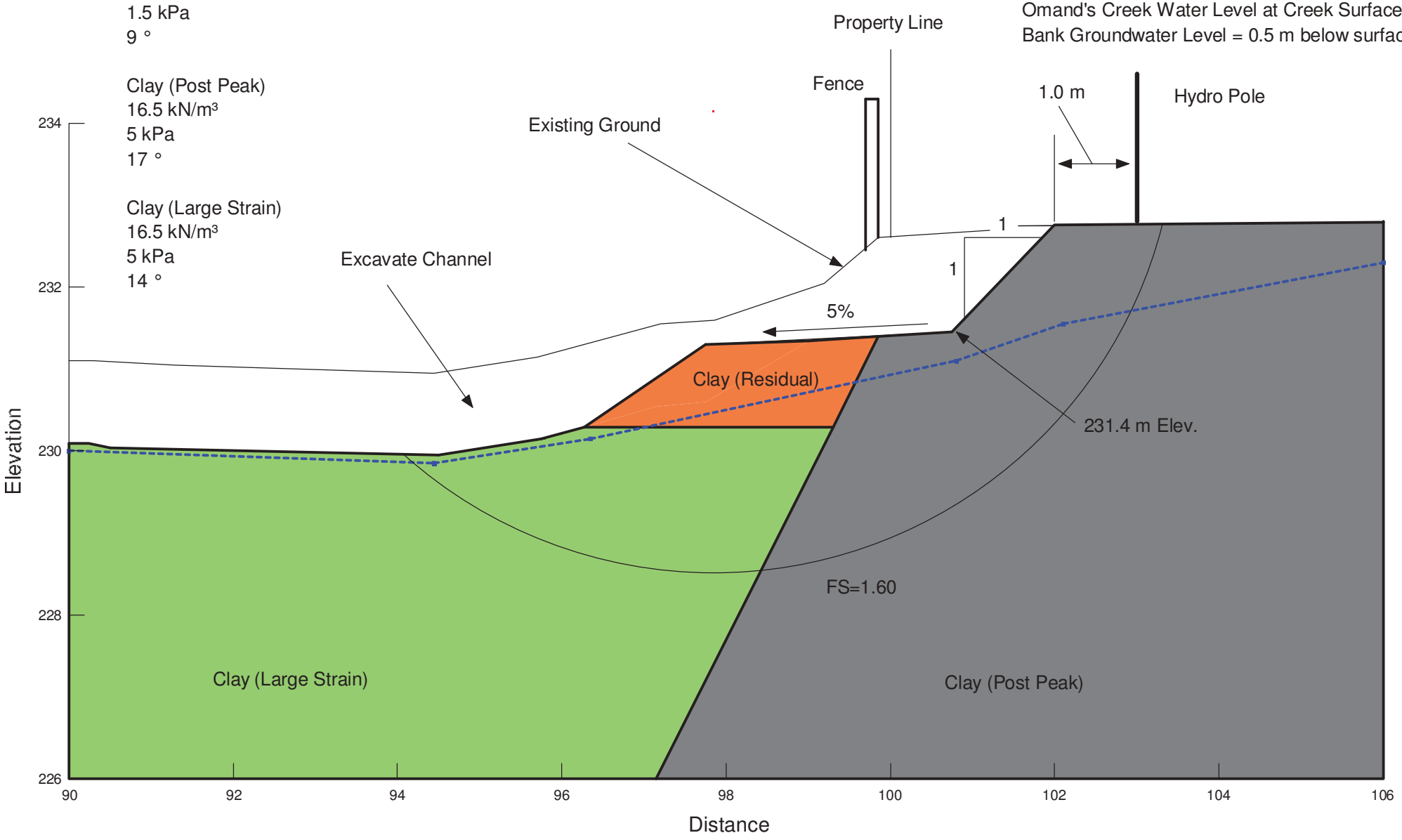
Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00
Cross Section D
Bench @ 231.4 with 5% Cross Slope
Channel Excavation

Omand's Creek Water Level at Creek Surface
Bank Groundwater Level = 0.5 m below surface

Clay (Residual)
16.5 kN/m³
1.5 kPa
9 °

Clay (Post Peak)
16.5 kN/m³
5 kPa
17 °

Clay (Large Strain)
16.5 kN/m³
5 kPa
14 °



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West Bank
Stage 3 - Backfill

Clay (Residual)
16.5 kN/m³
1.5 kPa
9 °

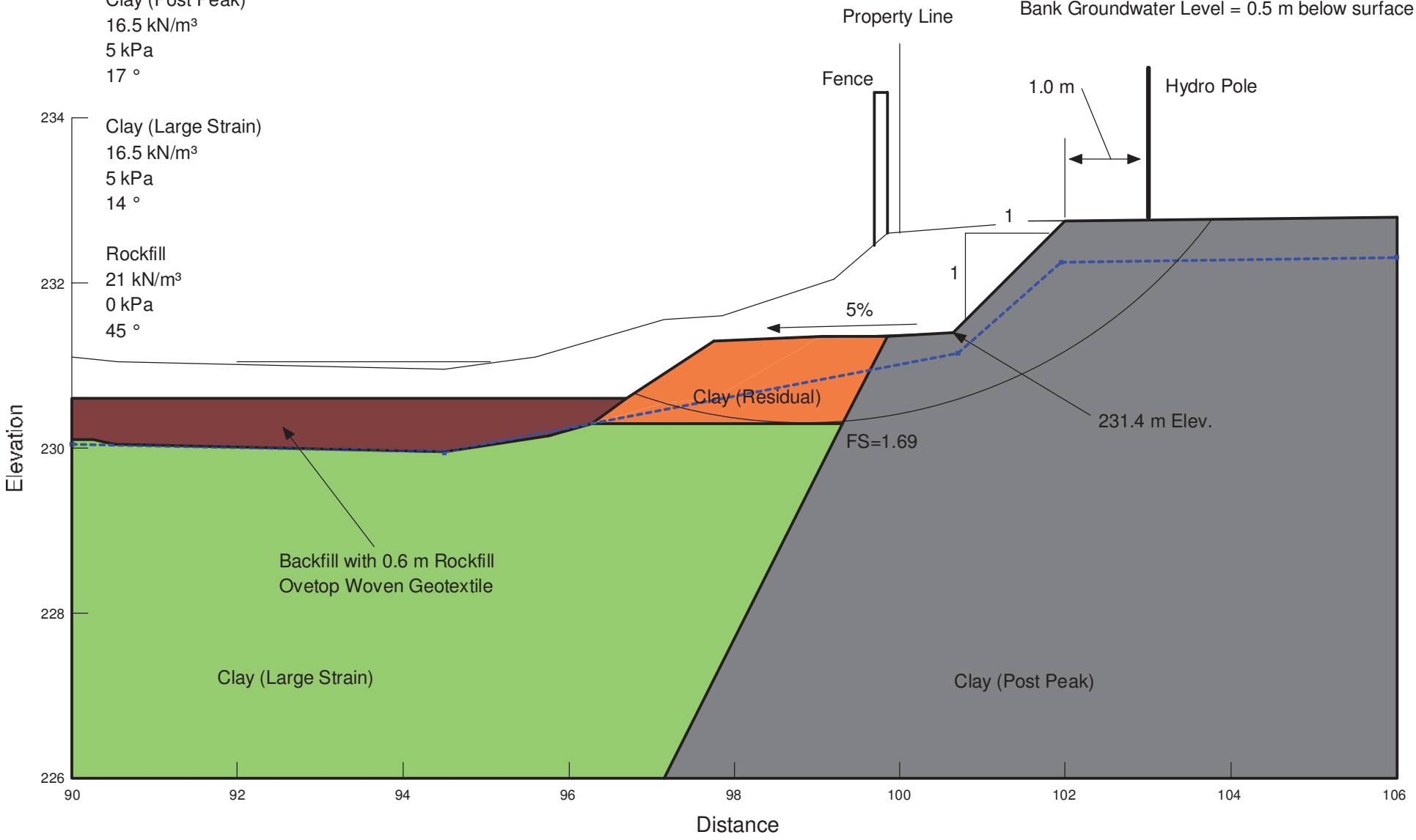
Clay (Post Peak)
16.5 kN/m³
5 kPa
17 °

Clay (Large Strain)
16.5 kN/m³
5 kPa
14 °

Rockfill
21 kN/m³
0 kPa
45 °

Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00
Cross Section D
Partially Backfilled Channel

Omand's Creek Water Level at Orginal Excavation Floor
Bank Groundwater Level = 0.5 m below surface



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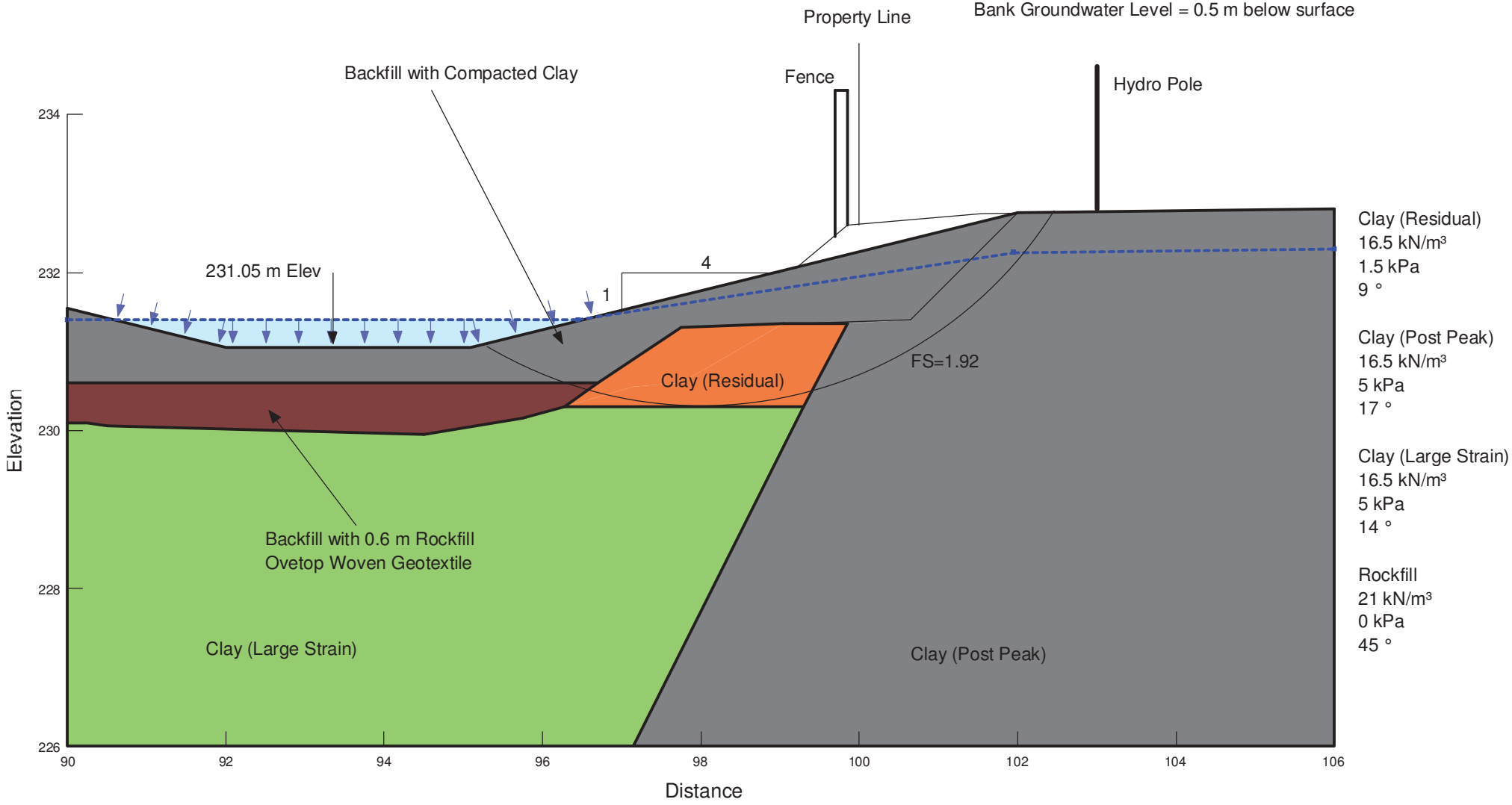
West Bank
Stage 4 - Backfill

Tetra Tech Inc.
Dominion Bridge Site Remediation
Stability Analysis for Remedial Works
0002 011 00
Cross Section D
Backfilled Channel

Omand's Creek Water Level = 231.4 m Elev.
Bank Groundwater Level = 0.5 m below surface



Clay (Residual)
16.5 kN/m³
1.5 kPa
9 °

Clay (Post Peak)
16.5 kN/m³
5 kPa
17 °

Clay (Large Strain)
16.5 kN/m³
5 kPa
14 °

Rockfill
21 kN/m³
0 kPa
45 °

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APPENDIX C

REMEDIAL ACTION PLAN FOR UPLAND WORKS

TETRA TECH

September 16, 2013 1312940100-LTR-V0001-00

Ms. Tracy Stople, C.E.T., PMP
Project Officer
Project Services Branch
Municipal Accommodations Division
Planning, Property and Development
City of Winnipeg
4th Floor, 185 King Street
Winnipeg, MB R3B 1J1

Dear Tracy

Subject **Remedial Action Plan, City of Winnipeg**
Former Dominion Bridge Operations Yard,
1460 Dublin Avenue, Winnipeg, Manitoba

Tetra Tech WEI Inc. (Tetra Tech) is pleased to present the City of Winnipeg with this proposed remedial action plan (RAP) for the remediation of surface soil at the site and creek bed sediments in Omand's Creek that runs along the west property line.

OBJECTIVES

The purpose of this RAP is to provide a plan for the remediation of soil and sediment to mitigate risks to human health and/or the environment for the current land use. The contaminants of concern (COCs) and the risks to human health or the environment have been identified through previous environmental site assessments at the site.

BACKGROUND

Site Setting

The former Dominion Bridge Operations yard consists of approximately 11.05 ha of land and is located at 1460 Dublin Avenue in Winnipeg, Manitoba (hereinafter referred to as the Site). The Site was originally constructed in approximately 1910 and is currently owned by the City of Winnipeg who leases portions of it to several industrial manufacturing tenants. The Site is currently occupied by the following buildings:

- The Main Shop with an attached Works Office, Galvanizing Shop and Stores Building;
- Transept Shop that is attached to the north side of the Main Shop, with a grit blast room and a Paint Shop;
- Planning and Stock Office;
- Gate Shop;

Tetra Tech
400-161 Portage Avenue E., Winnipeg, Manitoba R3B 0Y4, Canada
Tel 204.954.6800 Fax 204.988.0546 www.tetratech.com

- Former Manufacturing Building;
- Shipping Office;
- PCB Shed; and
- Security Building.

Other current development at the Site includes four large overhead cranes.

Omand's Creek runs along the west property line of the subject site and flows south towards the Assiniboine River, located approximately 3 km to the south of the subject site. According to previous reports, it is believed that it was rerouted in the early 1900s to its current location along the west property line. The original channel of Omand's Creek reportedly traversed the property in the approximate location of the west wall of the Main Shop building. A site location map is shown on Figure 1 and a site plan can be found on Figures 2 and 3, attached.

The land surrounding the former Dominion Bridge Operations yard consists of commercial and industrial properties, as described below:

- North: Dublin Avenue , across which is commercial/industrial;
- East: Commercial/Industrial
- South: Saskatchewan Avenue, across which is industrial
- West: McCrossen Street right-of-way, followed by commercial/industrial.

The layout of the current site facilities are presented on Figure 2 and 3, attached.

Geological Setting

Regional Geology and Hydrogeology

The regional soil stratigraphy consists of up to 20 m of overburden overlying limestone bedrock. This overburden contains lacustrine deposits, primarily lake bottom clays, above consolidated and unconsolidated tills. The underlying carbonate bedrock is part of the Red River Formation; a well fractured, water bearing unit which constitutes the main potable aquifer beneath the City of Winnipeg and the surrounding area.

The clays are generally of low permeability and contain some degree of fracturing. Water bearing silt layers are usually interlayered with the clays. These soils are glaciolacustrine in nature, having been deposited as lake bottom sediments by the former glacial Lake Agassiz.

A search of the Manitoba Water Stewardship water well database by Manitoba Water Stewardship personnel did not identify any registered domestic use water wells located within 800 m of the site.

Site Stratigraphy

Based on previous environmental site assessments, the general stratigraphy encountered at the site consists of the following:

- Fill materials – Fill material was encountered across the site from grade to depths ranging between 1.0 and 2.3 m below grade. The fill material generally consisted of clay or

gravel, sand and silt. Some debris was found in the fill material across the site which consisted of wood, glass, brick, steel, and concrete. There is an area where the former waste oil drum storage area (shown on Figure 2 and 3 as area 4 in the site legend), that the fill is overlain by asphalt of unknown thickness.

- Silt and Sand – Beneath the fill material a partially saturated light brown sandy silt layer extending to depths ranging from 1.7 to 2.7 m below grade. The amount of silt and sand varied with depth in the layer and location on-site.
- Clay – Underlying the silt and sand layer, a grey and brown clay or clay till layer was found containing varying amounts of silt and is generally stiff, plastic and dry to moist. This clay/clay till unit extends to the bedrock surface at approximately 12 to 15 m below grade.

Constituents of Concern

Base on previous environmental site assessments, constituents of concern (COCs) in soil, sediment, groundwater, and/or surface water at the site include petroleum hydrocarbons (PHCs), polycyclic aromatic hydrocarbons (PAHs, carcinogenic and non-carcinogenic), and metals that could potentially pose a risk to human health and/or the environment. These COCs were found at various locations across the Site as summarized below:

- Paint Shop UST Area and West Paint Shop in soil – PHC and PAH
- Waste Oil Drum Storage area in soil – PHC
- Landfilling area in soil and groundwater – metals
- South Crane Runway in soil - PAH
- Solvent AST area in soil – PHC and PAH
- Sulphuric Acid Drum Storage area in soil and groundwater – metals
- Waste Paint Storage area in soil and groundwater – metals
- Former Saskatchewan Avenue Landfill in soil and groundwater – metals and PAH
- Polychlorinated Biphenyls Storage area in soil (metals and PAH) and groundwater (metals)
- Omands Creek in sediment – metals and PAH and in surface water (total and dissolved metals).

Each of the areas listed above can be found on Figures 2 and 3 in the legend with corresponding number labelled on the site plan.

EXPOSURE PATHWAYS

The AECOM report prepared for the City of Winnipeg in 2011, entitled: *Remedial Action Plan Former Dominion Bridge Operations Yard, 1460 Dublin Avenue – Winnipeg, Manitoba*, identified five major human health and environmental exposure pathways:

- Direct exposure by humans to PHC, PAH and metals impacted soil (i.e. dermal contact, soil ingestion, and particle inhalation);
- Exposure to volatile components of subsurface PHC and PAH impact in the outdoor environment;
- Exposure to PHC, PAH and metals impacts by ecological receptors in impacted surficial soil (Ecological Soil contact);
- Exposure of surface water to PHC, PAH and metals impacts in surficial soils that flow into Omand's Creek and/or sewer systems; and
- Exposure of Aquatic Life to metals and PAH impacts in sediment and surface water within Omand's Creek.

Land use at the former Dominion Bridge Operations yard is not expected to change and only current land use has been addressed as part of this RAP. If future land use changes, additional remedial activities may be required to address remaining impacts to soil, sediment, surface water and/or ground water.

PROPOSED SITE REMEDIAL ACTION PLAN

Surface Soils

The proposed method of remediation of surface soils at the former Dominion Bridge Operations yard consists of the excavation of surface soil to 0.3 m below grade in the areas identified by previous environmental site assessments to contain COCs in the surface soils exceeding the applicable soil quality guidelines. It is estimated that approximately 13,979 m^3 of soil will be excavated from four areas of the former Dominion Bridge Operations yard, as described below:

- Site 1 – approximately 4957 m^3
- Site 2 – approximately 2419 m^3
- Site 3 – approximately 6275 m^3
- Site 4 – approximately 328 m^3

Site's 1 through 4 can be found labelled on Figure 3, attached.

Once the surface soils have been excavated from below grade they will be transported for off-site disposal at the MidCanada Soil Treatment Facility in Iles des Chenes, Manitoba or an appropriate facility if concentrations of COCs in soil exceed what MidCanada is licensed to accept.

Groundwater management is not expected to be necessary within the surface soil excavation since the depth of the proposed remediation to 0.3 m below grade. However, if groundwater entering the excavation occurs or surface water due to precipitation accumulates within the excavation, temporary water storage may be required to allow for dewatering or water collection activities on an as needed basis. Disposal of any collected water will be undertaken based on the water quality determined through sample collection and laboratory analyses which would include analysis of the contaminants of concern (i.e., BTEX and PHC Fractions F1

and F4, PAHs and/or metals). Based on the laboratory analytical results the excavation water may be either discharged off-site (following approval by Manitoba Conservation and the City of Winnipeg) or will be disposed by the contractor at a licensed disposal facility (e.g., A-1 Environmental Services).

Backfilling of these excavations will be completed with suitable material to replace to the equivalent to pre-remediation conditions.

Other debris (railway ties, concrete, steel etc.) present in these areas will be removed from below grade and disposed at an appropriate disposal facility.

Omand's Creek Bed/Bank Sediment

The proposed method of remediation of the base and bank sediment in Omand's Creek located to the west and immediately adjacent of the former Dominion Bridge Operations yard consists of the excavation of sediment on the creek bed and banks to a depth of 1.0 m below the normal water level from Dublin Avenue to Saskatchewan Avenue. The excavation of the creek sediment will require temporary water control in the form of installation coffer dams immediately adjacent upstream and downstream of the work area for the purpose of pumping water to bypass the excavation area. It is estimated that approximately 6,600 m^3 of sediment (from creek bed and bank's) and approximately 2,300 m^3 of surface soil (from bench cutting the top of the east bank of Omand's Creek) will be excavated from the section of Omand's Creek between Dublin Avenue and Saskatchewan Avenue immediately adjacent to the west property line of 1460 Dublin Avenue (the former Dominion Bridge Operations yard).

Once the sediment is excavated it will be dewatered on-site prior to transport for off-site disposal at the MidCanada Soil Treatment Facility in Iles des Chenes, Manitoba or an appropriate facility if concentrations of COCs in soil exceed what MidCanada is licensed to accept.

Surface and groundwater infiltration into the creek is expected. Surface water management will be conducted by construction of coffer dams during the period of remediation immediately upstream and downstream of the excavation area and the surface water will be diverted from upstream of the excavation area by pumping to downstream of the excavation area. Groundwater seepage into the excavation is expected following the construction of coffer dam and dewatering of the excavation area. If groundwater seepage into the excavation becomes an issue, temporary water storage may be required to allow for dewatering or water collection activities on an as needed basis. Disposal of any collected water will be undertaken based on the water quality determined through sample collection and laboratory analyses which would include analysis of the contaminants of concern (i.e., BTEX and PHC Fractions F1 and F4, PAHs and/or metals). Based on the laboratory analytical results the excavation water may be either discharged downstream of the excavation area, into sanitary sewer systems (following approval by Manitoba Conservation and the City of Winnipeg) or will be disposed by the contractor at a licensed disposal facility (e.g., A-1 Environmental Services).

Backfilling of the Omand's Creek excavation will consist of a placement of clay bottom with appropriate riprap structure's to create sinuosity in the creek bottom. The final design of Omand's Creek will have been prepared in communication with Fisheries and Ocean's

Canada, City of Winnipeg Waterways, and Transport Canada Navigable Waterways Protection Program.

Other debris (i.e.: shopping carts, concrete, steel, etc.) present in these areas will be removed from below grade, cleaned of any sediment and disposed off-site at an appropriate disposal facility.

REPORTING

Upon completion of the remedial activities, a Remediation Summary Report will be prepared summarizing the remedial activities completed at the site and confirming concordance with this RAP, signed and sealed by a professional engineer, and suitable for submission to the City of Winnipeg. It is our understanding that the City of Winnipeg fill provide final copies of the report(s) to Manitoba Conservation.

SCHEDULE OF RAP IMPLEMENTATION

The following is a proposed schedule for implementation of the RAP:

- Late September 2013, submission of final RAP to the City of Winnipeg and Manitoba Conservation.
- Mid-October 2013, approval of RAP by Manitoba Conservation.
- Late-October/Early November 2013, initiation of remedial activities.
- December 2013, completion of surface soil remedial activities and site restoration.
- End of February 2014, completion of Omand's Creek sediment remedial activities and creek bed and bank restoration.
- Late March 2014, submission of Draft Remediation Closure Report to the City of Winnipeg.
- April 2014, submission of Final Remediation Closure Report to the City of Winnipeg.

If you have any questions regarding the information detailed herein, please contact the undersigned.

Sincerely

TETRA TECH WEI INC.

Ryan Wizbicki, P.Eng.
Senior Environmental Engineer

Review by

TETRA TECH WEI INC.

Rob Brogan, M.Sc., P.Ag.
Senior Project Manager

RW/gs

Attachments: Figures 1-3

PROVINCE OF MANITOBA
R. D. 2013-09-16
WIZBICKI
Member
22319
REGISTERED PROFESSIONAL ENGINEER

APEGM
Certificate of Authorization
TETRA TECH WEI Inc.
No. 5313 Date: April 30, 2014

References

Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (CEQG) 2007.

Canadian Council of Ministers of the Environment (CCME), Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil (CWS) 2008.

Wardrop Engineering Inc., September 1999. *Phase II & III Environmental Site Assessment Former Dominion Bridge Facility, Winnipeg, Manitoba.*

AECOM Environment, February 2011. *Phase III Environmental Site Assessment Former Dominion Bridge Operations Yard, 1460 Dublin Avenue - Winnipeg, Manitoba.*

AECOM Environment, March 2011. *Remedial Action Plan Former Dominion Bridge Operations Yard, 1460 Dublin Avenue - Winnipeg, Manitoba.*

LIMITATIONS

The scope of this report is limited to the matters expressly covered and is intended solely for the client to whom it is addressed. Tetra Tech WEI Inc. makes no warranties, expressed or implied, including without limitation, as to the marketability of the site, or fitness for a particular use. The assessment was conducted using standard engineering and scientific judgment, principles and practices, within a practical scope and budget. It is partially based on the observations of the assessor during the site visit, in conjunction with archival information obtained from a number of sources, which are assumed to be correct. Except as provided, Tetra Tech WEI Inc. has made no independent investigations to verify the accuracy or completeness of the information obtained from secondary sources or personal interviews. Generally, the findings, conclusions, and recommendations are based on a limited amount of data (e.g., the number of sample points, and the number of samples submitted for laboratory analyses) interpolated between sampling points, and the actual conditions (e.g., the type, level, and extent of impacted media) on the property may vary from that described above. Any findings regarding site conditions different from those described above upon which this report is based will consequently change Tetra Tech WEI Inc.'s conclusions and recommendations.

THIRD PARTY DISCLAIMER

The content of this document is not intended for the use of, nor is it intended to be relied upon by any person, firm or corporation, other than the client and Tetra Tech WEI Inc. Tetra Tech WEI Inc. denies any liability whatsoever to other parties for damages or injury suffered by such third party arising from use of this document by them, without the express prior written authority of Tetra Tech WEI Inc. and our client. This document is subject to further restrictions imposed by the contract between the client and Tetra Tech WEI Inc. and these parties' permission must be sought regarding this document in all other circumstances.

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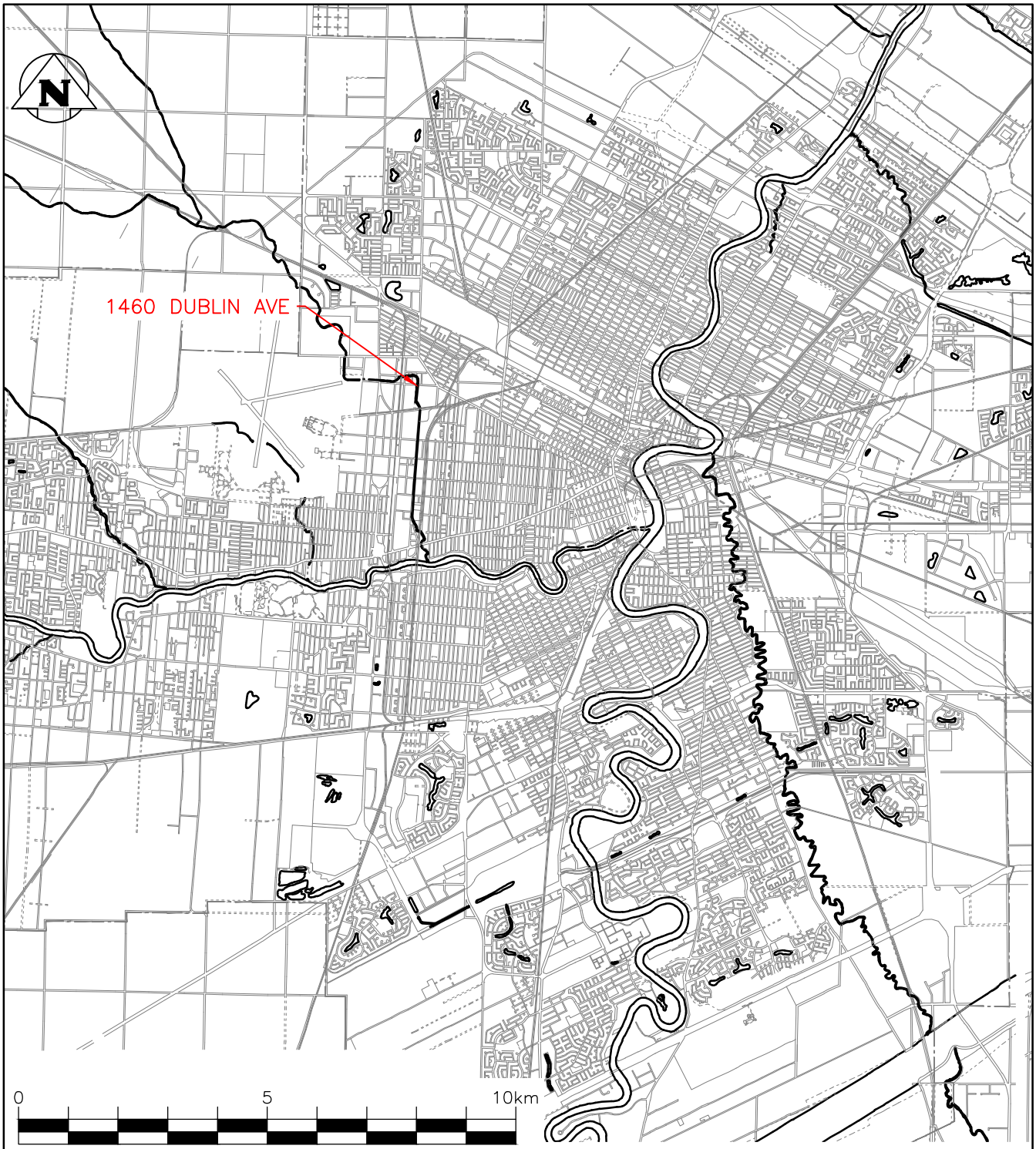

REFERENCE DRAWINGS: AECOM - 601642-20-H-F01-ROX

TETRA TECH

NO.	DATE	DESCRIPTION	ISSUED BY

REVISIONS/ISSUE

AUTHORIZED BY: RW
DATE: 13/09/18

CLIENT DRAWING NO.

CLIENT
CITY OF WINNIPEG

DRAWING DESCRIPTION
FIGURE 1: SITE LOCATION MAP
DOMINION BRIDGE RAP
1460 DUBLIN AVENUE, WINNIPEG, MB

DESIGNED BY:	RW	DRAWN BY:	SP	DRAWING NO.	REV.
REVIEWED BY:	RW	SCALE:	N.T.S.	1312940100-SKT-V0001	00

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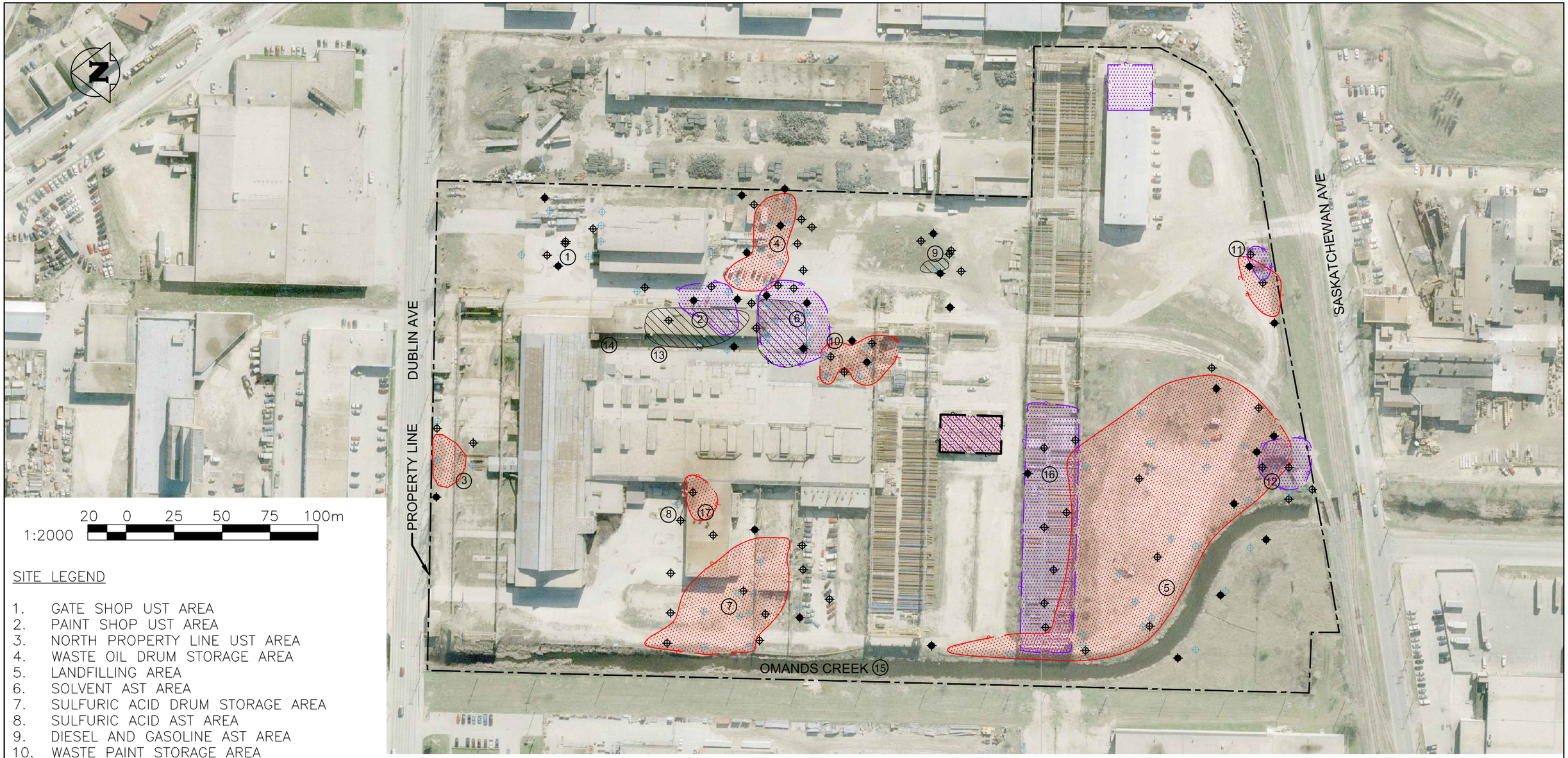

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1:2000

SITE LEGEND

1. GATE SHOP UST AREA
2. PAINT SHOP UST AREA
3. NORTH PROPERTY LINE UST AREA
4. WASTE OIL DRUM STORAGE AREA
5. LANDFILLING AREA
6. SOLVENT AST AREA
7. SULFURIC ACID DRUM STORAGE AREA
8. SULFURIC ACID AST AREA
9. DIESEL AND GASOLINE AST AREA
10. WASTE PAINT STORAGE AREA
11. FORMER SASKATCHEWAN AVENUE LANDFILL
12. POLYCHLORINATED BIPHENYLS STORAGE AREA
13. WEST OF PAINT SHOP AREA
14. WHEELABRATOR DUST
15. OMANDS CREEK
16. SOUTH CRANE RUNWAY
17. GALVANIZING PIT

LEGEND

- BOREHOLE (AECOM)
- MONITORING WELL (AECOM)
- BOREHOLE (PRIOR TO 2010)

ESTIMATED EXTENT OF:

- PHC IMPACTED SOIL
- PAH IMPACTED SOIL
- METAL IMPACTED SOIL

NO.	DESCRIPTION
REFERENCE DRAWINGS	

NO.	DATE	DESCRIPTION	PREPARED	REVIEW	DESIGN	AUTHORIZE
REVISIONS/ISSUE			DRAFTING		ENGINEERING	

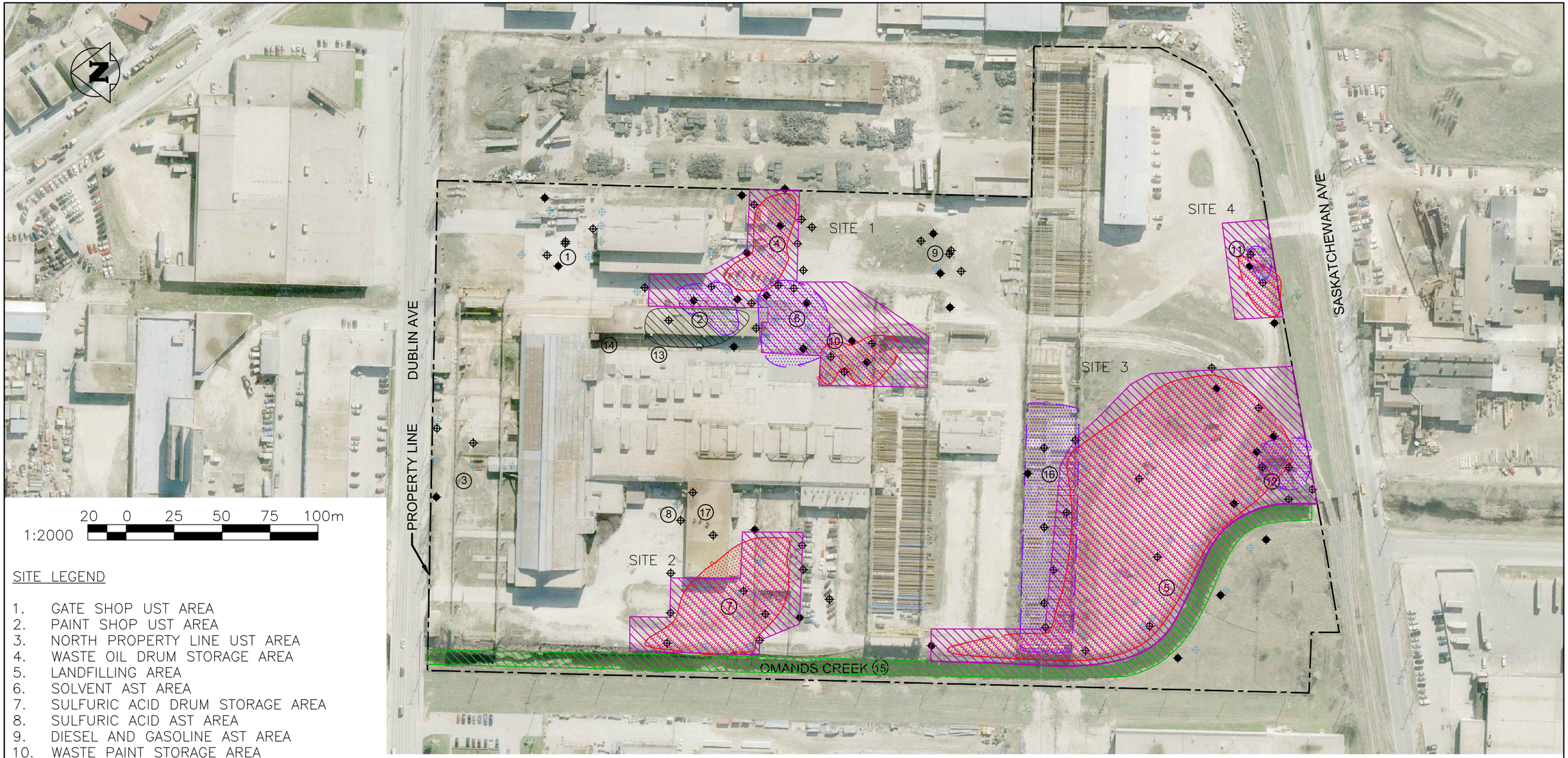
TETRA TECH

AUTHORIZED BY: RW
DATE: 13/09/18
CLIENT DRAWING NO.

CLIENT
CITY OF WINNIPEG

DRAWING DESCRIPTION
FIGURE 2: EXTENT OF SOIL IMPACT
DOMINION BRIDGE RAP
1460 DUBLIN AVENUE, WINNIPEG, MB

DESIGNED BY:	DRAWN BY:	DRAWING NO.	REV.
RW	SP	1312940100-SKT-V0002	00
REVIEWED BY: RW	SCALE: 1:2000		



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1:2000

SITE LEGEND

1. GATE SHOP UST AREA
2. PAINT SHOP UST AREA
3. NORTH PROPERTY LINE UST AREA
4. WASTE OIL DRUM STORAGE AREA
5. LANDFILLING AREA
6. SOLVENT AST AREA
7. SULFURIC ACID DRUM STORAGE AREA
8. SULFURIC ACID AST AREA
9. DIESEL AND GASOLINE AST AREA
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13. WEST OF PAINT SHOP AREA
14. WHEELABRATOR DUST
15. OMANDS CREEK
16. SOUTH CRANE RUNWAY
17. GALVANIZING PIT

LEGEND

- BOREHOLE (AECOM)
- MONITORING WELL (AECOM)
- BOREHOLE (PRIOR TO 2010)

ESTIMATED EXTENT OF:

- PHC IMPACTED SOIL
- PAH IMPACTED SOIL
- METAL IMPACTED SOIL
- SEDIMENT EXCAVATION
- SURFACE SOIL EXCAVATION

NO.	DESCRIPTION
REFERENCE DRAWINGS	

NO.	DATE	DESCRIPTION	PREPARED	REVIEW	DESIGN	AUTHORIZE
REVISIONS/ISSUE			DRAFTING		ENGINEERING	

TETRA TECH

AUTHORIZED BY: RW
DATE: 13/09/18
CLIENT DRAWING NO.

CLIENT
CITY OF WINNIPEG

DRAWING DESCRIPTION
FIGURE 3: ESTIMATED EXTENT OF - EXCAVATION - DOMINION BRIDGE RAP
1460 DUBLIN AVENUE, WINNIPEG, MB

DESIGNED BY:	DRAWN BY:	DRAWING NO.	REV.
RW	SP	1312940100-SKT-V0003	00
REVIEWED BY: RW	SCALE: 1:2000		

APPENDIX D

OMANDS CREEK HYDRAULICS MEMO

TETRA TECH

Memo

To	File
From	McRae, Kirby
Date	September 9, 2013
Document No.	1312940100-MEM-C0001-00
Project Name	Dominion Bridge Operations Yard
Subject	Omand's Creek Hydraulics

This memorandum summarizes information on Omand's Creek, used to design the replacement creek cross-section as part of the Dominion Bridge Operations Yard site remediation project.

Site Location

The site is located between Dublin and Saskatchewan Avenues, immediately east of the McCrossen Street right of way in the City of Winnipeg. This section of Omand's Creek is an artificial channel constructed to reroute some of the Colony Creek system directly south to the Assiniboine River. The creek runs through the former Dominion Bridge Operations Yard at 1460 Dublin Avenue and is impacted by metals and hydrocarbons. The proposed work includes removal of 1.0 m of material from the entire 520 m length of creekbed running through the site and removing 0.3 m of surface soils from two sections along the east bank. The removed material will be transported to a waste management facility. The resultant excavated areas will be reinstated with clean fill material. The creek bank will be re-vegetated with native grass and perennial flower seed. The industrial site is being sold by the City of Winnipeg, but ownership of the parcel containing the creek will be retained by the City of Winnipeg.

The creek is part of the Province of Manitoba Water Resources Branch Designation of Drains (DES) Map No. 26, Sturgeon Creek and Associated Watersheds. The creek is a 4th Order Drain and discharges into the Assiniboine River 3.2 km south of the project area. The creek has an approximate watershed area of 76 km2 at the project site, with headwaters in the RM of Rosser draining the east Colony Creek system. The creek receives treated runoff from the Winnipeg Airport Authority (WAA) de-icing system downstream of the project area.

The creek has been designated as Type A habitat (Complex habitat with Indicator Species present) on Map 062H14 in Fisheries and Oceans Canada 2013 "Fish Habitat

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Classification for Manitoba Agricultural Watersheds". This is the highest level of fish habitat. Map 062H16 is shown as **Figure 1**.

Regional Flood Estimate

A Water Survey of Canada flow gauging station was formerly operated on Omand's Creek approximately 900 m of the project site between 1978 and 1993 (Station 05MJ007, watershed area 74.8 km2), and was located at Metro Route 90 (King Edward Street near Dublin Avenue). A new level-only gauging station (05MH013, watershed area 79.8 km2) has been operating in 2012 and 2013 and is located near Empress Street and Westway.

Regional discharge coefficients have been computed by the Province of Manitoba, Water Stewardship for former station 05MJ007 and are directly applicable to the project site. The coefficients are regularly updated, and the October 2011 version of the coefficients was used. The creek is within Provincial zone 3 with exponent n=0.765. Local flood flow can be estimated using the Regional Discharge Formula:

$$Q = CA^n$$

Where:

- Q is the estimated flow in cms.
- C is a coefficient determined from frequency analysis (October 2011).
- A is the watershed area in km2 (76 km2 at the project site).
- n is a regional exponent equal to 0.765 for this part of the Province.

Table 1 – Flood Flow in Omand's Creek

Flood	Return Period (years)	Regional Discharge Coefficient	Estimated Flow (cms)
1%	100	0.940	25.82
2%	50	0.755	20.74
3%	33	0.656	18.02
20%	20	0.534	14.67
10%	10	0.390	10.52
20%	5	0.253	6.89
30%	3.3	0.181	4.97
50%	2	0.102	2.75

Flow-Duration Analysis

Eleven year of seasonal (March through October) average daily flow are available for Water Survey of Canada gauge 05MJ007 for the years 1978, 1983-1988, and 1990-1993. Inspection of the daily data from the Water Survey of Canada HYDAT database indicates that Omand's Creek exhibits typical ephemeral behavior common to many prairie streams, including high springtime flow due to snowmelt, high summertime flow in response to rainstorms, and long periods with no flow where the creek is reduced to a series of puddles.

The flow hydrograph for station 05MJ007 for the period of Record is shown as **Figure 2**.

The fraction of time that flow falls below a specified value is shown in the following table, for the Spring and Summer seasons.

Table 2 – Flow Frequency

Flow	Spring (March, April, May)	Summer (June through October)	Overall (March through October)
No flow	27.5%	47.9%	40.2%
< 0.1 cms	72.9%	90.5%	83.9%
< 0.5 cms	85.0%	96.5%	92.2%
< 1.0 cms	90.1%	97.7%	94.9%
< 2.0 cms	94.7%	98.8%	97.3%

The flow duration curve for the entire period of record based on 2695 daily flow values (11 years, March through October) is shown as **Figure 3**. Based on the historic flow record, the flow will be less than 0.3 cms 90% of the time and less than 1.0 cms 95% of the time.

Deign Cross-Section

Nine cross-sections through the project site were surveyed on July 23, 2013. The creek was been known to completely dry up in dry years, however daily rainfalls of 16.5 mm on July 18, 2013 and 31.5 mm on July 21, 2013 (as measured at Environment Canada Station 5023226 – Winnipeg Richardson AWOS) prior to the survey produced

noticeable flow in the creek and maximum depth of 1.0 m or deeper in scour holes. Flow and velocity were not measured.

The water surface elevation was measured at two locations, Section B = 232.073 m and Section G=232.001 m. The sections were 289 m apart, resulting in a hydraulic grade line slope (and average channel bed slope) of 0.025%.

The Manning roughness of the existing creek varies with depth, and was estimated assuming n=0.045 for the vegetated banks and n=0.030 for the relatively weed-free channel bottom.

The hydraulic performance of the existing creek was analyzed at cross-sections D and G, which are generally representative of the channel. The depth of flow required to convey the required flow was estimated for the sample cross-sections using the Manning formula, for the typical sections. The calculations are shown on **Figure 4** and summarized on Table 3.

The required conveyance A*R^(2/3) was determined from the Manning formula, as follows:

$$Q = \left(\frac{k}{n}\right) AR^{2/3}S^{1/2} \qquad AR^{2/3} = \frac{Qn}{kS^{1/2}}$$

Where

- Q is the flow (cms)
- k is a constant of unit conversion (equal to 1.0 for the metric units shown)
- n is the Manning roughness
- A is the cross-sectional area of flow
- R is the hydraulic radius
- S is the channel bed slope

Table 3 – Estimation of Required Depth of Flow

Section	Return (years)	Flow (cms)	$\frac{Qn}{kS^{1/2}}$	$AR^{2/3}$	Stage (m)	Depth (m)
D						
	2	2.75	6.1	6.1	231.944	1.007
	5	6.89	15.3	15.3	232.507	1.570
	10	10.52	23.3	23.3	232.852	1.916
G						
	2	2.75	6.1	6.1	231.824	0.987
	5	6.89	15.3	15.3	232.418	1.581
	10	10.52	23.3	23.3	232.809	1.972

Based on the above analysis, the existing channel depth and conveyance area were estimated to convey the design flow. The existing channel sideslopes vary from 2.0:1 to 8:1, with the average sideslope being 2.7 – 2.8:1. It was decided that flattening the sideslopes to 4:1 would greatly improve long term slope stability. The required bottom width for a trapezoidal channel with 4:1 sideslopes to convey the required flood flow at the approximate depth matching the estimated existing depth was computed as follows, assuming a composite Manning Roughness of 0.035.

Table 4 – Estimation of Required Bottom Width for Trapezoidal Channel

Return (years)	Flow (cms)	Depth (Rounded) (m)	Flow Area (sq m)	Bottom Width (m)
2	2.75	1.0	8.0	4.0
5	6.89	1.6	16.0	3.5
10	10.52	2.0	21.0	2.5

A bottom width of 3.0 m was selected for the replacement channel based on the above properties and fitting the channel within the City's newly established 18.288 m Right of Way. The channel centreline for the straight portion of the alignment located approximately 10.6 m west of the new west property line (or 7.7 m east of the McCrossen Street east limit). However, the channel bottom location was permitted to vary within the Right of Way to work with the different ground elevations on the east and west sides.

The selected channel section will perform as follows, assuming a composite Manning n=0.035:

Table 5 – Hydraulic Properties of Recommended Channel

Return (years)	Flow (cms)	Normal Depth (m)	Flow Area (sq m)	$AR^{2/3}$	Velocity (m/s)
2	2.75	1.086	7.98	3.148	0.35
5	6.89	1.633	15.572	13.689	0.44
10	10.52	1.979	21.602	27.929	0.49

The selection of channel dimensions to match the required depth and flow area, and the hydraulic properties of the selected channel are shown on **Figure 5**. The conveyance area and depth of the proposed channel reasonably matches the existing creek somewhere between the 5 and 10 year return flood level.

The channel bottom width has been reduced over the existing creek, so the creek will tend to flow deeper during typical low flows. This will improve the condition to maintain puddle depth during no flow periods.

The overall flow area has been increased for higher depths of flow because of the flattened sideslopes, so the creek will tend to flow shallower during floods of 10 years or greater. This is a benefit to mitigating flooding.

Channel Structures and Habitat Redevelopment

The channel is straight and contained within a limited width right of way. The bed slope is very flat and stable, but it would be desirable to disturb the straight flow path in order to create local habitat areas of faster and slower velocity.

Riffle structures are not desired because of the problem of trapping fish behind the riffle. However, low riffles have been proposed to act as sediment traps. These will function for the first few years following reconstruction to aid in trapping sediment from un-vegetated bed and banks. Given the very flat 0.025% bed slope, riffles 0.2 m high are proposed every 100 m along the creek.

Wing deflector structures constructed of rock rip rap are proposed to deflect flow away from the creek banks, create local higher velocity areas (and scour holes), and help introduce sinuosity into the creek. Note that the deflectors were not required for grade control, because the existing gradient is quite flat. The deflectors are proposed on opposite banks at 25 m spacing, and extend slightly above the 2 year flood level. These deflectors will accelerate flow in the thalweg and redirect the thalweg towards to opposing bank, with the intent of forming a scour hole near the deflector and preventing the creek bottom from infilling with cattails. The top of revetment and top of wing deflector at the bank was set to elevation 232.4, or 0.3m above the 2 year flood level.

The opposing bank downstream of a deflector will be protected from scour by rip rap revetment, extending nominally 10 m upstream from the opposite wing deflector. The length of revetment will be extended on the outside bends of curves to provide limited protection against channel movement onto the adjoining property. Approximately half the length of creek bank will be protected with either revetment or the wing deflectors, and the remainder would be soil.

Minor realignment of the south end of the creek immediately upstream of Saskatchewan Avenue is proposed to correct the channel direction heading into several rail and road bridges and to try and save some of the mature trees growing along the east bank upstream of the Saskatchewan Avenue crossing. Since the entire channel bed is being excavated, realigning the channel bottom does not involve significant additional work.

The proposed remediation and reconstruction work is planned for the late fall of 2013. Re-vegetation will not be possible until the spring of 2014, and therefore the reconstructed area will be subject to erosion during the 2014 spring flood. Floating turbidity barriers cannot typically withstand direct in-channel flood flow, and would be destroyed either by freezing into the creek or floating ice, and are therefore not recommended. Covering the banks with erosion control blankets or geotextile stapled to the banks for the winter could be effective at mitigating erosion, but would be prohibitively expensive and could be destroyed / washed downstream by the spring flood, and are therefore also not recommended either.

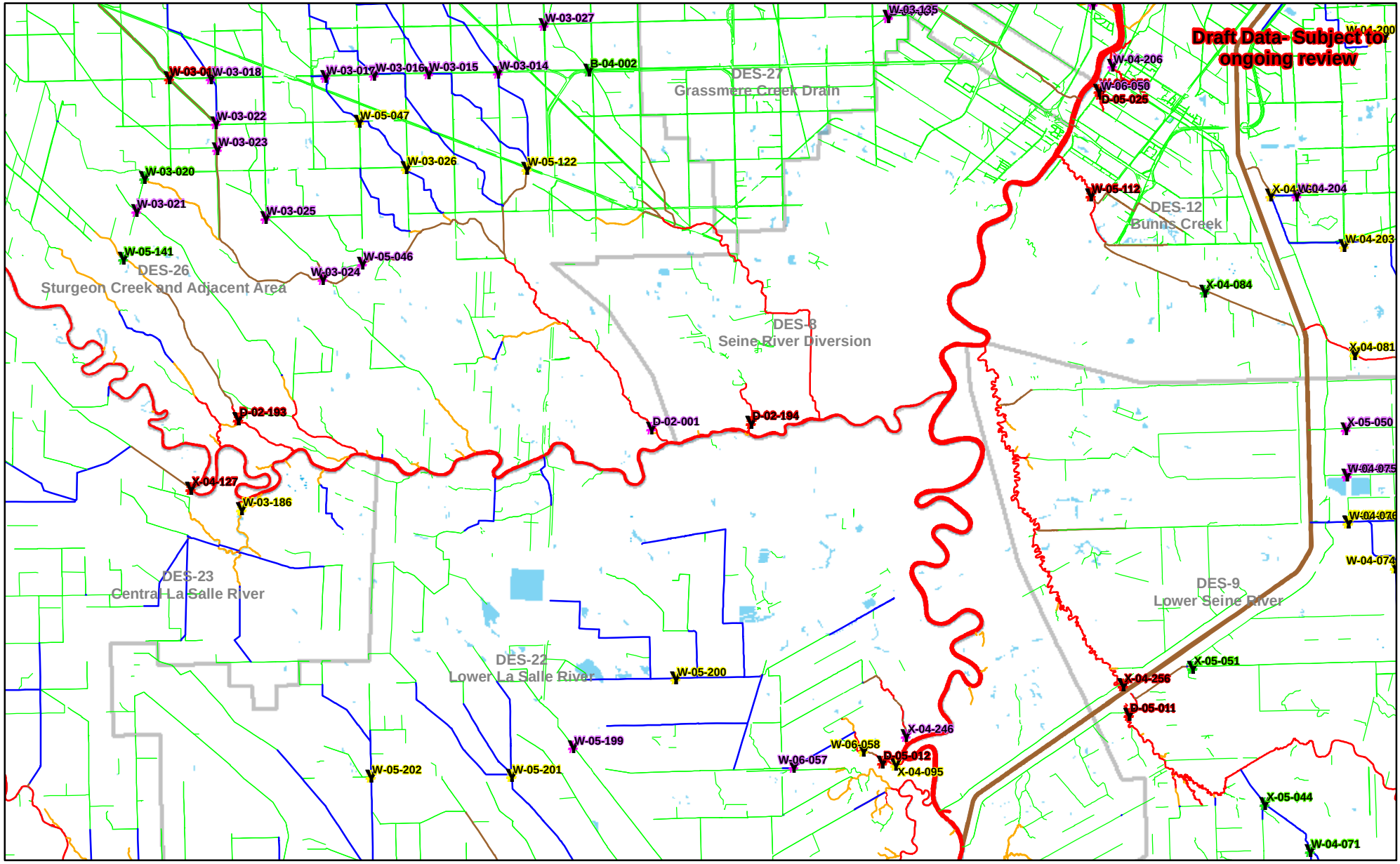
It is recommended that the creek be left to erode during the first spring flood. A high fraction of the suspended sediment should be trapped by the low riffles (channel bed) and revetment / wing deflectors (banks), especially since about 50% of the bank areas will be protected by revetment or wing deflectors.

Silt fences will be installed at the top of the revetment level in the late fall of 2013 following construction (elevation 232.4 m), to capture erosion from the upper creek banks.

Re-vegetation of the upper banks is proposed for the spring of 2014 after June 15 (that being the date where Fish spawning activity is normally over). The soils banks will be amended with peat moss and sand rototilled into the top 100 mm to avoid bringing weed-bearing topsoil into the site, the soil graded and compacted. The banks will then be Hydroseeded with a native grass and native perennial flower mix with a cover crop of Oats. The banks and silt fencing will be maintained until dense growth has been established, typically occurring within one growing season.

Figures

Figure 1 – Map 062H14 (Fish Habitat from Milani, D., "Fish Habitat Classification for Manitoba Agricultural Watersheds, Fisheries and Oceans Canada, 2013)
Figure 2- Historic flow from HYDAT database (Station 05MJ007)
Figure 3 – Flow-Duration Curve from all historic data.
Figure 4 – Hydraulic Performance of Existing Cross-Sections
Figure 5 – Design of Replacement Cross-Section



062I04	062I03	062I02
062H13	062H14	062H15
062H12	062H11	062H10

Habitat Classification

A
B
C
D
E

Fishing Results

Indicator Species
Non-Indicator Species
No Catch
No Fishing Effort

Appendix 9

Sampling sites, fish captures and habitat classification of streams and constructed drains throughout agricultural areas of Manitoba (2002 – 2006)

062H14

Produced April 2012

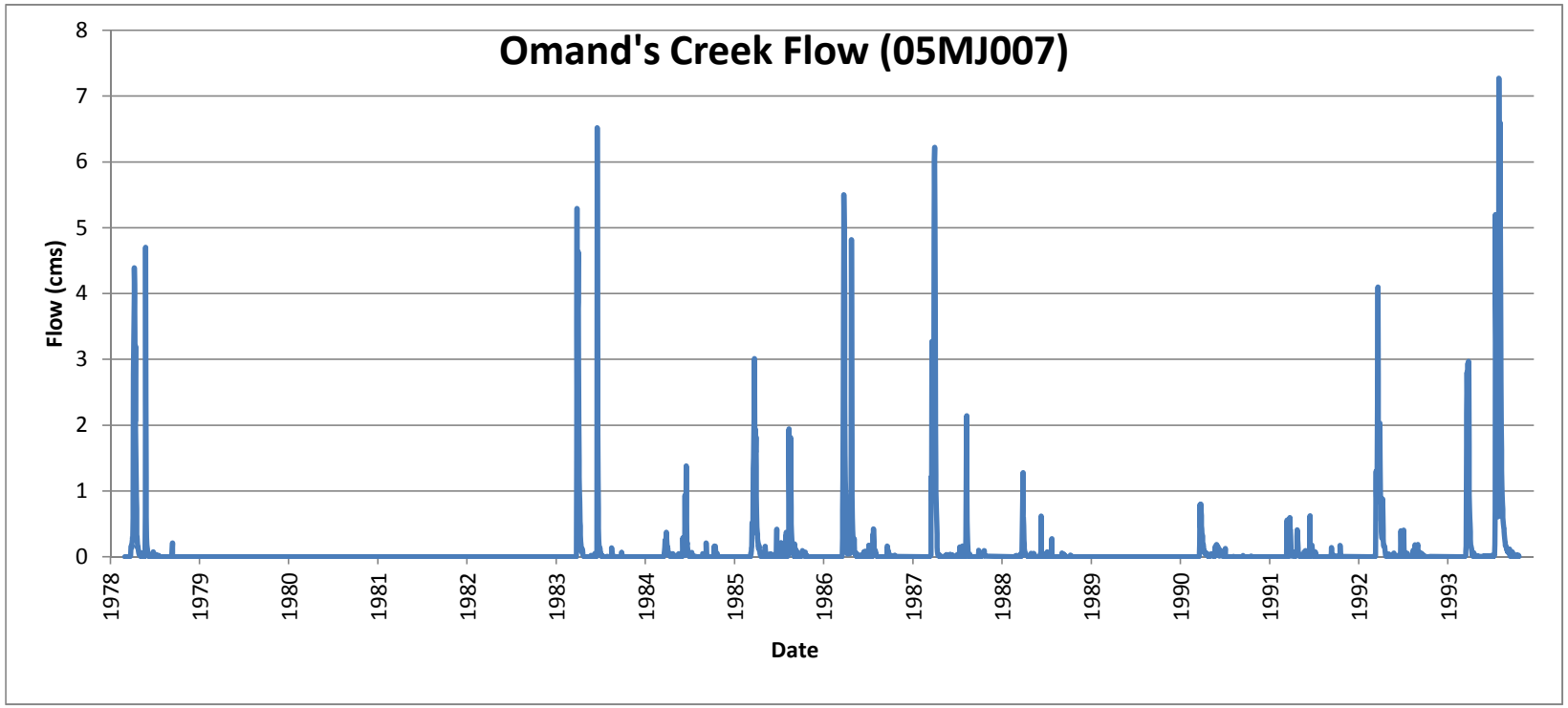

Omand's Creek Flow (05MJ007)
Flow (cms)
0
1
2
3
4
5
6
7
8
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
Date

Figure 2

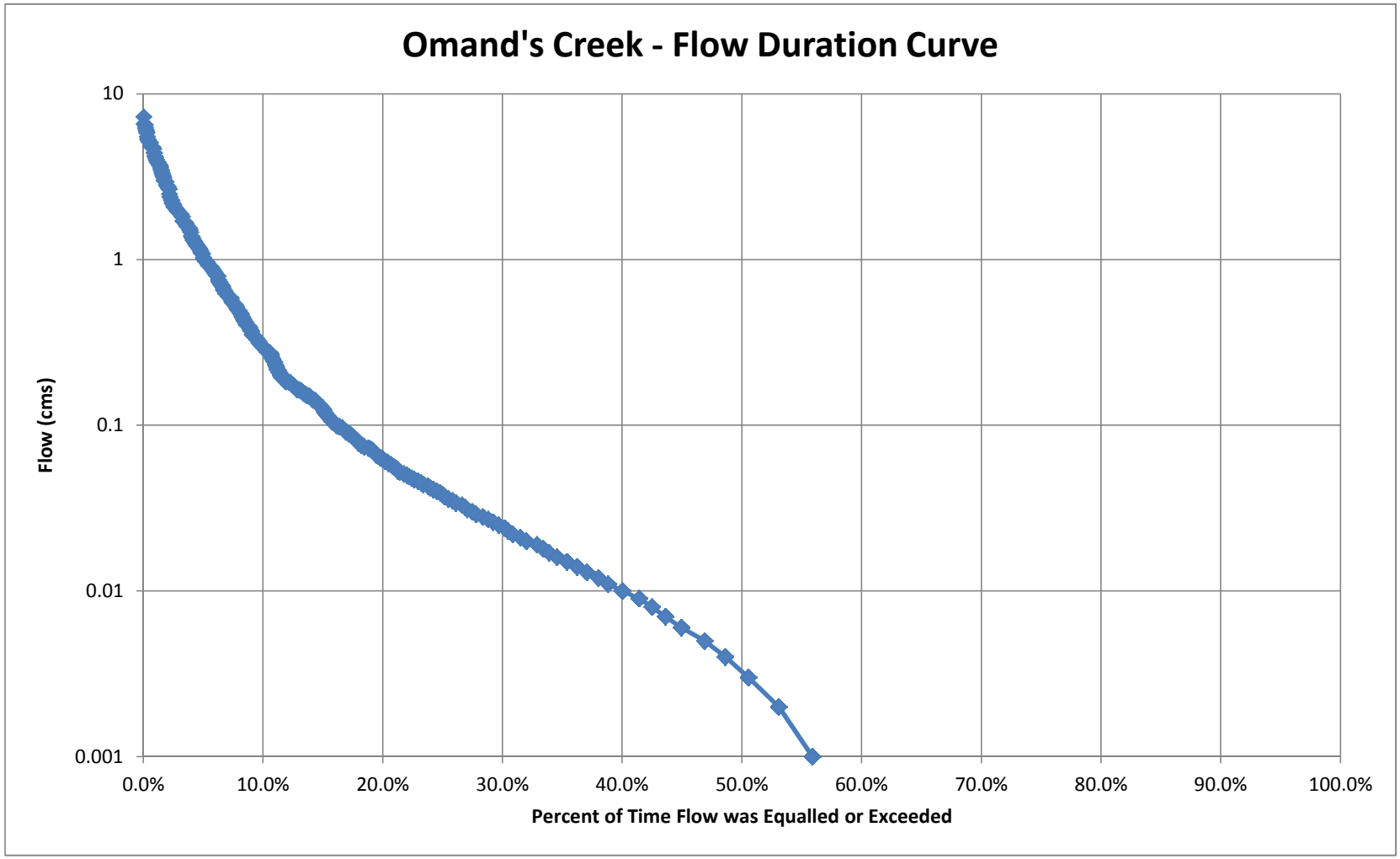

Omand's Creek - Flow Duration Curve
10
1
0.1
0.01
0.001
Flow (cms)
0.0%
10.0%
20.0%
30.0%
40.0%
50.0%
60.0%
70.0%
80.0%
90.0%
100.0%
Percent of Time Flow was Equalled or Exceeded

Figure 3

Omand's Creek
Existing Channel Hydraulics

Manning Roughness for each section of creek cross-section
n= 0.03 clean, winding open channel
n=0.045 clean, winding open channel with weeds and stones

From Regional Flood Formulae

Probability	Return (years)	Flow (cms)
50%	2	2.75
20%	5	6.89
10%	10	10.52

$Q = k/n * A * R^{2/3} * S^{1/2}$

$Q * n/k * 1/S^{1/2} = A * R^{2/3}$

k =	1	
n=	0.035	estimated average
S =	0.025%	computed from survey data

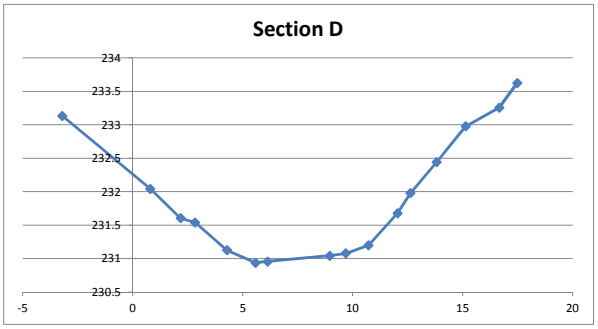
Cross-Section D

Surveyed Cross-Section

estimated NWL 232.041

stage range: 231 to 233
interval 0.1

Station	Offset	Elevaton	Manning Roughness	
9+96.798	-3.202	233.134	0.045	
10+00.796	0.796	232.043	0.045	
10+02.175	2.175	231.606	0.045	
10+02.834	2.834	231.541	0.045	
10+04.279	4.279	231.127	0.030	
10+05.580	5.58	230.937	0.030	Bottom
10+06.138	6.138	230.957	0.030	
10+08.959	8.959	231.044	0.030	
10+09.688	9.688	231.08	0.030	
10+10.718	10.718	231.2	0.030	
10+12.036	12.036	231.679	0.045	
10+12.662	12.622	231.981	0.045	
10+13.810	13.81	232.442	0.045	
10+15.136	15.136	232.979	0.045	
10+16.662	16.662	233.258	0.045	
10+17.476	17.476	233.627	0.045	



Hydraulic Properties

Stage	Depth	Area	Wet Per	Hyd Rad	Top Wid	Rough	A * R$^{2/3}$
231.0	0.063	0.073	2.389	0.031	2.384	0.030	0.007
231.1	0.163	0.486	5.411	0.090	5.396	0.030	0.098
231.2	0.263	1.094	6.727	0.163	6.694	0.031	0.326
231.3	0.363	1.795	7.383	0.243	7.318	0.031	0.699
231.4	0.463	2.558	8.039	0.318	7.942	0.032	1.192
231.5	0.563	3.383	8.695	0.389	8.566	0.033	1.803
231.6	0.663	4.283	9.738	0.440	9.583	0.034	2.477
231.7	0.763	5.274	10.387	0.508	10.198	0.034	3.357
231.8	0.863	6.320	10.936	0.578	10.708	0.035	4.384
231.9	0.963	7.416	11.486	0.646	11.218	0.035	5.540
232.0	1.063	8.563	12.046	0.711	11.739	0.036	6.821
232.1	1.163	9.767	12.681	0.770	12.342	0.036	8.206
232.2	1.263	11.032	13.338	0.827	12.966	0.037	9.721
232.3	1.363	12.360	13.994	0.883	13.590	0.037	11.378
232.4	1.463	13.750	14.650	0.939	14.214	0.037	13.181
232.5	1.563	15.202	15.301	0.994	14.832	0.038	15.137
232.6	1.663	16.716	15.947	1.048	15.445	0.038	17.250
232.7	1.763	18.292	16.593	1.102	16.059	0.038	19.519
232.8	1.863	19.928	17.239	1.156	16.672	0.039	21.950
232.9	1.963	21.626	17.886	1.209	17.285	0.039	24.545
233.0	2.063	23.386	18.593	1.258	17.962	0.039	27.250

Normal Depth to Convey Design Flow

Return Period (years)	Q * n/k * 1/S1/2 equals A * R$^{2/3}$	Stage (m)	Depth (m)	Rounded Depth (m)	Flow Area (sq m)
2	6.100	231.944	1.007	1.00	7.840
5	15.282	232.507	1.570	1.60	15.763
10	23.334	232.853	1.916	1.90	20.556

Figure 4

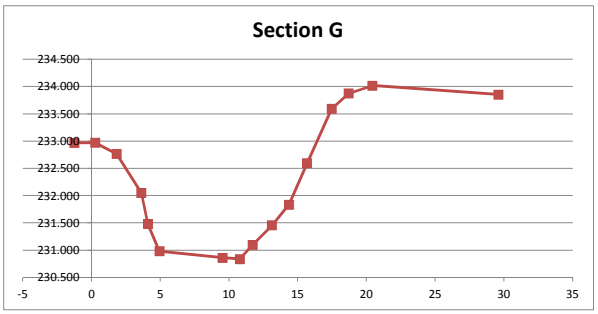
Cross-Section G

Surveyed Cross-Section

Survey NWL 232.001

stage range: 231 to 233
interval 0.1

Station	Offset	Elevaton	Manning Roughness	
9+98.743	-1.257	232.967	0.045	
10+00.276	0.276	232.971	0.045	
10+01.821	1.821	232.769	0.045	
10+03.621	3.621	232.050	0.045	
10+04.101	4.101	231.480	0.045	
10+04.938	4.938	230.983	0.030	
10+09.535	9.535	230.861	0.030	
10+10.777	10.777	230.837	0.030	Bottom
10+11.710	11.71	231.097	0.030	
10+13.118	13.118	231.458	0.045	
10+14.362	14.362	231.837	0.045	
10+15.686	15.686	232.599	0.045	
10+17.466	17.466	233.593	0.045	
10+18.694	18.694	233.876	0.045	
10+20.429	20.429	234.018	0.045	
10+29.591	29.591	233.856	0.045	



Hydraulic Properties

Stage	Depth	Area	Wet Per	Hyd Rad	Top Wid	Rough	A * R$^{2/3}$
231.0	0.163	0.594	6.481	0.092	6.453	0.030	0.121
231.1	0.263	1.266	7.051	0.180	6.981	0.031	0.403
231.2	0.363	1.992	7.649	0.260	7.539	0.031	0.812
231.3	0.463	2.773	8.248	0.336	8.098	0.031	1.341
231.4	0.563	3.611	8.846	0.408	8.656	0.032	1.987
231.5	0.663	4.504	9.407	0.479	9.172	0.032	2.757
231.6	0.763	5.442	9.881	0.551	9.584	0.033	3.656
231.7	0.863	6.421	10.354	0.620	9.997	0.033	4.669
231.8	0.963	7.441	10.828	0.687	10.409	0.034	5.795
231.9	1.063	8.500	11.212	0.758	10.724	0.034	7.066
232.0	1.163	9.585	11.543	0.830	10.982	0.035	8.467
232.1	1.263	10.698	11.944	0.896	11.323	0.035	9.940
232.2	1.363	11.852	12.414	0.955	11.747	0.035	11.491
232.3	1.463	13.047	12.884	1.013	12.171	0.036	13.158
232.4	1.563	14.286	13.354	1.070	12.595	0.036	14.943
232.5	1.663	15.567	13.824	1.126	13.020	0.036	16.848
232.6	1.763	16.890	14.294	1.182	13.444	0.037	18.877
232.7	1.863	18.256	14.769	1.236	13.873	0.037	21.026
232.8	1.963	19.667	15.399	1.277	14.462	0.037	23.150
232.9	2.063	21.160	16.376	1.292	15.406	0.038	25.103
233.0	2.163	22.792	18.662	1.221	17.661	0.039	26.043

Normal Depth to Convey Design Flow

Return Period (years)	Q * n/k * 1/S1/2 equals A * R$^{2/3}$	Stage (m)	Depth (m)	Rounded Depth (m)	Flow Area (sq m)
2	6.100	231.824	0.987	1.00	7.833
5	15.282	232.418	1.581	1.60	14.760
10	23.334	232.809	1.972	2.00	20.219

Figure 4

Omand's Creek
Redesign of Channel Section

Existing Channel Sideslopes

delta y exaggerated by a factor of 10

cross sect	left side delta x	delta y		left side slope	right side delta x	delta y		right side slope	
A	1.963	0.535	0.273	3.7	4.040	0.570	0.141	7.1	Upstream
B	0.000	0.000		0.0	2.570	1.254	0.488	2.1	
C	0.000	0.000		0.0	2.631	1.068	0.406	2.5	
D	3.483	0.896	0.257	3.9	3.092	1.251	0.405	2.5	
E	3.102	1.458	0.470	2.1	3.163	1.422	0.450	2.2	
F	4.183	1.488	0.356	2.8	3.954	1.936	0.490	2.0	
G	3.825	1.411	0.369	2.7	4.349	2.186	0.503	2.0	
H	3.082	1.468	0.476	2.1	2.991	1.322	0.442	2.3	
I	5.186	0.662	0.128	7.8	1.921	0.985	0.513	2.0	Downstream
Average			0.333	2.793 :1			0.426	2.727 :1	

Design Channel Section

Sideslope 4 :1

Return	2 years	Return	5 years	Return	10 years
Depth	1.0 m	Depth	1.6 m	Depth	2.0 m
Flow Area	8.0 m2	Flow Area	16.0 m2	Flow Area	21.0 m2

Bottom Width	Flow Area	Bottom Width	Flow Area	Bottom Width	Flow Area
1.00	5.00	1.00	11.84	1.00	18.00
1.25	5.25	1.25	12.24	1.25	18.50
1.50	5.50	1.50	12.64	1.50	19.00
1.75	5.75	1.75	13.04	1.75	19.50
2.00	6.00	2.00	13.44	2.00	20.00
2.25	6.25	2.25	13.84	2.25	20.50
2.50	6.50	2.50	14.24	2.50	21.00
2.75	6.75	2.75	14.64	2.75	21.50
3.00	7.00	3.00	15.04	3.00	22.00
3.25	7.25	3.25	15.44	3.25	22.50
3.50	7.50	3.50	15.84	3.50	23.00
3.75	7.75	3.75	16.24	3.75	23.50
4.00	8.00	4.00	16.64	4.00	24.00
4.25	8.25	4.25	17.04	4.25	24.50
4.50	8.50	4.50	17.44	4.50	25.00
4.75	8.75	4.75	17.84	4.75	25.50
5.00	9.00	5.00	18.24	5.00	26.00

Select 3.0m bottom width

Performance of Proposed Cross-Section

Bottom width 3.0 m
Sideslope 4.0 : 1
Manning n 0.035 estimated average
Bed Slope 0.0250%

Return Period (years)	Flow (cms)	Normal Depth (m)	Flow Area (sq m)	Hyd Radius (m)	AR^2/3	Velocity (m/s)
2	2.75	1.086	7.980	0.667	3.148	0.345
5	6.89	1.633	15.572	0.946	13.689	0.442
10	10.52	1.979	21.602	1.118	27.929	0.487

Design Requirements

Return Period (years)	Normal Depth (m)	Flow Area (sq m)	Hyd Radius (m)	AR^2/3	Flow (cms)	Capacity of New vs. Existing	
2	1.000	7.000	0.622	2.352	1.063	39%	Less
5	1.600	15.040	0.929	12.688	5.732	83%	Less
10	2.000	22.000	1.129	29.061	13.128	125%	More

Depth (m)	Flow Area (sq m)	Hyd Radius (m)	AR^2/3	Flow (cms)	Velocity (m/s)
0.100	0.340	0.089	0.001	0.001	0.002
0.200	0.760	0.163	0.012	0.005	0.007
0.300	1.260	0.230	0.043	0.019	0.015
0.400	1.840	0.292	0.109	0.049	0.027
0.500	2.500	0.351	0.225	0.102	0.041
0.600	3.240	0.408	0.411	0.186	0.057
0.700	4.060	0.463	0.690	0.312	0.077
0.800	4.960	0.517	1.087	0.491	0.099
0.900	5.940	0.570	1.630	0.736	0.124
1.000	7.000	0.622	2.352	1.063	0.152
1.100	8.140	0.674	3.289	1.486	0.183
1.200	9.360	0.726	4.479	2.024	0.216
1.300	10.660	0.777	5.966	2.695	0.253
1.400	12.040	0.828	7.796	3.522	0.292
1.500	13.500	0.878	10.018	4.526	0.335
1.600	15.040	0.929	12.688	5.732	0.381
1.700	16.660	0.979	15.864	7.166	0.430
1.800	18.360	1.029	19.606	8.857	0.482
1.900	20.140	1.079	23.982	10.834	0.538
2.000	22.000	1.129	29.061	13.128	0.597