Earthworks Methodology Port Lands, Toronto

Prepared for

Waterfront Toronto

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Contents

Acronyms and Abbreviations

CH2M	CH2M HILL Canada Limited
CSA	Canada Standards Association
DEM	Digital Elevation Model
ECA	Environmental Compliance Approval
FPL	Flood Protection Landform
LIDAR	Light Detection and Ranging
M	metre
m^3/d	cubic metre per day
m^3/y	cubic metre per year
MVVA	Michael Van Valkenburgh Associates Inc.
O. Reg.	Ontario Regulation
Plan	Earthworks Methodology
Riggs	Riggs Engineering
TBD	To be determined
TRCA	Toronto and Region Conservation Authority
v	Vapour
WT	Waterfront Toronto

Tab H. Earthworks Methodology

This Earthworks Methodology (Plan) has been prepared to develop and describe a practical approach in constructing the Port Lands flood protection elements and enabling infrastructure that conform with the approved environmental assessment and preliminary design prepared by Michael Van Valkenburgh Associates Inc. (MVVA) and their team. The Plan addresses the following major work elements involving earthworks and civil construction:

- River Valley construction (including the spillway)
- Roads, bridges and utility; and decommissioning existing structures
- Grade raise required for flood protection, outside designated flood-protection landforms
- Flood-protection landform construction
- Essroc Quay lake filling (lake fill designed by others)

This Plan describes preliminary methodology for completing soil excavation, handling, and fill placement activities (jointly referred to as earthworks herein), related to major earthworks and civil construction elements. The work limit consists of two areas that are differentiated by the types of earthwork activities required by the project:

- **Upland area:** Project zones outside the River Valley, including development blocks, flood-protection landforms, and public spaces. These areas are the "dry side" of the regulatory floodline. In general, work in the upland area includes raising grades to reduce flood risk and constructing new infrastructure to support revitalization of the areas. Note, activities within the development blocks are generally outside this scope.

- **River Valley area:** The area between the regulatory floodline encompassing the River Valley. These areas are the "wet side" of the regulatory floodline. In general, work within the River Valley includes excavation and construction of the new River Valley landscape.

H.1 Site Conditions

The earthworks methodology design and equipment selection are driven by many factors including site conditions. This section provides an overview of site conditions of the proposed River Valley area (landscape design) that influence the proposed preliminary earthworks methodology.

H.1.1 River Valley Area Stratigraphy

A Conceptual Site Model (Tab A) and Geotechnical Conditions (Tab D) describe the existing soil stratigraphy and groundwater conditions. The simplified site stratigraphy comprises the following units descending from ground surface:

1. Heterogeneous fill

2. Poorly graded native sand unit extending to bedrock, which is predominant along the western to eastern alignment of the River Valley from Station 0+000 to Station 1+050 (Figures 8 and 9A).

3. Discontinuous peat/organics layers up to 6.8 metres (m) thick within the sand unit. Peat/organics layers can be interbedded with sandy and silty layers at localized locations. The peat/organics layers are present along the northern to southern segment of the proposed River Valley alignment from Station 1+050 to Station 1+500 (Figures 8 and 9A).

4. Discontinuous native silt, clayey silt to clay till within the sand unit. These layers are also more present along the northern to southern segment of the proposed River Valley alignment from Station 1+050 to Station 1+500 (Figures 8 and 9A).
5. Shale bedrock interbedded with limestone approximately 10.8 to 41.31 metres below ground surface. Bedrock surface topography gently slopes down from north to south (Figure 7).

The unconfined groundwater table is generally encountered at approximately 74.8 metres above sea level and is directly connected to Lake Ontario. It is a continuous hydrogeological unit extending from the water table surface to the bedrock.

The minimum excavation grade along the River Valley is below the water table within the native, poorly-graded sand, organic soil, and peat layers underlying the Site.

Excavation depths vary across the project based on the future river bed proposed by LimnoTech. In addition, the excavation depth may also vary because of the nature of the materials proposed for landscape construction and geoenvironmental properties of the native soils. The estimated minimum excavation depth required to construct the proposed River Valley landscape ranges from 5 to 8 m below existing ground surface. An overexcavation of about 2 m has been assumed because of equipment limitations and geoenvironmental concerns. The placement of proposed landscape material and a 1.5-m-thick cover over native soils is provided as an environmental risk management measure. In some areas, excavation will extend below the minimum grades necessary for landscape construction to remove geotechnically-unsuitable and environmentally-impaired soil. The excavation of unsuitable materials is referred to as overexcavation. The final excavation grade includes both the minimum and overexcavation required to construct the final landforms.

H.1.2 Implications on Earthworks

The River Valley excavation will be done under two different conditions: 1) dry material excavation above the groundwater table; and 2) wet material excavation, which are situated below the groundwater table and saturated. The soils in the wet excavation zone could range from Type 3 to Type 4 soils (O. Reg. 213/91, s. 226 (1)). They are expected to form at slope angles of 4H:1V or 5H:1V, or possibly less in excavation within still water. Dry excavation faces greater than 3H:1V may become unstable and require stabilization or shoring because of the compaction inconsistency within the fill material.

Because the proposed River Valley morphology design includes slopes up to 2H:1V, significant overexcavation and replacement with structural and granular fill are expected. The removal of soft material and environmentally-impaired soil will also be required, particularly within the shallower excavation depths.

Excavations for new infrastructure construction (such as utilities) may require shoring and are dependent on the selected construction method, where large excavation areas are not practical. Dewatering or water-tight shoring methods will be required to provide suitably-dry, temporary conditions.

H.2 Digital Elevation Model

To support the overall design and earthworks planning, CH2M HILL Canada Limited (CH2M) constructed a Digital Elevation Model (DEM) for the project by generating a series of surfaces (layers) that represent individual elements of the project and physical site settings. The project DEM layers are three-dimensional and georeferenced to support the calculation of the project excavation (cut) and fill volumes. The critical elements influencing the project earthwork activities were defined as:

- Design of final grades and new infrastructure
- Existing ground surface
- Site geology

- Site hydrology and hydrogeology
- Environmental contaminant distribution
- Maintaining the current utility services around the Site

The DEM was generated based on a database generated by Toronto and Region Conservation Authority (TRCA) of historical stratigraphy information from subsurface investigations at the Site. Table H1 provides the layers representing the critical elements constructed using the ArcGIS software platform to generate the project DEM.

Table H1. Digital Elevation Model Layers

DEM Layer Name	Layer Type	Data Source	Date or Version	Comment
Existing ground	Existing condition	TRCA LIDAR	TBD	-
Finished surface	Design condition	MVVA	TBD	-
Final excavation surface	Design condition	CH2M designed	TBD	-
Existing fill materials	Geological	CH2M interpretation of TRCA database	TBD	CH2M interpretation
Organic soils surface	Geological	CH2M interpretation of TRCA database	TBD	CH2M interpretation
Poorly-graded sand surface	Geological	CH2M interpretation of TRCA database	TBD	CH2M interpretation
Bedrock surface	Geological	CH2M interpretation of TRCA database	TBD	CH2M interpretation
Groundwater table	Hydrogeological	CH2M interpretation of TRCA database	TBD	CH2M interpretation

Notes:

LIDAR - Light Detection and Ranging

TBD - to be determined

The accuracy of the DEM is based on the LIDAR and geological information provided by the TRCA. The following notes are to be addressed as part of the next stage of the project:

- No information describing the accuracy of the LIDAR data used to generate existing conditions was provided by the data source.
- CH2M could not verify or validate data contained in the TRCA database that was used to construct geological and contaminant distribution layers.

H.3 Work Sequence

For preliminary planning purposes, the schedule and sequence of civil activities have been developed for 6-year construction period. The project has been divided into four construction phases to be completed.

The construction phases will be coordinated with the overall project schedule as it is developed by the Schedule Consultant (HDR). Each phase has been subdivided into work activities and activity areas.

H.3.1 Work Sequence Overview

Phases 1 through 4, presented in Figures 33A to 33D, show major activities planned by area. Each phase represents approximately one construction season starting in March, and continuing through

November. It is anticipated that limited work will occur between December and February. Some activities may span more than one construction season and will overlap subsequent phases; therefore, there are fewer phases than calendar years in the project. Project phases will be reviewed with the overall scheduler to coordinate start and finish dates of major activities and to further refine the preliminary sequence. To the extent practical, the excavation required for soil remediation will be completed before the excavation of the River Valley begins, to reduce the potential for contaminant migration and cross-contamination. The specific sequence of excavation activities will be planned on an area-by-area basis, based on remediation needs and excavation requirements for landscape construction. The preliminary earthworks sequence has been developed based on estimated production rates of equipment and methods anticipated to complete the project. Specific activities related to each phase are presented in the earthworks sequencing Figures 33A to 33D.

For planning purposes, CH2M has made the following assumptions:

- An excavation rate of 750 cubic metres/day (m^3/d) to 1,000 m^3/d is required to meet the sequencing excavation schedule. An overall average 0.25 million cubic metre per year (m^3/y) has been considered for the project, based on a single day-shift operation.
- No work will be permitted within Lake Ontario between March and July, to accommodate aquatic habitat protection; however, this does not include the excavation works, which will happen within the enclosed proposed River Valley zone (with no direct open water connection to Lake Ontario).
- Construction seasons start in March.
- Construction seasons end in November.
- Filling activities will progress as fill becomes available and filling encumbrances are removed.
- Environmental treatment, dewatering, and geotechnical stabilization of the excavated material will take place as part of the earthworks process.
- Activities will not include live plantings within the River Valley. A specific schedule for live plantings is required based on design and approach currently not developed.
- Design, permitting, and procurement are not included in the preliminary project sequence.
- The sequence does not include unplanned work stoppages or delays (such as, extreme weather, strikes, procurement delays, contractor delays, and owner delays).
- Further development of the project schedule is required to refine the sequence-activity bundles.
- A procurement approach has not been considered in the preliminary schedule. It is assumed a single entity or multiple contractors could deliver the work activities.
- The “First Gulf” flood protection landform will be constructed by others. It is not part of the project sequence presented in this Plan.

H.4 Excavation, Soil Handling, and Filling Methods

Proposed preliminary earthworks approaches include commonly implemented methods in civil construction and a specialized approach to address project-specific complexity such as project scale, site conditions, unique design elements, and complexity of constructing naturalized landscapes. This section describes the general site preparation requirements for earthworks across the Site. The section also describes the specialized approached developed to address the project-specific challenges and complexity within the Upland and River Valley areas of the project.

H.4.1 General Methods and Approaches

Before earthworks activities begin, it is anticipated that the general activities described herein are required to establish environmental control and prepare the Site for earthworks activities that will disturb the existing ground surface.

H.4.1.1 Early Environmental Remediation

Environmental contamination within the limit of work will require soil and groundwater remediation actions. Where possible, soil and groundwater contamination will be remediated before starting new construction in the affected area. This will be required to improve worker safety; avoid contaminating clean soil and water; improve water quality in the River Valley excavation; and reduce remediation timeframe, cost, and risk of emissions. Preliminary environmental remediation requirements are presented in Tab E. For preliminary earthworks planning, it is assumed remediation will be complete before starting new construction activities in affected areas by excavating contaminated soil (and hauling it to the soil-processing facility) or in situ treatment of soil and groundwater to meet established project-specific target concentrations. Where appropriate, remediation excavations will be used for new construction activities to optimize excavation cost. If new work cannot follow remediation, excavation will be temporarily backfilled with suitable materials until new construction can begin.

H.4.1.2 Environmental controls

Work activities will require environmental controls to comply with applicable environmental approvals, regulations, standards, and codes. Environmental-control measures will include active management to prevent release of harmful substances and administrative controls to appropriately-restrict site activities. The following sections describe generic active and administrative measures required to complete the project earthworks activities. Specialized control measures required for environmental remediation are described in Remediation and Treatment Options (Tab E). Specialized control measures related to unique earthworks activities are described in in this Plan.

H.4.1.2.1 Erosion, Sediment Control, and Stormwater Management Devices

Soil erosion and sediment control measures for work completed will be installed in accordance with a soil erosion and sediment control plan. This plan will be developed as part of design activities and will detail the migration of sediment and soils from the Site. Because of the environmental quality of the soil across the Site, silt management is also critical in preventing contaminant migration and dispersion by stormwater.

For preliminary planning purposes, soil erosion and sediment controls will include the following:

- Upland work areas
  - Silt fence
  - Hay bales
  - Rock fill filtered check dams
- Stabilized construction entrances
- River Valley and open water work areas
  - Suspended turbidity barriers (silt curtains)
  - Floating adsorption booms to control hydrocarbon sheen

It is anticipated that temporary stormwater management features (such as, berms, diversion ditches, and shallow settlement valleys) may be necessary to divert stormwater runoff around work areas, collect stormwater discharges from the construction site, and convey stormwater for offsite discharge.

Stormwater discharge from the Site will require an Environmental Compliance Approval as temporary sewage work. Continuous water quality monitoring will be required in compliance with the project Environmental Management Plan.

H.4.1.2.2 Air Monitoring

Organic vapour and airborne particulate (dust) monitoring will take place in accordance with the site-specific Air Monitoring Plan that will be developed. Air monitoring instrumentation will be positioned within the work zone and at the perimeter of the work areas where ground disturbance is occurring. Air monitoring within the work zone will be performed to evaluate air quality (levels of contaminants and airborne particulate) for worker health and safety protection. Air monitoring stations will be established at upwind and downwind locations along the perimeter of the Site. Air monitoring will be done to confirm site activities are not negatively impacting air quality. Before initiating major construction activities that could influence air quality, baseline air quality characterization will be required to compare air quality measured during construction activities.

To reduce the risk of unacceptable dust and odour (vapour) emissions, suppression measures will be implemented as necessary during work activities. Dust control measures could include:

- Stop dust-generating activities when sustained winds speeds and gusts exceed trigger levels defined in the project Environmental Management Plan.
- Mist potable water in the air or wet disturbed surfaces that generate dust.
- Apply odour-suppressant foam or ground cover on excavated soils that generate odours and/or volatile vapour.
- Activate perimeter-misting systems to mask or mitigate odours at the Site boundary.

H.4.1.2.3 Work Zones and Decontamination Areas

Establishing suitable work zones will be necessary to limit the potential for workers exposure to contamination, to protect the public and surrounding environment from site hazards, to prevent unauthorized entry into the work area, and to avoid spread of contamination. To accomplish these goals, the Site will be divided into the following three zones: Support Zone, Contamination-reduction Zone, and Exclusion Zone. The location of the Support Zone will be established to allow access to the Contamination-reduction Zone, to reduce traffic flow in the Contamination-reduction Zone, and to reduce potential exposures to site hazards.

The Support Zone will contain the construction trailers, portable toilets, potable water, and imported supplies and materials. All traffic entering and leaving the Site will pass through this zone. Access to the Support Zone will be restricted to individuals involved with the project. Access to the Contamination-reduction Zone and Exclusion Zone will be limited to project personnel with requisite training. In addition, truck drivers delivering fill material and transporting excavated materials will also be permitted within the Contamination-reduction Zone and Exclusion Zone. These individuals will be confined to the cab of their trucks and will not be permitted to exit the truck until they have entered the Support Zone.

A Contamination-reduction Zone will be established between the Exclusion Zone and the Support Zone. Allowing the Contamination-reduction Zone to be constructed next to the Support Zone enables the movement of equipment and personnel in and out of the excavation area. Equipment and personnel decontamination activities will occur in this zone. Temporary decontamination pads will be constructed near the active work zone to facilitate decontamination of equipment that comes in contact with contaminated soil or water. The decontamination pads will consist of a bermed and lined area with a sump that will be constructed at the lowest point, and will facilitate the collection of decontamination water. Water generated during decontamination procedures will be containerized for proper offsite disposal. Personnel decontamination stations will also be established with hand wash, boot wash, and eye wash stations for construction personnel that come in contact with contaminated soil or groundwater. The decontamination stations will be temporary, portable structures designed for the intended purpose and easily remobilization.

H.4.1.3 Site Preparation

Following mobilization to Site, the Site will be prepared for construction activities. The following sections describe activities that will be completed as part of site preparation.

H.4.1.3.1 Establishment of Survey Controls

Historical survey benchmarks with geodetic points will be used to establish survey controls for construction. Construction layout surveys, including bathymetric surveys, will be performed as necessary to establish excavation limits, depths, and grades to maintain horizontal and vertical control of the Site. In addition, a final survey will be conducted to document as-built conditions. Surveying will be performed by a registered land surveyor using documented methods and survey control points to describe data accuracy.

H.4.1.3.2 Utility Location and Relocation and Abandonment

Major utility locations for sanitary and storm sewer and water main services have been provided by Waterfront Toronto. The earthworks sequencing has been prepared to avoid service disruptions during the project and to switch from existing services to future services during the last phase of the project.

Utility location will be completed by a utility location subcontractor to locate and identify all utilities and other anomalies within the limits of disturbance. It is anticipated that ground-penetrating radar and electromagnetic technologies could be employed to identify locations of subsurface utilities. Test pitting using soft dig methods (for example, air knifing) would be used as necessary to confirm utility locations. Utilities within or near the limits of disturbance will either be abandoned or relocated to accommodate excavation activities. Electrical utilities that are to be abandoned will be de-energized and locked out before the removal of the conduits and wiring. Valves of piping utilities that are to be abandoned will be closed to facilitate abandonment; piping will then be removed and capped before mass excavation. Pipes that are to be left in place will need to be filled and plugged with slurry cement or bentonite slurry before abandonment. Utilities that are needed to maintain service to facilities outside of the limits of disturbance will be relocated with no disruption to service.

H.4.1.3.3 Demolition of Structures

There are some historical buildings around the Site; however, those buildings are outside the proposed River Valley excavation boundaries. All other aboveground and at-grade structures within the limits of disturbance will be demolished to facilitate excavation activities. Before demolition, universal waste removal, lead abatement, and asbestos abatement will be performed as needed within buildings; these materials will be managed and disposed appropriately in accordance with applicable laws and regulations. Material from structure demolition will be segregated for recycling, disposal, or reuse during Site redevelopment activities.

H.4.1.3.4 Monitoring Well Abandonment

Groundwater monitoring wells within the limits of disturbance will be abandoned by a licensed well contractor in accordance with Ontario Regulation (O. Reg.) 903, before initiation of excavation activities. Where possible, well casings will be removed while continuously backfilling the annular space with Portland cement or cement/bentonite grout sealant. Well casings that cannot be removed will be plugged by pumping sealant into the well’s inner casing using a tremie pipe that discharges at the bottom of the well. The sealing material will be pumped into the monitoring well until the water is displaced and the sealing material overflows the inner casing. The driller will inspect the grouted wells at least 24 hours after the initial sealing to evaluate if settling of the grout has occurred. If settling has occurred, additional sealing material will be added.

H.4.1.3.5 Clearing and Grubbing of Vegetation

Vegetation within the limits of disturbance will be cleared in advance of excavation activities. All trees, shrubs, and bushes located in and around the excavation limits will be removed to allow access and facilitate excavation and project activities. Woody material will be chipped, if needed, and reused onsite for soil erosion control purposes or mulch for future tree plantings. Stumps and roots within uncontaminated areas will be grubbed and grinded for reuse as mulch for future plantings; stumps and roots from contaminated areas will be assumed to be impacted and will be appropriately sized and handled for offsite disposal at a permitted landfill.

It is proposed that a survey of mature trees outside the excavation limits is conducted to determine the possibility of saving such trees.

H.4.1.3.6 Stripping and Stockpiling Topsoil

In areas where topsoil environmental quality criteria for immediate reuse is acceptable, topsoil will be stripped and stockpiled for future reuse. Existing and future sampling data will be used to delineate topsoil areas that are suitable for reuse.

H.4.1.4 Material Handling

Material to be handled by earthwork activities includes excavated soil, fill and backfill required to construct the infrastructure, and flood-protection elements. Materials will be hauled to destination sites by standard or articulated dump trucks. Truck type and size will vary based on area of work, transport destination and route-required productivity. Truck destination will be selected based on processing requirements to address moisture content, environmental quality, and geotechnical properties before reuse. Unsuitable materials such as waste debris may be loaded and directly transported for offsite disposal. Wet soil will be transported for processing in water-tight truck beds to avoid spread of potential contaminants. It may be practical in some areas to allow the excavated wet soils to gravity drain near the excavation zone before loading for transport, to avoid risk and cost of hauling excessive water. The decision to drain before hauling will be dependent on the constraints of the work zone and distance from the soil processing facility. Gravity drain process will be carried out in a contained, bermed area to collect the drained water. This process may become possible along the eastern to western alignment of the proposed River Valley, where sandy soils have been identified.

To reduce the risk of spillage, trucks carrying wet soil will be loaded to less than the rated load capacity; therefore, these trucks should be expected to run below optimal productivity.

H.4.1.4.1 Truck Haul Routes

Onsite construction equipment and traffic will be contained to dedicated haul roads. Haul roads will be constructed using locally available soils to maintain a safe flow of construction traffic throughout the site. Traffic control measures will be implemented to allow safe site operations while completing construction activities. Haul roads will be temporary in nature but constructed to support the intended duty. Haul roads in and around excavation zones will be designed to support hauling materials into and out excavation zones and may require granular surfaces to provide appropriate running surfaces. Roads will be progressively constructed and decommissioned as construction progresses. Roads will be environmental controls to avoid spreading contaminants.

Construction traffic will traverse Cherry Street, Commissioners Street, Villiers Street, Polson Street and Don Road Way at various stages of the project to transport processed soil from the SPF to filling locations and to import/export offsite materials. It is assumed the existing public roads can support anticipated traffic. However, existing conditions of the roads require an assessment to find out if they can sustain future increased traffic due to material haulage or if they require upgrades or modifications.

Haul routes will be identified based on available existing routes and proposed temporary routes to minimize travel distance and promote sustainability.

H.4.1.4.2 Water transportation

Transport of some materials to and from the project by barge/ship may provide value (cost, sustainability, socio-economic). Specific materials and potential benefits should be evaluated during subsequent design phases.

H.4.1.4.3 Stockpiles

Stockpiles will be generated and managed as described in the Soil Management Plan (Tab F).

H.4.1.4.4 Load tracking

Tracking soil movement will be important to optimize soil reuse, manage contaminated soils, endorse sustainability and document construction activities. Conceptually materials hauled within the limit of work and exported from the site would be monitored and tracked using electronic tracking and monitoring systems. Hauling trucks will be equipped with a Global Positioning System tracking systems and onboard load monitor to efficiently monitor material origin, destination, and quantities. Load data would be retained and analyzed to support quality assurance and quality control.

H.4.1.5 Fill placement and compaction

Preliminary fill types and the specified properties are described in the Geotechnical Conditions report (Tab D). Fill will be placed in a controlled fashion using standards methods based on material type and design specifications for compaction. Refer to Tab D for geotechnical requirements for specific material types. Table H2 provides the fill placement and compaction.

Table H2. Fill Placement and Compaction

Material type	Compaction comment	Typical Equipment
Structural fill	Specified minimum compaction	Smooth drum, vibratory roller
Controlled fill	Specified minimum compaction	Smooth drum, vibratory roller
Clay	Specified minimum compaction	Sheeps foot roller
Road Base material	Specified minimum compaction	Smooth drum, vibratory roller
Topsoil	Avoid compaction	Small light dozer
Wetland soil	Avoid compaction	Small light dozer

H.4.2 Upland Earthworks and Infrastructure Construction

Upland earthworks consist of work completed outside the River Valley necessary to install new services and utilities and construct flood protection landforms. Major earthwork elements specific to this area include construction of new infrastructure (roads, water/wastewater, stormwater) and raising grades to achieve flood protection requirements. Utilities include conveyance pipelines and pump stations as well as support shafts necessary for trenchless construction methods. Excavation of contaminated soils to support environmental remediation will also be necessary to support the project.

H.4.2.1 Excavation Methods

The construction approach proposed to install new infrastructure and roads addresses poor geotechnical ground conditions (loose sands), high groundwater table and potential presence of contamination within the shallow soils. Preliminary excavation methods for major infrastructure elements are presented in Table H3.

Table H3. Preliminary Excavation Methods

Element	Excavation Depth	Preliminary Excavation Method	Comment
Shallow utilities (gas, power, communication, water supply) roads	• 1.5 to 3 metres below final ground surface elevation. Above groundwater water table.	• Open cut using conventional excavator.	• May require shoring in soft sands and areas with limited access. • May encounter contaminated soil and fill during excavation.
Deep utilities (sewer and oil and grit separator)	• 3 to 13 metres below final ground surface; 2 to 11 metres below groundwater table.	• Open cut with shoring and active dewatering using conventional excavator.	• Lose sand soils and shallow groundwater table will require sheet pile shoring and active dewatering with well points or eductors to stabilize excavation. • Dewatering will extend 0.5m below excavation base to provide dry working surface and reduce washout risk.
Pump stations	• Up to 15 m deep, 14 m below groundwater table.	• Secant pile shaft constructed at each pump station location • Shaft excavated with conventional excavator after secant wall is constructed	• Shafts will be constructed with secant pile walls founded in the bedrock to control groundwater and excavation stability. • Little or no active dewatering required.
Deep sewer crossing constructed River Valley	• Up to 15m deep, 14m below groundwater table.	• Sewer installed by micro-tunneling using micro-tunnel boring machine. • Secant pile shafts constructed at launch and receiving sites. • Shaft excavated with conventional excavator after secant wall is constructed.	• Shafts will be constructed with secant pile walls founded in the bedrock to control groundwater and excavation stability. • Little or no active dewatering required.
Environmental remediation	• Above water table. • Up to 5 m below ground surface, 4m below groundwater table.	• Open excavation using conventional excavators. • Excavation faces sloped to stable geometry based on material (up to 4:1 for loose soils). • Shoring were excavation area is restricted. • Material segregation will be completed at excavation zone with mobile screening plant.	• Shallow soil geotechnical properties vary. • Excavation of material below the water table will proceed in the wet because of high groundwater yield. Dewatering is not expected to be practical.

H.4.2.2 Fill Placement Methods

Fill placement within the upland work area is required to:

- Construct the designated flood-protection landforms (flood protection landform and valley wall feature) located on the eastern side of the Don Roadway.
- Raise grades in areas other than the designated flood-protection landforms. These areas surround the Villiers Island development block and include land creation at Essroc Quay.

Fill placement will be carried out generally in following the sequence plan. Fill materials will be placed using conventional equipment and following specific sequence and methods necessary to control settlement and consolidation of the underlying fill and native sediments. Preliminary approaches to complete fill placement and manage ground stability are presented in Section H.5.

Depending on the quality of excavated soils, and before reuse and placement, portions of these materials may have to be amended, possibly by adding additives or cement.

H.4.3 River Valley Earthworks and Construction

River Valley earthworks consist of activities required for construction of the River Valley. Earthworks requires excavation and placement of materials required for landscape construction above and below the water table. Major earthworks elements include excavation to the final excavation grades, backfilling to replace over-excavated materials and achieve landform shapes and installation of channel armoring and landscape features.

H.4.3.1 Constraints for Excavation Method Selection

Soil conditions within the River Valley excavation zone are challenging for excavation. The following factors and constraints were considered and influenced the excavation methodology selection:

- The overburden aquifer is near ground surface and extends in a single continuous unit to the bedrock surface at depth.
- The native overburden mostly consists of wet fine sands with relative density of very loose to loose for the most part that will not support steep excavation faces. Pore pressure within the sand unit caused issues during borehole investigation, which will contribute to instability of this unit during excavation.
- Aquifer yield and the excavation size will result in very high groundwater inflow into the excavated areas making dewatering without groundwater control impractical.
- Unconstrained dewatering could result in unacceptable subsidence in areas outside the excavation zone increasing risk to existing structures, buildings and utilities.
- Groundwater control measures such as cut-off walls are costly because full containment will be required and they would need to be constructed around the entire excavation footprint and extend from ground surface into bedrock to effectively reduce groundwater inflow.
- If a full containment wall is constructed to minimize groundwater flow into the excavation zone, parts of the Cut-off walls (crossing the river valley section) would need to be removed following construction of the River Valley to re-establish natural groundwater flow conditions resulting in additional cost.

H.4.3.2 Excavation Methods

Based on review of the proposed finished grading plan for new River Valley in the context of the constraints identified within the limits of work, two approaches are proposed for excavation and fill placement. In general the excavation methods proposed are:

- Existing grade to a depth of up to approximately 2.5 m into water table using conventional bucket excavators operating from land
- Depth of 2.5 m into water to final excavation grade using dredge equipment operating from land. The excavation will not be dewatered.

Because of the groundwater conditions at the Site and large excavation required below the water table, dewatering the River Valley excavation is not expected to be practical. Excavation below the water table will progress “in the wet” without dewatering.

The actual depths when transition from conventional excavators to dredge may change based on productivity rates, final excavations depths of a work area and overall excavation geometry. The proposed transition point of 2.5 m was selected as an average depth for planning purposed based on the assumed practical reach of a standard reach excavator and 4H:1V to 5H:1V expected excavation slope of loose sands in still water.

As noted in Section H.3, to the extent practical, excavation required for soil remediation will be completed prior to starting excavation of the River Valley to reduce potential for contaminant migration and cross contamination. The specific sequence of excavation activities will be planned on an area by area basis based on remediation needs and excavation requirements for landscape construction.

H.4.3.2.1 Dry Excavation

Excavation within the River Valley will include different methods for soil above and below the water table. Excavation from the existing ground surface to the elevation of the water table will be performed using conventional large capacity earthwork equipment such as track mounted excavators. The excavated material will be predominately dry and able to be transported and stockpiled without significant drying or conditioning. Additionally, use of traditional earthwork equipment will facilitate segregation of excavated materials at the excavation face based on physical property, presence of environmental contamination and reuse value. Once the materials are excavated and confirmed acceptable in terms of their geo-environmental conditions, they will go through a screening process to get sorted based on their size. The screened and sorted material will then be used as fill onsite, based on fill criteria requirements. If the excavated material requires treatment, a separate treatment process will be taken to address the contaminants.

H.4.3.2.2 Wet Excavation

Excavation below the water table to the final excavation grade could be completed with conventional excavator buckets until productivity is slow and dredging equipment can operate efficiently. Numerous dredging approaches and equipment are commercially available to execute underwater excavations. For this project mechanical dredging using a crane-mounted clamshell bucket has been identified due to their longer reach span of near 25 m max. The dredge crane would be track-mounted and operated on dry land. Most of the excavation will be done to a depth of about 4 m below groundwater table, therefore having a limited amount of draft for a clamshell float operation. As a gentle slope if 5H:1V is predicted for the soft/loose wet native material, and due to limited span reach, construction of temporary rockfill finger berms will be required in some areas to add to the excavators reach. Depending on the location of the rockfill berms, they can either be left in place and become permanent river bank protection elements or get removed and re-used as rockfill berms in other locations. Based on current design the excavation zone near the Polson Slip will have up to 8 m of water depth at the excavation front which will be able to support a clamshell float and barge operation.

Although clamshell dredging is a slower operation than other dredge types such as hydraulic dredging, clamshell dredging provides the following advantages over hydraulic dredging:

- Segregation of soil material types within distinguishable soil strata or chemistry profiles;
- Lower water content of dredged material, thus reducing effort needed to dry post-dredge material
- Ability to conduct excavation from shore avoiding the need for barge mounted equipment in the confined River Valley
- Same equipment and work approach can be used to complete fill placement and landscape construction

Prior to excavating the main valley channel, some channel amour elements may be constructed by trenching. These elements running parallel to the River Valley would be constructed by excavating trenches and backfilling with specified amour rock at the required 2H:1V sloped toward the River Valley. The berms would act as shoring elements to improve excavation geometry stability thereby reducing overall excavation and backfill volumes. The berm surface could also serve as stable haul roads during excavation and restoration activities. This approach requires further analysis as design progresses to determine if there is cost saving and overall benefit to River Valley construction. The summary of redge method alternatives is presented in Table H4.

Table H4. Summary of Dredge Method Alternatives

Dredge type	Advantages	Disadvantages	Comment
Hydraulic	• Faster • Direct pumping to disposal or dewatering facility • Greater turbidity control during dredging resulting from dredge suction • Commonly used for environmental remediation dredging	• Typically barge mounted (requires draft) • Debris can become an issue • higher water content of dredged material and large volumes of dilution water	• Secondary approach to be further evaluated as part of detailed excavation design
Mechanical	• can operate from barge or land • Capable of removing stiff material • Can remove debris • Can work in tight areas and from land • Easy mobilization • Greater ability to segregate material during excavation • Lower water content dredged material • Commonly used for environmental remediation dredging	• Lower productivity	• Preferred based on the preliminary excavation design
Barge mounted dredge	• Reach is unlimited in areas with minimum draft	• Very limited open water for barge and support vessels to operated • Requires transfer barge • Need docking area to load/unload transfer barge	• Impractical for preliminary excavation geometry
Dry land positioned dredge	• Dredge can load hauling truck directly	• Reach is limited by soil behavior, equipment and shore configuration	• preferred option based on preliminary excavation geometry

Dredge production efficiency is a function of bucket capacity and bucket travel time from excavation face to unloading area. A limiting factor completing the excavation and filling program from dry land is the expected slope geometry. The maximum slope expected for excavation of the native loose sand in still water is 4:1 and in some areas may result in 5:1 slopes. To excavate 5 m deep in these conditions from dry land will require the dredge to be positioned up to 25 m back from the bottom of the excavation. For preliminary planning purpose a crane dredges with a minimum horizontal reach of 20 m was assumed. To overcome this reach restrictions and improve efficiency, the dredge size and position will be selected during detailed design and construction planning to maximize the working area and maintain efficient material handling.

Conceptually the rockfill finger dikes would be constructed of average 300 mm diameter rock, waste concrete or precast concrete blocks that are able achieve steeper face slopes of minimum 2H:1V and allow the crane dredge operation to extend further into the River Valley excavation zone than would be achievable working from the native sediment surface.

The dredge would cast directly to articulated dump trucks positioned in loading zones adjacent to the fingers for hauling to the soil processing facility. The rockfill finger dikes would be used to place backfill/fill for restoration activities and then recovered as restoration progressed toward shore. The rockfill finger dike material could be reused for construction of subsequent pads.

A physical sweep (Bathymetric survey) of dredged areas will be conducted to confirm the excavation meets the excavation design grades and specifications for ground elevation and conditions prior to commencing backfilling and landscape construction.

H.4.3.2.3 Temporary Excavation Support

In most areas native soil conditions may not allow the required sloping for the excavation faces needed to construct the River Valley elements because of limited space and adjacent infrastructure. Excavation faces may require localized temporary support or shoring systems to control excavation geometry and improve excavation face stability. Temporary shoring would be constructed to provide soil support only and is not intended reduce groundwater inflow.

The MVVA design includes permanent sheet pile installed parallel to the River Valley to act as a temporary shoring system and permeant erosion barrier. The sheet pile will provide shoring during excavation to manage slope geometry and reduce the excavation volume. The sheet pile will remain in place after valley construction to serve as burrier erosion barrier under flooding conditions. It will be installed prior to excavation of the River Valley

H.4.3.2.4 Turbidity Control

Water turbidity during dredging activities needs to be managed to avoid mobilizing environmental contaminants and disturbing completed excavations. Turbidity will be managed by reducing the amount of sediments resuspended and containing sediment that is resuspended to the active work zone.

To reduce sediment suspension caused by overfilling and spillage from the bucket an enclosed “environmental” clamshell bucket would be used to reduce resuspension. Environmental buckets provide a tighter seal than conventional buckets reducing leakage and allowing for more controlled sediment handling. Environmental buckets also reduce the volume of water removed with the excavated materials that will need to be removed from the soil and processed.

Turbidity that is generated in the water of the active work zone would be contained using suspended turbidity barriers (silt curtains) positioned a few meters inside the maximum reach of the dredge. The curtain include a float and ballast system to provide a suspended vertical barrier that can be deployed around the work zone to contain suspended particles. It will be moved progressively with the excavation positioned to protect areas where target excavation depths have been achieved. The barrier will remain in place until filling activities are complete within the containment zone. Prior to disturbing a new area, the barriers will be redeployed to isolate the new work zone.

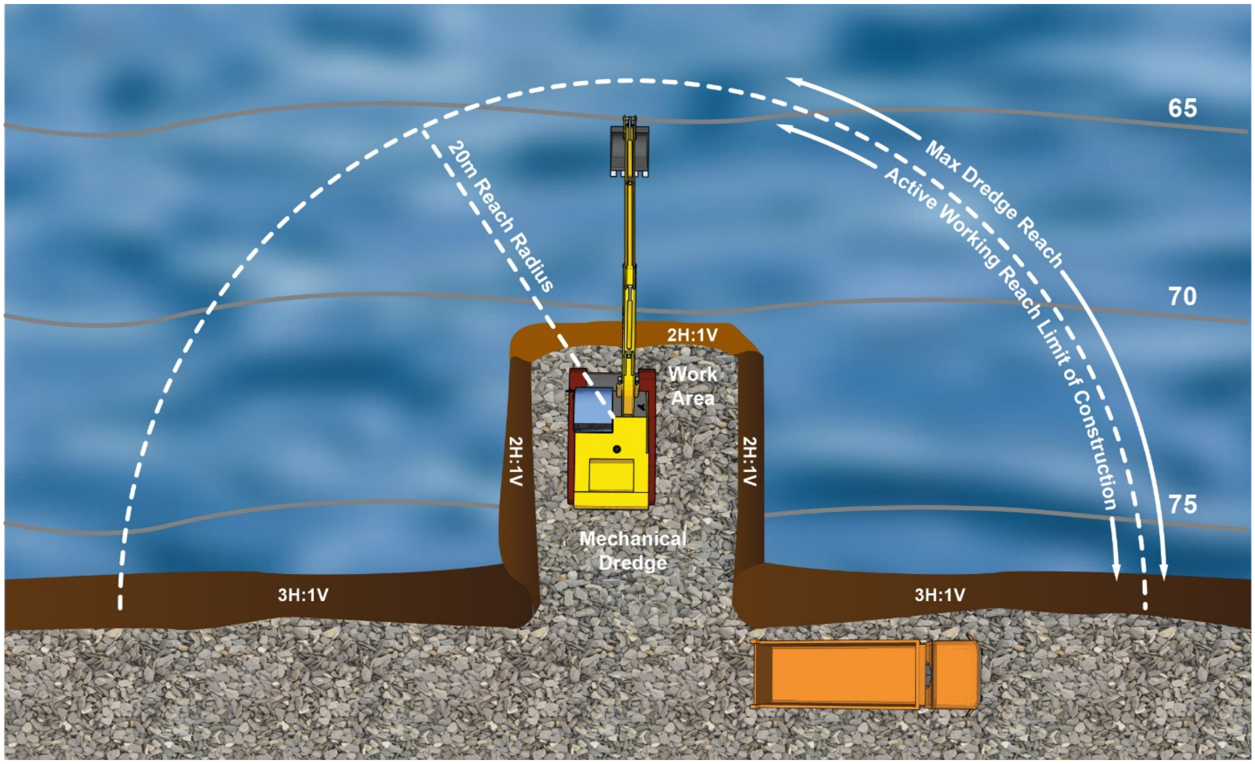

Exhibit H1. Schematic Dredging Operation Plan View

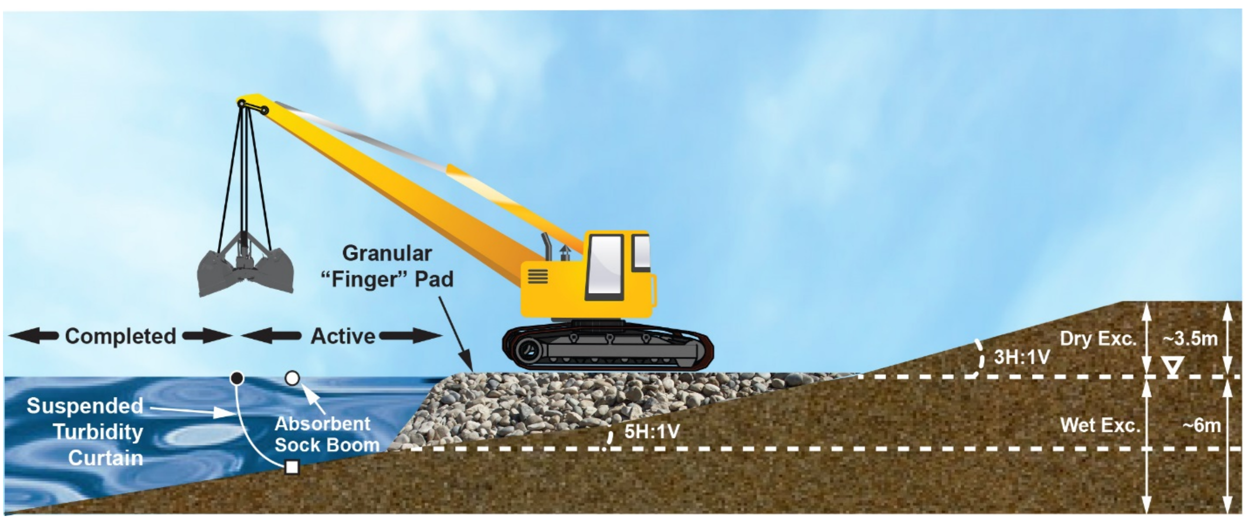

Exhibit H2. Schematic Excavation Geometry

H.4.3.2.5 Environmental Contamination Control

Environmental contamination is prevalent in several areas of the River Valley excavation zone. To extent practical, environmental remediation will be completed prior to dredging the River Valley to reduce the amount of contamination that could be released into excavation zones during dredging activities. Preliminary plans to manage environmental quality of water in the River Valley during excavation are presented in Tab E. When working in potentially contaminated materials, designated work zones and equipment decontamination procedures will be implemented to reduce worker exposure and the potential for cross contamination or environmental release.

H.4.3.2.6 Excavation under Bridges

For preliminary planning purposes it is assumed the foundations and decking for the South Cherry Street and Commissioners Street Bridges across the greenway and Don River will be constructed prior to excavating to the final excavation depths required for the River Valley in the area. Some excavation may be required during bridge construction prior to excavating the new river channel. The sequence of activities related to bridge and River Valley construction will be further developed as part of ongoing design. The following section describes conceptual approaches to River Valley construction around the new bridges.

H.4.3.2.7 Commissioners Street Bridge

For preliminary planning purposes it is assumed Commissioners Street Bridge will be constructed prior to excavating the soil directly beneath it to form the River Valley. Soil excavation under the bridge to construct the River Valley will be completed using smaller sized conventional excavators and mechanical dredge. Soil on the west side of the bridge and within reach directly beneath the bridge would be excavated from a barge stationed in Polson Slip. Soil on the east side of the bridge and within reach directly beneath the bridge would be excavated from a barge stationed in the River Valley. Excavation from shore would also be completed to reduce the need for barge operations. Suspended silt curtains will be used to contain turbidity. Temporary shoring may be required to support soil during excavation to avoid undermining the bridge foundations.

H.4.3.2.8 South Cherry Street Bridge

For preliminary planning purposes it is assumed South Cherry Street Bridge will be constructed in an operation prior to excavating the soil directly beneath it to form the River Valley. Excavation of soil under the Cherry Street Bridge to form the River Valley will be completed using smaller sized conventional excavators and mechanical dredge. Soil on the west side of the bridge and within reach directly beneath the bridge would be excavated from a barge stationed in Polson Slip. Soil on the east side of the bridge and within reach directly beneath the bridge would be excavated from a barge stationed in the River Valley. Excavation from shore would also be completed to reduce the need for barge operations. Suspended silt curtains will be used to contain turbidity. Temporary shoring may be required to support soil during excavation to avoid undermining the bridge foundations.

The dock wall would be removed progressively with the excavation in a controlled manner to avoid slope destabilization or wall failure.

H.4.3.3 Marine Wall Removal and Opening the River Valley to Lake Ontario

Section of existing marine walls in Keating Channel and Polson Quay will be removed to connect the new River Valley to Lake Ontario. A section of the marine wall in the Shipping Channel will be removed to connect the Greenway to Lake Ontario. Specific designs for interim conditions and removal will be completed as part of ongoing design by the Marine Engineering Consultant (Riggs). For preliminary earthworks planning it is assumed the walls can be altered as excavation progresses. Excavation of soils against the marine will be completed using conventional excavators or mechanical dredge equipment.

To achieve the preliminary design grades and support placement of channel armour the native loose sand will be over-excavated and backfilled with appropriate fill material.

H.4.3.4 Material Handling

Material from dry excavations will be handled as described in Section 4.1.3.

Dredged soil will have high water content and will have specific handling and processing requirements prior to reuse. Soil will be hauled to the soil processing facility in articulated dump trucks with water tight payload beds. To reduce risk of spillage, trucks will be loaded to less than the rated load capacity therefore should be expected to run below optimal productivity. Organic soils with high silt and muck content may stick to truck beds and require plastic bed liners to maintain typical offloading efficiency and rounding cycles.

For preliminary dewatering of the dredged material a prepackaged mobile dewatering system (Deltank Total Clean System) has been envisaged. CH2M has successfully used this system in similar dredging projects. The system is capable of removing oversized debris if present. The wet slurry is then pumped to a series of hydrocyclones/shaker units, where the sand size material is segregated and the remaining solids are sent to the pump suction for additional solids removal. The remaining effluent which has now been reduced considerably compared to the original flow volume can then be treated with polymer and thickened in clarifiers. The thickened underflow can then be sent to either geotextile tubes or filter presses for further dewatering. The Deltank system will be part of the soil processing facility as shown in Exhibit F4 of the Soil Management Plan report (Tab F).

The preliminary river channel design prepared by MVVA includes several armoring strategies to provide river channel stability. Materials specific to river channel include large rock (1m diameter) and wood elements to be placed within the constructed landforms. Conceptually these materials would be placed using conventional and long-reach excavators. Temporary access roads, specific equipment and positioning strategies may be required for some materials and placement zones that will be developed as the design evolves. In extreme cases cranes could be used for precise placement if preferred equipment cannot be stages close enough to the placement zone.

H.4.3.5 Fill Placement and Compaction

Various fill types and construction material are needed within the River Valley to achieve the final landscape design. Tab D describes specific conceptual property of the fill types anticipated for construction. Because much of the excavation will be completed below the water table, fill will need to be placed in water. Fill and backfill placement in water requires specific material types and placement methods to achieve stable landforms and avoid future settlement. Fill placed below water level will consist of clean granular material with low fines content requiring no active compaction.

Where possible, fill will be placed progressively following dredging of an active work area. Filling will be completed by the dredge or excavator with a bucket appropriate for the type of fill being placed or end – dumped where equipment can access fill zones. Fill materials would be delivered to the dredge for placement using the same haul roads established during excavation activities allowing work to progress out of the restored area in a controlled manner minimizing rework and repairs.

Specific fill gradations profiles or geotextiles may be required to achieve necessary compatibility between native soils and fill materials to achieve stable landforms, prevent the native sand from flowing through larger diameter fill materials or prevent fill from sinking in to the native sand or soft organic soils.

H.5 Ground Stabilization

Site overburden consists of loose poorly graded sands, compressible soils and organic deposits. These conditions can result in consolidation if surface loads are increased relative to current conditions, if organic matter continues to degrade over time and in response to changes in pore water pressure.

For the purposes of this assessment, the term ‘organics’ or ‘organic material’ are being used for material layers described in the TRCA database as ‘muck’, ‘peat’, and ‘organic’. Each of these layers could contain material containing methanogenic bacteria and organic material that could be broken down through anaerobic degradation to produce methane, hydrogen sulfide, or carbon dioxide gases.

Figures show the distribution of peat and organic soils across the Site.

H.5.1.1 Settlement Considerations

Geotechnical subsurface conditions were reviewed at the various locations within the Site area, and settlement evaluations were performed as a result of the expected grade changes. Below is a discussion regarding areas: (i) the Northeast Area of the Site; (ii) the Southeast Area of the Site; (iii) North Side of the Don River East-West Segment; (iv) South Side of the Don River East-West Segment; (v) West End of the Site, South of Essroc Quay; and (vi) Essroc Quay.

H.5.1.1.1 Northeast Area of the Site

The available subsurface data indicates the largest thickness of compressible soils at the Site are present in the northeast corner, in the area of Don Roadway and Commissioners Street. Up to 5 m compressible soils were encountered in this area. The proposed regrading plan indicates approximately up to 2 m of fill material will be placed in this area. Settlement analyses indicate approximately 310 mm of primary consolidation will result from the filling, and for 90% consolidation to be completed a period of approximately 20 months will be required. After primary consolidation is completed, secondary compression can be expected due to breakdown of the organic matter present in the compressible cohesive soils. Approximately an additional 100 mm of settlement can be expected long term onsite. Therefore, over the life of the project, a total of 410 mm of settlement can be expected at the northeast area, where the organic compressible soils are approximately 5 m thick. Note this estimated settlement is due to the proposed regarding work, and does not consider any future additional loads, or live loads in the area.

Within this portion of the Site, the area with 5 m of compressible organic soils is limited; the majority of the northeast area has 3m of compressible organic soils or less, with an average fill thickness of about 1 m. For these areas, the settlement analyses indicate approximately 110 mm of primary consolidation will result from the filling, and for 90% consolidation to be completed a period of approximately 8 months will be required. After primary consolidation is completed secondary compression can be expected; approximately an additional 70 mm of settlement can be expected long term in the area. Therefore, over the life of the project, a total of 180 mm of settlement can be expected at the northeast area, where the organic compressible soils are approximately 3m thick, or less. Note, again this estimated settlement is due to the proposed regarding work, and does not consider any future additional loads, or live loads.

H.5.1.1.2 Southeast Area of the Site

The available subsurface data indicates the presence of compressible soils at the southeast area of the Site, east of Don Roadway. Up to 2.5 m compressible soils were encountered in this area. The proposed regrading plan indicates approximately 2 m of fill material will be placed in this area. Settlement analyses indicate approximately 150 mm of primary consolidation will result from the filling, and for 90% consolidation to be completed a period of approximately 6 months will be required. After primary consolidation is completed secondary compression can be expected; approximately an additional 70 mm of settlement can be expected long term onsite. Therefore, over the life of the project, a total of 220 mm of settlement can be expected at the southeast area, where the organic compressible soils are approximately 2.5 m thick.

Within this portion of the Site, the area with 2.5 m of compressible organic soils is very limited; the majority of the southeast area has 2.0 m of compressible organic soils or less, and will receive only 0.5 m of fill as part of the regrading. For these areas, the settlement analyses indicate approximately 36 mm of primary consolidation will result from the filling, and for 90% consolidation to be completed a period of approximately 4 months will be required. After primary consolidation is completed, secondary compression can be expected; approximately an additional 60 mm of settlement can be expected long term in the area. Therefore, over the life of the project, a total of 100 mm of settlement can be expected at the southeast area, where the organic compressible soils are approximately 2.0 m thick, or less, and filling will consist of 1m. Note, again this estimated settlement is due to the proposed regarding work, and does not consider any future additional loads, or live loads.

H.5.1.1.3 North Side of the Don River East-West Segment

The available subsurface data indicates the presence of compressible soils at the north side of the new Don River East-West Segment. Up to 3.5 m compressible soils were encountered in this area. The proposed regrading plan indicates approximately 1 m of fill material will be placed in this area. Settlement analyses indicate approximately 160 mm of primary consolidation will result from the filling, and for 90% consolidation to be completed, a period of approximately 10 months will be required. After primary consolidation is completed, secondary compression can be expected; approximately an additional 80 mm of settlement can be expected long term in the area. Therefore, over the life of the project, a total of 240 mm of settlement can be expected at area north of the new Don River.

H.5.1.1.4 South Side of the Don River East-West Segment

The available subsurface data indicates the presence of compressible soils at the south side of the new Don River East-West Segment. Up to 2 m compressible soils were encountered in this area. The proposed regrading plan indicates approximately 1 m of fill material will be placed in this area. Settlement analyses indicate approximately 76 mm of primary consolidation will result from the filling, and for 90% consolidation to be completed, a period of approximately 4 months will be required. After primary consolidation is completed, secondary compression can be expected; approximately an additional 60 mm of settlement can be expected long term in the area. Therefore, over the life of the project, a total of 140 mm of settlement can be expected at area south of the new Don River.

H.5.1.1.5 West End of the Site, South of Essroc Quay

The available subsurface data indicates the presence of compressible soils at the west end of the Site at Lake Ontario, and south of Essroc Quay. Up to 3 m compressible soils were encountered in this area. The proposed regrading plan indicates approximately 1.5 m of fill material will be placed in this area. Settlement analyses indicate approximately 240 mm of total settlement will result from the filling, and for 90% primary consolidation to be completed, a period of approximately 8 months will be required.

A summary of the estimated settlements and additional fill required are provided in the following table:

Preliminary estimated settlements and additional fill required for settlement compensation are presented in Table H5.

Table H5. Preliminary Estimated Settlements and Additional Fill Required for Settlement Compensation

Area	Potential Average Settlement	Estimated Additional Fill Volume to Compensate for Settlement (m^3)	Estimated Timeframe to Achieve 90% Settlement (months)	Potential Implications	Management Approach	Risks
Northeast Area of the Site	• 180 mm in most areas • Isolated areas where compressible soils are approximately 5m thick may experience 410 mm of settlement	8,000	areas with less than 3m of compressible soil: 8 months areas with 5 m of compressible soil: 20 months	• Ground settlement after construction could affect roads and new shallow sewers installed within or above the compressible soils • No impact on deep sewer below the compressible soil • Additional fill required to compensate for estimated settlement	• Preload the sensitive infrastructure areas prior to construction of new services for an 8 month period • Include camber in the road design to accommodate long-term settlement • Accelerate treatment of areas with higher surcharge and additional design measures to accelerate drainage	• Potential construction schedule impact • Accelerating consolidation will increase cost to account for additional soil handling • Settlement estimate is approximate based on very limited data collected by others for other purposes. Specific analysis required to refine estimates
Southeast Area of the Site	• 100 mm in most areas • Isolated areas where compressible soils are approximately 2.5m thick may experience 220 mm of settlement	6,500	4 to 6	• Ground settlement after construction could affect roads and new shallow sewers installed within or above the compressible soils • Additional fill required to compensate for estimated settlement	• Preload fill areas • Consolidation time frame can be reduced by surcharging	• Potential construction schedule impact • Accelerating consolidation will increase cost to account for additional soil handling • Settlement estimate is approximate based on very limited data collected by others for other purposes. Specific analysis required to refine estimates • Area includes development block which will include other loads in the future that could result in further consolidation

Table H5. Preliminary Estimated Settlements and Additional Fill Required for Settlement Compensation

Area	Potential Average Settlement	Estimated Additional Fill Volume to Compensate for Settlement (m^3)	Estimated Timeframe to Achieve 90% Settlement (months)	Potential Implications	Management Approach	Risks
North Side of the Don River East-West Segment	• 240 mm in most areas	38,000	10	• Ground settlement after construction could affect roads and new shallow sewers installed within or above the compressible soils • No impact on deep sewer below the compressible soil • Additional fill required to compensate for estimated settlement	• Preload fill areas • Consolidation time frame can be reduced by surcharging	• Area includes development block which will include other loads in the future that could result in further consolidation • BFF facility needs to be designed to accommodate potential long-term settlement • Settlement could affect heritage buildings
South Side of the Don River East-West Segment	• 140 mm in most areas	5,000	4	• Settlement could affect Polson Road and shallow utilities if not managed	• Preload fill areas • Design roads and services to accommodate post-construction settlement	• Preload could affect schedule and period of time the road is out of service to accommodate filling
West End of the Site, South of Essroc Quay	• 100 mm in most areas and up to 360 mm	11,000	8	• Settlement could affect heritage buildings	• Preload fill areas	• Settlement could affect heritage buildings

Notes:

- The estimates provided are preliminary and for planning purposes. Assessment of compressible soils for the purpose of assessing settlement potential was completed using data contained in the TRCA database. Specific field investigations to support this assessment have not been completed.
- Some area of the River Valley wall feature south of Basin Street is currently pre-loaded and may reduce additional fill volume required to compensate for settlement.
- Some areas may have been effectively preloaded by previous land uses and activities.
- The estimated settlement value is an average value based on depth of organic layers of each are
- estimated settlement is due to the proposed regarding work, and does not consider any future additional loads, or live loads in the area
- potential effect of consolidation on naturally occurring methane should be evaluated on an area-by-area basis during detail design to determine if there are potential
- Settlement in Essroc Quay is not included in this summary. To be determined by Marine Engineering Consultant (Riggs Engineering)
- Estimated fill required to compensate for settlement does not include development block areas and settlement resulting from loads imposed by development.
- Settlement in areas with grades lowered relative to current conditions are assumed to be stable.

Depending on sensitivity of the identified areas, existing project and future development schedules, preloading and additional surcharge can be carried out to achieve the estimated settlement in faster time frames. These options can be reviewed in detail during the next stage of the project.

Most of the future building infrastructure are anticipated to be founded on bedrock, however where required special ground improvement measures to facilitate drainage of the foundation soils can also be utilized to enhance foundation conditions. These options can also be reviewed in detail during the next stage of the project, for specific areas identified by the project team.

H.6 Methane Management

The purpose of this methane management assessment is to review available Site characterization information and identify potential project risks and hazards of naturally occurring methane and related biogenic gases that may be present within Site overburden. Associated hazards were reviewed in the context of the preliminary design plans developed but will need further consideration during the detail design phase, construction and post-construction phases of the project. CH2M has not conducted physical testing or assessment of actual Site conditions. This assessment is based on the presence of methane on other sites near the Lake Ontario shoreline and Site data collected by others. To our knowledge no specific assessment related to the occurrence or mobility of biogenic gases has been undertaken within the study area. This assessment is preliminary and is intended for the design team to inform current and future project planning and design phases. It is not intended as a health and safety plan.

H.6.1 Methane

Methane is an odorless, colorless gas formed naturally by the biological decomposition of organic matter in anaerobic conditions. Naturally generated methane may be accompanied by other naturally formed (biogenic) gases such as hydrogen sulfide that have detectible odours. Methane can migrate away from the generation source in response to concentration (diffusive) or pressure (advective) gradients causing it to accumulate or be present in areas devoid of the basic requirements of its formation. In general the biogenic formation of methane requires:

- Decomposable organic matter
- Methanogenic bacteria
- Water
- Anaerobic (absence of oxygen), near neutral pH environmental conditions

H.6.2 Site Conditions related to Methane Assessment

For the purposes of this assessment, the term ‘organics’ or ‘organic material’ are being used for material layers described in the TRCA database as ‘muck’, ‘peat’, and ‘organic’. A layer of heterogeneous fill materials is present overlying the native sediments across the Site. Each of these layers could contain organic material and methanogenic bacteria that could be break down organic material through anaerobic degradation producing methane, hydrogen sulfide, or carbon dioxide gases as metabolic byproducts.

The Port Lands were originally river delta and swamp lands. Beginning in the early 1900s the area was filled in with a variety of fill materials and the existing organic materials buried under the fill to create industrial lands. As described in Tab A, a discontinuous peat/organic layers up to 6.8 metres (m) thick is present within Site overburden. Peat/organic layers can be interbedded with sandy and silty layers at localized locations. The organics layers are discontinuous across the Site and can be found at different depths. Organic layer surface elevation and thickness are shown in Figures 5 and 6.

As part of the flood protection and enabling infrastructure works the significant excavation and new construction is planned to prepare the area for future development. Through construction activities existing buried organic material will potentially be excavated, exposed or interacted with through redesigning the Port Lands. Ground disturbance related to construction activities and new construction could:

- Release pockets of previously trapped methane or other gases.
- Change the vector of methane migration into construction areas/excavations or into infrastructure (pre- and post-construction).
- Gases could become confined or trapped below ground by compressing overlying soils or reducing soil permeability.
- New sub-grade construction (such as utility corridors or building foundations) could allow accumulation of gases or provide conduit for migration.

H.6.3 Regulatory Guidance

Provincial regulations related to methane management during design and construction include:

- Regulation 213 made under the Ontario Health and Safety Act: Construction Projects
- CSA Z94.4-02: Selection, Use and Care of Respirators, Canadian Standards Association

In some circumstances methane or related gases that result in odours may be considered deleterious substances and be regulated by the Ontario Environmental Protection Act. Altering natural emissions by activities such as intentionally venting or extracting gases that include a point-source discharge structure could require an Environmental Compliance Approval (ECA) prior to altering the natural emission. The determination is made on a case-by-case basis and may require Ontario Ministry of the Environment and Climate Change consultation to determine approval requirements. An ECA is not anticipated for natural venting that is expected during general excavation activities.

Federal regulations may apply to projects with federal governmental agency involvement or oversight. It is assumed provincial occupation health and safety regulations are most directly applicable to this project.

While not strictly applicable for this Site, Ontario landfill standards for methane management included in O. Reg. 232/98 can be used a guidance for defining action levels and criteria for methane monitoring and mitigation for the Port Lands project. Specifically, Section 14 (2) of O. Reg. 232/98 provides the following action limits for methane gas:

1. *The concentration of methane gas below the surface of the land at the boundary of the site must be less than 2.5 per cent by volume.*
2. *The concentration of methane gas must be less than 1.0 per cent by volume in any on-site building or enclosed structure, and in the area immediately outside the foundation or basement floor of the building or structure, if the building or structure is accessible to any person or contains electrical equipment or a potential source of ignition.*
3. *Paragraph 2 does not apply to a leachate collection, storage or treatment facility or landfill gas collection or treatment facility for which specific health and safety measures and procedures are in place relating to the risk of asphyxiation and the risk of explosion.*
4. *The concentration of methane gas from the site must be less than 0.05 per cent by volume in any off-site building or enclosed structure, and in the area immediately outside the foundation or basement floor of the building or structure, if the building or structure is accessible to any person or contains electrical equipment or a potential source of ignition. O. Reg. 232/98, s. 14 (2).*

In the absence of regulatory requirements for methane management for the Port Lands project the above action levels could be adopted as a best management practice for the project.

Also, the Toronto and Region Conservation Authority has prepared a letter providing guidance and direction "Methane Management Plan at the Lower Don FPL (Flood Protection Landform)" dated October 5, 2012.

H.6.4 Methane Management Measures

The following preliminary management measures would be implemented during the project to address potential hazards associated with methane:

H.6.4.1 Planning and Design Phases

During design and planning, the following management measures and consideration are proposed:

- Design elements intended to intentionally event and disburse methane should be review to determine if an ECA is required for the activities. Design elements that may trigger this requirement could include:
  - Permanent venting layers or systems under structure that include a point-source exhaust structure
  - Temporary venting systems required to reduce subsurface gas pressures
  - Active gas extraction from the subsurface and dispersion to atmosphere
- Methane monitoring and management should be included in construction health and safety plans for activities where organic soils could be encountered or disturbed.
- Assess the methane hazard potential of locations around the project by conducting in situ soil gas assessment near sensitive receptors before and/or during activities that could result in ground disturbances and changes to methane movement in the subsurface. The soil gas assessment is required to assess Site-specific potential presence of trapped gas locations, of the potential for methane generation of the existing organic layers, and the ongoing hazard that could be present during and post-construction.
- In situ testing consists of characterizing subsurface gases with appropriately constructed soil probes using portable gas analyzer.
- Where methane risk is confirmed by in situ testing results, include dedicated in Methane monitoring, and mitigation into, existing, temporary and new permanent buildings, also consider sources of ignition
- Determine if there is potential added buoyancy pressure on new structures that could result from gas accumulation.
- There is a potential for subsurface methane transmission via utility corridors backfill/bedding materials. Utilize low permeable soil (or similar) backfill trench plugs to break transmission pathways.

H.6.4.2 Construction Phase

During construction the follow management measures should be implemented:

- Where possible excavation should be wide to promote air circulation. Avoid narrow deep excavation (trenches) where possible.
- If levels of methane above the guideline values are measured in excavation zones stop operations and ventilate the space. Utilize methane monitoring in equipment, also consider sources of ignition and mitigation methods during future activities within the affected work zone.
- Within in excavation or areas where methane could accumulate monitor air quality (oxygen, carbon dioxide, carbon monoxide, and hydrogen sulfide) using bulk air sampling equipment.

- Conduct methane monitoring at property boundary near sensitive receptors for offsite migration of methane, both at grade and below grade during activities that could disturb trapped gases such as preloading and surcharging soils intended to compress organic soils.
- Re-assess the potential for underground methane gas to move in new ways due to excavation, loading and water level changes during and after construction based on actual conditions encountered during construction activities.
- Adhere to confined space entry protocol when working in confined spaces such as trenches, pump stations or shafts where the accumulation of gases is possible.
- Assess bulk air quality in excavation and low lying areas for potential gases.
- Conduct subsurface monitoring near sensitive receptors such as historic building.

H.6.4.3 Post Construction Phase

After construction the follow management measures should be implemented:

- Conduct Site-specific in situ soil monitoring to assess migration potential near susceptible structures or receptors.
- Assess the need for passive and/or active sub-slab depressurization systems for all structures.
- Include methane awareness and monitoring program in operation and maintenance health and safety procedures.
- Trapped gas being released (bubbling up) when overburden is excavated or disturbed during construction.

H.7 Risks and Constraints

Major factors influencing the proposed earthworks methodology and project sequencing presented in Tab H are described in Table H6.

Table H6. Preliminary Influential Earthworks Factors and Management Approach

Factor	Risk	Management approach
Project cost and schedule is heavily influenced by cut/fill volumes: • Project design requires significant soil excavation and fill • Many project areas contain soil with poor geoenvironmental quality	• Limitations characterizing existing geoenvironmental conditions may result in actual excavation and fill volumes that vary from estimates	• Create a 3-dimensional digital elevation model for the project to support earthworks analysis in the context of geoenvironmental conditions • Run multiple scenarios to define project sensitivities and range of volumes (book-end analysis)
Existing ground conditions: • Much of the valley excavation will be in lose sand that could result in maximum excavation slopes of 4H:1V to 5H:1V. The design landscape slopes are 2:1	• Increase rock fill requirements, reduce excavation volume • Increase excavation and fill volumes.	• Over excavate and backfill with material that will achieve the required slope profile • Utilize sheet pile or other shoring system to manage excavation slopes
Interim flood risk: • Raising existing grades could cause increased flood risk to areas previous not at risk	• May increase soil handling cost to temporarily stock pile materials in areas that will not increase flood risk • Potential damage to constructed features if large event occurs during construction	• Filling program has been designed to be very flexible based on potential impact of raising grades • TRCA to evaluate filling scenarios through modeling to confirm flood risk is not increased • Delay raising grades until flood relief is provide by new drainage features • Use fill in specific areas as preload and increased surcharge, and then move them in later stages of the project
Active land uses: • Existing tenants and infrastructure to stay in service	• May result less cost efficient project sequence • Temporary servicing may be required	• Work programs have been sequenced to avoid service disruptions
Existing hydrogeological conditions: • Water table is shallow and will result in very high dewatering requirement in open excavations	• May require higher cost construction methods to avoid need for dry excavations • Lower excavation productivity • Water quality management challenges	• Excavation in the River Valley will be completed "in the wet" • Trenchless construction methods can be used selectively to reduce dewater requirement
Sustainability goals: • Work should be planned in a manner that reflects WT's sustainability policy and objectives	• Soil reuse may be expensive and technically difficult because of project constraints and timeline	• leverage international experience and emerging technologies
Design excellence: • WT has a strong interest in maintaining high design standards for the completed works.	• Some design elements may be very expensive to construct because of site conditions	• Conduct design optimization to balance design, constructability and cost