Appendix O
Stormwater Management Report
(Hatch - 2019)

City of Kingston
Third Crossing

Stormwater Management Report

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Project Report

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City of Kingston
Third Crossing Bridge

Stormwater Management Report

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1. Introduction

1.1 Purpose

The City of Kingston has undertaken the detailed design of the Third Crossing Bridge (K3C) and associated infrastructure over the Cataraqui River. The Stormwater Management Report (SWMR) outlines the strategy and detailed design of the stormwater management (SWM) works for the land features of the bridge crossing, which include the east and west roadway approaches, bridge structure and Highway 15 intersection improvements. This report has been developed during the validation phase of the Third Crossing Bridge Project.

1.2 Site Location and Description

The new Third Crossing of the Cataraqui River is proposed to connect John Counter Boulevard on the west bank (West Segment (S1)) and Gore Road on the east bank (East Segment (S3))(Figure 1-1). The approach road network will be extended to Montreal Street in the west and Highway 15 in the east. Highway 15 will also be impacted by the new crossing with proposed improvements 150m north and south of the intersection.

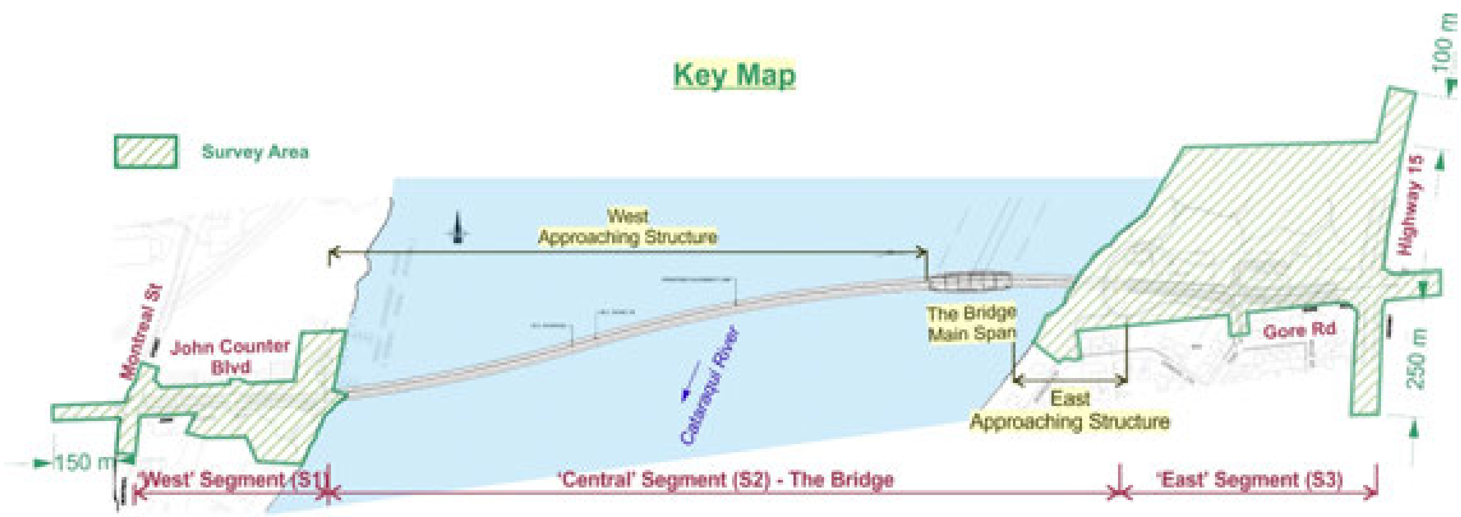


Figure 1-1: Key Plan

1.3 Geotechnical Information

Consistent with the SWM Report prepared by J.L. Richards & Associates Limited (JLR) (April, 2017), the soil characteristics will be a combination of Hydrological Soil Groups (HSG) B and D, which have been developed from the Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA) soil mapping for Kingston.

2. Drainage Design Criteria and Stormwater Objectives

The stormwater management objectives and drainage design criteria have been developed in consultation with the City of Kingston and references developed as part of the Preliminary Design. The following sections will illustrate the standards in order of precedence applied for the drainage and SWM design.

2.1 Reference Documents and Standards

Stormwater Management and drainage design will be undertaken in accordance with the criteria contained in this document and the following reference documents. In the event of a conflict between the criteria or requirements contained between the documents, the following descending Order of Precedence shall apply:

- City of Kingston Subdivision Development Guidelines and Technical Standards (2014);
- City of Kingston Site Plan Control Guidelines (2009);
- Cataraqui Conservation Authority; Appendix I: Guidelines for Stormwater Management (2014);
- MOE Drainage Manual (2003).
- MTO Highway Drainage Design Standards (2008).
- Ontario Provincial Standards for Roads and Public Works (OPS)

2.2 Drainage Design Criteria and Stormwater Management Objectives

The drainage and stormwater management (SWM) criteria for the Third Crossing of the Cataraqui River project has been developed and divided into four (4) design requirements, hydrology, hydraulics, SWM criteria and project specific requirements.

Each component has been defined using the hydrologic and hydraulic requirements of the reference documents in Section 2.1 while recognizing existing studies and background information in the project area. The following table documents the target criteria for the drainage and SWM for the Third Crossing Bridge.

Hydrologic Criteria	
Design Storm	Rainfall will be based on of the City of Kingston 2014 Subdivision Development Guidelines and Technical Standards.

Soil Information	Soil drainage condition will be estimated based on *Soil Survey of Frontenac County* and or on-site soil borehole testing
Hydrologic Modelling	Hydrologic modelling will remain consistent with the methodology set forth in the SWM Report prepared by JLR (2017). Modelling for will be conducted using PCSWMM (for stormwater management facilities). As required in the City of Kingston Subdivision Development Guidelines and Technical Standards, the Rational Method will be used for hydrologic modelling for storm sewer sizing. Design Hydrologic Flows for Freeway: • Major System flows (surface drainage): 100-year flow • Minor System flows (piped drainage): 10-year flow
Catchment Boundary	Maintain existing catchment boundaries from the *approved Hydrology Studies* or existing conditions to the extent that is feasible.
Catchment Parameters	Modelling Parameters (i.e. CN, T_p) will be based on the approved parameterization listed within the SWM Report prepared by JLR (2017).
Hydraulic Criteria	
Culvert Crossing Design Flows	City of Kingston and Design Standard WC-1, MTO Highway Drainage Design Standards (2008).
Storm Sewer Design Flows	Storm sewers should be designed to safely convey the 10-year design flow in accordance with City of Kingston requirements for an arterial road.
Storm Sewer Design	Catchbasin spacing shall not exceed the maximum distance of 90 metres in accordance with City of Kingston requirements. The sewer design method shall normally be the Rational Method. Design sheets shall be submitted in accordance with the City's standard format.
Culvert Crossing Criteria	City of Kingston, a minimum freeboard of 1 m to be provided from the design head water elevation to the edge of pavement, *WC-7, S3.2. Freeways, Arterial, Collectors, MTO Highway Drainage Design Standards (2008),* where roadway elevation permits.
Swale Design	Swale gradients and geometry shall be developed such that the maximum velocity at the design flow shall not exceed 0.9 m/s, which is the maximum permissible velocity for grass land cover in highly erodible soils. Swale design will be a combination of triangular (v) and flat bottom shaped structures with 2:1 or 3:1 slopes, a range of widths and varying depths based on site grading and conveyance requirements.
Stormwater Management Criteria	
Quantity	Control post-development 2-100 yr. stormwater runoff to be equal to or less than the pre-development level where feasible. Post-development peak flow rates up to the 100-yr stormwater runoff discharging to the Cataraqui River will not exceed the flows identified within the SWM Report prepared by JLR (2017) as follows: • West Segment: 0.68 m^3/s • East Segment: 1.32 m^3/s

Quality	On-site water quality treatment will be provided in accordance with *MOE Drainage Manual (2003)*. An 'Enhanced' level of stormwater quality control for 80% total suspended solids (TSS) removal for all proposed impervious areas, including the bridge deck.
Water Balance	Subject to soil drainage condition water balance can be achieved through implementation of infiltration LIDs where feasible. The design and implementation need to be based on the *MOE Drainage Manual (2003).*
Project Specific Requirements	
City of Kingston	A catchbasin on the south side of Gore Road east of Point St Mark will be designed to intercept flows before the pedestrian crossing. Flows at Station 11+507 will be diverted to the Cataraqui River around the embankment to eliminate a crossing underneath the embankment. Underground infrastructure shall not be located under a hard surface, where feasible.
CRCA	A Stormwater Management Plan will be developed to demonstrate how the SWM controls designed for the bridge and approaches will satisfy the stormwater management objectives in accordance with CRCA requirements for this project. A hydrologic and hydraulic analysis to assess the impact of proposed fill within the 1:100 year flood plain of the Cataraqui River in accordance with CRCA O.Reg 148/06 will be developed.

The vertical profile of the bridge allows the stormwater to drain from the middle of the navigational channel span to the approaches. Drains along the curb lines will collect the stormwater which will be piped to a stormwater management facility on-land (page 97 of PDR).

3. Existing Stormwater Management Conditions

The following section will illustrate the existing stormwater management conditions for the west, central, and east segments. Commentary regarding the drainage conveyance conditions, stormwater management facilities, and overall site outlets will be illustrated for the existing condition shown in Appendix A.

3.1 West Segment (S1)

The west segment, at the location of the proposed crossing, features a rural cross-section with poorly defined ditches handling runoff from John Counter Boulevard from Montreal Street to the river. The north side of John Counter Boulevard drains via a ditch along the south rear lots of the new subdivision. The south side drains via overland flow towards the Cataraqui River.

There is currently no controlled outfall to the river, all runoff enters the Cataraqui River via overland sheet flow.

3.2 Central Segment (S2)

The central segment is the Cataraqui River, no existing stormwater management features exists within this segment.

3.3 East Segment (S3)

The east segment features an existing 600mm storm sewer network draining along the south side of Gore Road towards the Cataraqui River. The minor system carries runoff from the intersection of Highway 15 and Gore Road with connections and ditch inlets at Point St Mark Drive towards the river. There is an existing 900mm culvert at the noted intersection, which receives external runoff from lands east of Highway 15. The culvert receives flow from the rural grassed ditches from the east and south of the intersection towards the Gore Road network.

The drainage network along the south of Gore Road ultimately drains to the forested areas east of the Cataraqui River, which flow into a ephemeral channel. The ephemeral channel ultimately drains via overland flow into the Cataraqui River.

4. Proposed Stormwater Management

4.1 West Segment (S1)

Design Conditions

The proposed roadway and bridge design conditions for the west segment approach is as follows:

- John Counter Boulevard - A three (3) lane urban cross-section with left and right turn lanes at Ascot Lane and Montreal Street, as well as a bus bay in front of 917 Montreal Street.

Drainage and SWM

The proposed drainage and stormwater management measures designed for the west segment are a combination of linear enhanced grass swales, conveyance culverts, storm sewers, and oil grit separators to satisfy the quantity and quality control objectives as well as the conveyance criteria. Proposed SWM design considers the recommendations from the SWM Report prepared by JLR, where applicable. The following is a break down of the treatment measures and structures designed for the west segment:

Quantity Control

- enhanced grassed swales with a 2 m wide, 3:1 side slopes will be installed to safely convey and control the outflow from the west approach;

Quality Control

- a stormwater treatment unit (oil-grit separator units such as ‘Stormceptors’) will be used at the outlet of the enhanced grass swale runoff;

Erosion Control

- Rip rap erosion protection has been designed at all storm sewer lead outfalls to the enhanced grass swales and outfalls.

Drainage Design – Minor System

- new stormwater piping (1:10 year event via to low point on the approach road) using 300 - 825 mm diameter outlet pipes conveying runoff from the approach and bridge to the enhanced grass swales along the north side of John Counter Boulevard;

Drainage Design – Major System

- from the low point, runoff is piped to the enhanced grass swales whereas major event flows will flow overland to the east towards the Cataraqui River

- bridge drainage joins the approach drainage also at the low point

For the West Segment Design drawing refer to Appendix A – Figures – Sheet C001.

4.2 Central Segment (S2)

The proposed roadway and bridge design conditions for the central segment is as follows:

- West Bridge design features the following design:
  - North; No Multi-use Path; 6.0m Deck Width
  - South; Multi-use Path; 10.5m Deck Width
- East Bridge design features the following design:
  - North; No Multi-use Path; 6.0m Deck Width
  - South; Multi-use Path; 10.5m Deck Width

Drainage and SWM

The proposed drainage and stormwater management measures designed for the central segment are a is management of conveyance with proposed deck drains and storm sewers on the bridge. Ultimate discharge locations are stormwater management facilities within the West and East segments designed to satisfy the quality control objectives as well as the conveyance criteria. Proposed SWM design considers the recommendations from the SWM Report prepared by JLR, where applicable. The following is a break down of the treatment measures and structures designed for the central segment:

Quantity Control

- No quantity control for the central segment based on the SWM Report prepared by JLR;

Quality Control

- Quality control will be captured through Sections 4.1 for the West Segment and Section 4.3 for the East Segment;

Erosion Control

- No erosion control required for the central segment;

Drainage Design – Minor System

- New stormwater piping (1:10 year event) using 300 - 525 mm diameter outlet pipes conveying runoff from the bridge to the east and west segment approaches;

Drainage Design – Major System

- Deck inlets and stormwater piping spaced appropriately to ensure lateral spread will not exceed the shoulder width in the 1:10 year event. In events up to the 1:100 year lateral spread will not encroach to a minimum of 2.5m of bridge outer lane width.

For the Central Segment Design drawing refer to Appendix A – Figures – Overall General Arrangement.

4.3 East Segment (S3)

Design Conditions

The proposed roadway and bridge design conditions for the west segment approach is as follows:

- Gore Road - A two (2) to five (5) lane urban cross-section with left and right turn lanes at Point St. Mark Drive, Library Road and Highway 15.
- Highway 15 – A four (4) lane urban cross-section with a dual left turn north bound at Gore Road and a single south bound left turn, as well as separate right turn lanes at Gore Road.

Drainage and SWM

The proposed drainage and stormwater management measures designed for the east segment are a combination of a dry pond facility, conveyance culverts, storm sewers, and oil grit separators to satisfy the quantity and quality control objectives as well as the conveyance criteria. Proposed SWM design considers the recommendations from the SWM Report prepared by JLR and Highway 15 Municipal Class Environmental Assessment (EA) (2018), where applicable. The following is a break down of the treatment measures and structures designed for the east segment:

Quantity Control

- a dry pond facility near the east segment, having a 4:1 length-to-width ratio, a 4:1 side slope, and an active storage depth of less than 1 m;
- two oversized storage pipes, 1350mm and 750mm diameter, which will outlet to the ditch in front of the Library

Quality Control

- a stormwater treatment unit (oil-grit separator units such as ‘Stormceptors’) will be used at the outlet of the enhanced grass swale runoff;

Erosion Control

- Rip rap erosion protection has been designed at all storm sewer lead outfalls to the enhanced grass swales, dry pond facility and outfalls.

Drainage Design – Minor System

- continued maintenance of the existing minor system that drains directly to the river along the south of Gore Road via a 600 mm diameter storm sewer. Relocated catchbasin leads from Gore Road. Flows will not be increased and ditch outfall location from existing conditions will be relocated.
- new stormwater piping (1:10 year event via to low point on the approach road) using 300 – 450 mm diameter outlet pipes conveying runoff from the approach and bridge to the north, flowing into enhanced grass swales, which drain to the dry pond facility.
- a new minor system conveying runoff to the enhanced grass swale north of Gore Road to capture the road widenings, including west of Point St. Mark Drive.
- a new minor storm sewer system will convey runoff to the four key outfalls along Highway 15 at the southwest ditch, southeast ditch, existing Gore Road intersection ditch inlet, and existing low point to the north of the Library entrance.

Drainage Design – Major System

The proposed major storm conditions will flow via surface flow across the roadway to the following locations:

- from the Gore Road approach roadway low point, runoff is piped to the enhanced grass swales whereas major event flows will flow overland to the west towards the Cataraqui River.
- from the Highway 15 intersection roadway low point, major storm runoff will flow to the north of the Library entrance.
- from the south end of the Highway 15 intersection improvements, major storm runoff flows to the existing drainage ditches.
- accommodation of bridge drainage and overland flows from major events into the dry pond facility.

For the West Segment Design drawing (East Shore and Highway 15) refer to Appendix A – Figures – Sheets C002 and C003.

5. Stormwater Management Design

The stormwater management design for the K3C bridge over the Cataraqui River has been developed using a variety of elements and design tools. The following section illustrates the hydrologic modelling, hydraulic design, and SWM design for all aspects of the K3C project.

5.1 Hydrologic Modelling

The hydrologic modelling to simulate the runoff conditions for the existing and proposed conditions were developed through PCSWMM software. Localized changes will be proposed where necessary. Parameterization and discharge rates to the Cataraqui River will remain consistent with the SWM Report prepared by JLR (2017) and the Highway 15 Municipal Class Environmental Assessment (EA) (2018).

The existing conditions scenario was modelled as follows:

- ***West segment*** was modelled as a single 4.03 ha catchment draining to the Cataraqui river.
- ***Central Segment*** was not modelled during existing conditions as it is currently within the Cataraqui River.
- ***East segment*** was divided into three (3) distinct catchments,
    - *East Bank* – 1.43 ha – drains along the shoreline of the Cataraqui River,
    - *East Approach* – 4.21 ha - drains the Gore Road roadway and approach roads,
    - *East Upstream* – 20.46 ha - drains into the existing storm sewer along Gore Road from the adjacent rural estate subdivision,

The proposed conditions scenario was modelled as follows:

- ***West Segment*** was divided into seven (7) distinct catchments
    - *West Montreal Street* – 1.94 ha – drains via a combination of surface and piped drainage to the Montreal Street and flows south along the roadway away from the west segment approach.
    - *North John Counter Blvd and west of Ascot Lane* – 0.60 ha – drains via surface ditching and piped leads along the roadway to a culvert at Ascot Lane.
    - *North John Counter Blvd and east of Ascot Lane* – 0.36 ha – drains via surface ditching and piped leads along the roadway to a culvert at the former Marina lands.

- *South John Counter Blvd and west of Ascot Lane* – 0.48 ha – drains via piped leads to the north of John Counter Blvd.
- South John Counter Blvd and east of Ascot Lane – 0.26 ha – drains via pipe storm sewer leads to the north of John Counter Blvd.
- *Former Marina lands* – 0.37 ha – drains via surface ditching to the outfall and west shore lands at the Cataraqui River.
- *West Shore North and South of John Counter Blvd Cataraqui River* – 2.02 ha – drains via surface sheet flow into the Cataraqui River.

- ***Central Segment*** was divided into two (2) distinct catchments,
  - *West Bridge* – 1.16 ha – drains from bridge high point to the west approach flowing via a pair of piped networks along the north and south side of the bridge.
  - *East Bridge* – 0.14 ha – drains from the bridge high point to the east approach flowing via a pair of piped networks along the north and south side of the bridge.
- ***East Segment*** was divided into six (6) distinct catchments,
  - *East Upstream* – 20.29 ha - drains into the existing storm sewer along Gore Road from the adjacent rural estate subdivision,
  - *Gore Road and Highway 15* – 0.16 ha – drains to the existing Gore Road and Highway 15 intersection south along Gore Road.
  - *North of Gore Road* – 1.26 ha – drains the library lands and areas along the north side of Gore Road to a culvert at the meadow.
  - *North of Gore Road, Meadow Lands* – 0.50 ha – drains the upstream library lands and meadow lands towards the dry pond facility.
  - *South of Gore Road at Point St Mark Drive to Highway 15* – 0.81 ha - drains via piped storm sewer leads to the existing Gore Road drainage network and outlet ditch.
  - *East Shore North and South of Gore Road* – 3.30 ha – drains via surface flow to the dry pond facility, which flows to the existing outfall into the Cataraqui River.

5.1.1 *Rainfall*

Rainfall distributions have been adopted from the SWM Report from JLR,(2017). To support the various design tools executed for the SWM design, the following is a summary of the rainfall and storm distributions utilized for each aspect of the design:

- The 24-hour SCS distribution from the Environment Canada gauge at the Kingston Pumping Station was selected for the PCSWMM model and design for each outfall, enhanced grass swale, pipe network, and pond design.
- The City of Kingston rational method ABC values and calculation was selected for the design and verification of the storm sewer network.
- The MTO IDF curve was selected for verification of the bridge storm sewers, Highway 15 works (consistent with the EA design), and the overall SWM design.

5.1.2 *Catchment Parameters*

The catchment parameters are based on the SCS Curve Number (CN) method used to simulate the runoff and infiltration of the catchments.

- The CN values used for the PCSWMM modelling are consistent with the existing SWM Report (2017) prepared by JLR.
- The proposed conditions level of imperviousness was recalculated based on the design roadway and bridge configuration including all lanes, sidewalks, and existing sources of imperviousness.

All other parameters can be found in Appendix B – Model Files within the model output files. All parameter values are consistent with the JLR design.

5.2 Hydraulics

The hydraulic analysis for the K3C project has been developed to evaluate all drainage infrastructure against the required design criteria from the City of Kingston. The following section illustrates the performance and approach for evaluating the storm sewers and culverts within the K3C limits.

5.2.1 *Storm Sewer Sizing*

The minor system conveyance will be a combination of enhanced grass swales and storm sewers, which will service the east, central and west segments.

- The storm sewer sizing has been developed and verified using the Rational Method, in accordance with City of Kingston criteria (Appendix C).
- The rainfall intensity utilized for the design of the sewers has been taken from the City of Kingston 2014 Subdivision Development Guidelines and Technical Standards.

- Storm sewer sizing was completed for the 10-year storm intensity from the Environment Canada Kingston Pumping Station rain gauge.

5.2.1.1 *East Segment*

The east segment storm sewer design has been divided into approach roadway for Gore Road and Highway 15:

Approach Roadway Network - Gore Road

- *STM100 to 101* – 300 to 375 mm PVC storm sewers draining the north side of Gore Road roadway west of Highway 15 to culvert STM300 at the Library Road flowing west towards the Cataraqui River.
- *STM102, STM103 and STM112* – 300 mm PVC storm sewer connections draining the south side of Gore Road between Point St. Mark Drive to the Highway 15 intersection in the east.
    - *STM102 and STM103* are proposed direct connections to the existing 600mm storm sewer running along Gore Road.
    - *STM112* is a catchbasin lead connection from the crosswalk at Point St Mark Drive.
        - Due to the configuration and orientation of this connection, a catchbasin manhole is proposed.
- *STM104 to 105* – 300 mm PVC storm sewer outlet to the east side ditch at Library Road.
    - Due to current topography and slopes experienced within this area, a catchbasin manhole ditch inlet is proposed to convey this runoff to the downstream v-ditch.
- *STM107* – 300 mm PVC storm sewer outlet to a rip rap pad flowing into the south enhanced grass swale along Gore Road towards the Cataraqui River.
- *STM108 to 109* – 300 mm PVC storm sewer outlet into rip rap pad flowing into the enhanced grass swale towards the dry pond facility.
- *STM110 to 111* – 300 to 475 mm PVC storm sewers draining both sides of Gore Road and the east bridge network.
    - *STM110* is a 300 mm PVC with a double catchbasin structure connecting the 300mm south PE piping from the bridge.

    - *STM111* is a 450 mm PVC outfall with a double catchbasin structure connecting both the south STM110 drainage and the north bridge 300 mm PE piping.
        - All runoff from this network discharges across a rip rap pad and into the dry pond facility prior to flowing into the Cataraqui River.

Approach Roadway Network – Highway 15

- *STM700* – 300 mm PVC storm sewer draining the west side of the Highway 15 roadway to the existing ditch at the limit of construction.
- *STM701* – 300 mm PVC storm sewer draining the east side of the Highway 15 roadway to the existing ditch at the limit of construction.
- *STM702 to STM704* – 300 to 900 mm PVC and Concrete storm sewers draining both sides of Highway 15 south of the Gore Road intersection to the existing ditch inlet and culvert crossing east to west south of the intersection.
    - *STM702* – 750 mm Concrete storm sewer draining the west and upstream STM704 runoff to the STM703 connection at the existing culvert crossing.
        - STM702 has been designed as a control sewer with a 232 mm orifice plate to meet the existing peak flow rates.
    - *STM703* – 900 mm Concrete storm sewer connected as an extension to the existing culvert, which is to tie into the existing ditch inlet catchbasin.
        - STM703 will feature a catchbasin manhole that will extend the existing storm sewer receive runoff upstream within the network, adjacent lands and Highway 15 drainage from the surface.
    - *STM704* – 300 mm PVC storm sewer draining runoff from the east side of Highway 15 across to the west storm sewer network at STM702.
- *STM705 to STM709* – 300 to 1350 mm PVC and Concrete storm sewers draining roadway runoff from both the west and east sides of Highway 15 north of the Gore Road intersection to the limit of construction, which discharges at the low point north of the Library entrance.
    - *STM705* – 300mm PVC storm sewer lead connection draining the southeast portion of the Highway 15 and Gore Road intersection flowing north to the STM706 structure.

- *STM706* – 1350mm Concrete storm sewer draining the east side of Highway 15 and upstream runoff to the STM709 structure.
    - STM706 has been designed as a control sewer with a 285 mm orifice plate to meet the existing peak flow rates.
- *STM707* – 300mm PVC storm sewer draining the east side of Highway 15 at the north limits of the project flowing into STM708.
- *STM708* – 300mm PVC storm sewer draining to the STM709 manhole structure controlling flows into the OGS3.
- *STM709* – 375mm PVC storm sewer draining all upstream runoff from prior to and after the OGS3 filtration and discharge into the Library entrance ditch.

5.2.1.2 Central Segment

The proposed bridge storm sewer network flows are divided into four distinct networks given the road layout and multi-use path along the south portion of the bridge. The bridge network is as follows:

- North east bridge design from 11+219.5 to 11+428.8 features the following storm sewer design:
    - STM500 to STM501 – 300 mm PE storm sewer draining along the north side of the bridge structure to STM111.
- South east bridge design from 11+219.5 to 11+428.8 features the following storm sewer design:
    - STM503 to STM504 – 300 mm PE storm sewer draining along the south side of the bridge structure to STM110.
- North west bridge design from 11+219.5 to 10+294 features the following storm sewer network:
    - STM600 to STM607 – 600 mm PE storm sewer draining along the north side of the bridge structure to STM205.
- South west Bridge design from 11+219.5 to 10+294 features the following storm sewer network:
    - STM608 to STM617 – 600 mm PE storm sewer draining along the south side of the bridge structure to STM204.

5.2.1.3 West Segment

The west segment storm sewer design has been divided into approach roadway for John Counter Blvd:

Approach Roadway Network – John Counter Blvd

- *STM200 to 202* – 300 to 375 mm PVC storm sewers draining the south side of the John Counter Blvd roadway west of Ascot Lane to culvert STM400 at Ascot Lane flowing east towards the Cataraqui River.
- *STM203 to 206* – 375 to 825mm PVC storm sewers draining both sides of John Counter Blvd between the bridge and east of Ascot Lane as well as the bridge storm sewers along the north and south sides of the roadway.
  - *STM203* is a double catchbasin with a 375mm PVC lead connection to STM206 outfall towards the river.
  - *STM204* is a 600mm PVC storm draining to the main sewer line along the south of the bridge.
  - *STM205* is a 525mm PVC storm sewer draining to the main sewer line along the north of the bridge.
  - *STM206* is an 825mm PVC storm sewer outfall draining to the proposed enhanced grass swale.

All conveyance design including capacity and layouts are featured within Appendix A and Appendix B, and Appendix C for drawings and storm sewer design sheets

5.2.2 Swale and Ditch Conveyance Design

The conveyance design for the east and west segment road approaches require the utilization of enhanced grass swales and ditches of a variety of geometries to provide safe conveyance of runoff to the treatment facilities and ultimately, the outfalls into the Cataraqui River.

The following are the proposed ditching for both the east and west segment drainage systems:

5.2.2.1 East Segment

- *EGS-100* – 2m wide flat bottom with 2.5:1 side slopes - enhanced grass swale south along Gore Road draining to the Cataraqui River outfall north of Gore Road.
- *EGS-101* – 2m wide flat bottom with 2.5:1 side slopes - enhanced grass swale north along Gore Road to the dry pond facility.

- *EGS-102* – 2m wide flat bottom with 2.5:1 side slopes - enhanced grass swale east along Library Road flowing into STM105 ditch inlet catchbasin.
- *VS-100* – 0.6m deep with 2:1 side slopes - v-ditch swale north of Gore Road flowing into STM105 ditch inlet catchbasin.
- *VS-101* – 0.6m deep with 2:1 side slopes - v-ditch swale northwest along Library Road flowing into the EGS-101 towards the dry pond facility.

5.2.2.2 West Segment

- *EGS-200* – 2m wide flat bottom with 2.5:1 side slopes - enhanced grass swale south along Gore Road draining to the Cataraqui River outfall north of Gore Road.
- *EGS-201* – 2m wide flat bottom with 2.5:1 side slopes - enhanced grass swale north along Gore Road to the dry pond facility.
- *EGS-202* – 2m wide flat bottom with 2.5:1 side slopes - enhanced grass swale east along Library Road flowing into STM105 ditch inlet catchbasin.
- *VS-200* – 0.6m deep with 2:1 side slopes - v-ditch swale north of Gore Road flowing into STM105 ditch inlet catchbasin.
- *VS-201* – 0.6m deep with 2:1 side slopes - v-ditch swale northwest along Library Road flowing into the EGS-101 towards the dry pond facility.

5.2.3 Culvert Design

The following is an inventory of the conveyance culverts, grouped by east and west segments and categorized as centreline and entrance culvert structures.

5.2.3.1 East Segment

The conveyance culverts constructed to convey runoff for the east are as follows:

- *STM300* – 450 mm Concrete culvert draining lands east of Library Road including the roadway runoff from Gore Road towards the Highway 15 intersection.
- *STM301* – 450 mm PVC culvert draining the dry pond facility through both the inlet and outlet of the OGS1 facility towards the Cataraqui River.

5.2.3.2 West Segment

The conveyance culverts constructed to convey runoff for the west segment are as follows:

- *STM400* – 450 mm CSP culvert draining lands west of Ascot Lane along the north side ditch of John Counter Boulevard.
- *STM401* – 450 mm CSP culvert draining the v-ditch around the ring road south of Gore Road.

- *STM402* – 450 mm CSP culvert draining the ditch south of John Counter Boulevard underneath the new trail.
- *STM403* – 450 mm PVC culvert draining upstream lands on the west approach at the inlet and outlet ends of OGS2 into the rip rap level spreader at Catarqui River.

5.3 Stormwater Quality Control

The stormwater management quality control targets are based on the City of Kingston and MOE requirements, influenced by the SWM report prepared by JLR. The water quality measures are as follows:

- ***West Segment***
  - *OGS1* – an OSR 2000, oil grit separator provides filtration of runoff removing suspended solids discharging from the enhanced grass swales into the outfall,
  - Enhanced Grass Swales – swales are designed along the north and south sides of John Counter Boulevard to provide filtration and velocity control of runoff prior to discharge into the Cataraqui River, and,
  - Rip rap protection and check dams – erosion protection at the storm outfalls and throughout the ditching provide velocity reduction, which promotes settling within the ditches.
- ***East Segment***
  - OGS2 – an STC 2000, oil grit separator provides filtration of runoff removing suspended solids discharging from the dry pond facility into the Cataraqui River,
  - Enhanced Grass Swales – swales are designed along the north and south sides of Gore Road to provide filtration and velocity control of runoff prior to discharge into the Cataraqui River, and,
  - Rip rap protection and check dams – erosion protection at the storm outfalls and throughout the ditching provide velocity reduction, which promotes settling within the ditches.

OGS treatment unit sizing is summarized within the Table 5-1. Stormceptor sizing reports are located within Appendix D.

Table 5-1 – OGS Sizing Summary

Location	Drainage Area (ha)	Imperviousness (%)	OGS Device	TSS Removal %
West Segment – John Counter Blvd Outfall	3.84	58.5	OSR 2000	80
East Segment – Gore Road Outfall	3.42	49.6	STC2000	80
East Segment – Highway 15 Outfall	0.66	80	STCEF6	60

5.4 Stormwater Quantity Control

The stormwater management quantity control target for the K3C project is to satisfy the post to pre development plus the uncontrolled runoff from the bridge deck surface between shorelines for the 100-year storm event.

The following Table 5-2 summarizes the water quantity control targets and corresponding release rates for both the west and east segments;

Table 5-2 - Quantity Control Targets

Flow Condition	West Segment (m^3/s)	East Segment – Gore Road (m^3/s)	East Segment – Highway 15 (m^3/s)
Pre-development peak flow to river	0.43	1.29	0.19
Peak runoff from bridge surface	0.25	0.05	0
Target peak flow (Pre plus bridge)	0.68	1.33	0.23
Post development peak flow to river	0.63	1.32	0.19

As indicated within Table 5-2 the peak flow quantity controls for the bridge, west and east segments, as well as the Highway 15 portion of the site are met.

5.5 Required Storage

The stormwater management controls have been developed and sized to provide sufficient storage to meet the peak outflow rates at the site outfalls, specifically into the Cataraqui River.

The following section illustrates the control structures, pond facilities, and oversized storage pipes developed to satisfy the outflow rates.

5.5.1.1 *East Segment Dry Pond*

The east segment pond is located at the north side of Gore Road along the Cataraqui River with the following characteristics:

- Pond has been sized with a length to width ratio of 4,
- Side slopes are designed at 4:1
- Active storage depth is less than 1m.

The stage storage relationship is summarized within Table 5-3. Pond relationship and model results are included within Appendix B.

Table 5-3 - East Segment Stage Storage Relationship

East Pond	Elevation (m)	Area (m^2)	Volume (m^3)	Uncontrolled Flow In (m^3/s)	Controlled Peak Flow Out (m^3/s)
Base of Pond	76.3	181	0	0.399	0.162
Maximum Water Level	77.2	456	285		
Top of Pond	77.6	560	458		

5.5.1.2 *East Segment – Highway 15 – Oversized Storage Pipes*

The east segment Highway 15 design has been developed to recognize the peak flow release rates at the main outfall at the low point north of the Library entrance.

In addition to that outfall location, there is a second segment of peak flow control at the connection between the STM703 and the existing ditch inlet at the southeast corner of Gore Road and Highway 15.

Each storage control was developed using a the modified rational method calculation under the 100-year peak flow condition recognizing the post and pre development site conditions.

The oversized storage pipe sizing is contained within the following Table 5-4. All sizing calculations are included within Appendix D.

Table 5-4 - Oversized Storage Pipe Sizing

Storm Sewer	Existing Peak Flow (m^3/s)	Proposed Uncontrolled Peak Flow (m^3/s)	Proposed Controlled Peak Flow (m^3/s)	Storage Volume Required (m^3)
STM703	0.09	0.12	0.09	16.0
STM706	0.19	0.23	0.19	23.0

5.5.1.3 West Segment Enhanced Grass Swales

The west segment flow controls have been developed to recognize the identified peak flow control rates and associated volumes. The west segment grass swales offer the required linear volume during the 100-year storm event with the peak flow controlled to the pre development plus bridge level.

5.6 Outlet Structure

The outlets from both the west and east approaches are as follows:

- West Segment – 450 mm storm sewer outfall from the proposed OGS2 unit into a level spreader
    - The level spreader has been constructed to dissipate runoff velocity that is discharged from the enhanced grass swales into the Cataraqui River.
- East Segment – 450 mm storm sewer outfall from the proposed OGS1 out of the dry pond facility into the channel flow into the Cataraqui River.

6. Criteria Summary

The following is a summary of the specific elements designed within the K3C project to satisfy the drainage criteria and SWM objectives:

Quantity Control

- enhanced grassed swales with a 2 m wide, 2.5:1 side slopes will be installed to safely convey and control the outflow from the west and east approach;
- a dry pond facility has been sized to provide quantity control for the east segment approach roads
- two oversized storage pipes have been installed to satisfy the peak flow control at the two key Highway 15 outfalls.

Quality Control

- will follow a treatment train approach with the measures including OGS units, enhanced grass swales, and check dams for erosion protection.

Erosion Control

- Rip rap erosion protection has been designed at all storm sewer lead outfalls to the enhanced grass swales and outfalls.

Drainage Design – Minor System

- new stormwater piping (1:10 year event via to low point on the approach road conveys runoff from the approach and bridge to the enhanced grass swales along both the east and west approach roads as well as Highway 15;

Drainage Design – Major System

- from the low point, runoff is piped to the enhanced grass swales whereas major event flows will flow overland to the east towards the Cataraqui River
- bridge drainage joins the approach drainage also at the low point

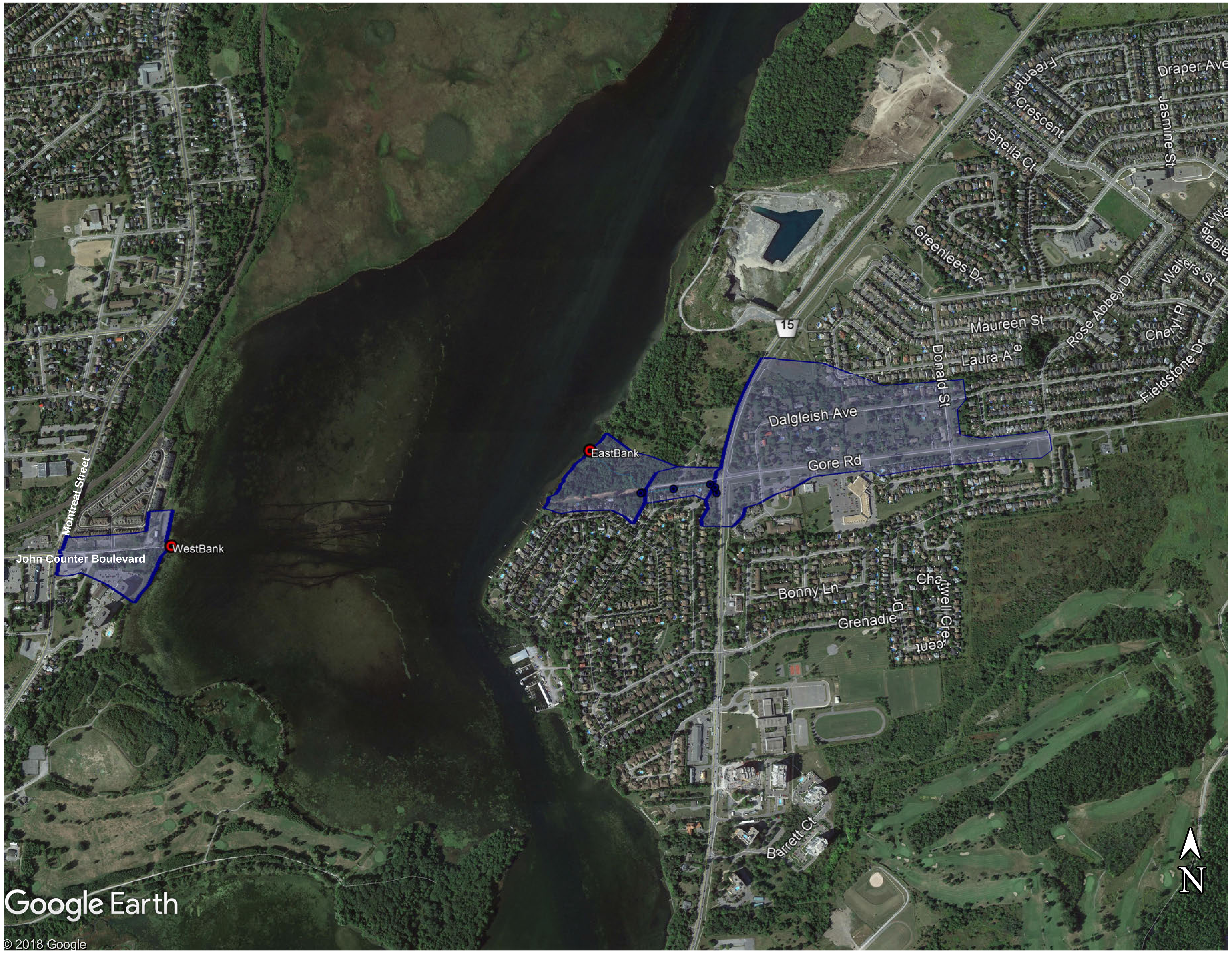
7. Conclusions

The proposed bridge and associated approach roadway infrastructure will impact the local drainage conditions such that the impervious levels will be increase. In order to satisfy the identified water quantity, quality, and erosion protection objectives as well as the minor and major system drainage design conditions a stormwater management design is required to safely handle all runoff. The following are the key conclusions drawn from the K3C project:

- All key drainage criteria and stormwater management objectives have been developed for the K3C project.
- The existing site drainage patterns for the area have been clearly illustrated for both the east and west approaches.
- The hydrologic modelling has been executed using PCSWMM software recognizing the existing and proposed site conditions.
    - All hydraulic components of the drainage network and SWM measures were modelled within the PCSWMM model.
- The proposed design conditions including the bridge and roadway improvements were illustrated with the following elements considered:
    - SWM design developed to provide water quantity control for the east and west approaches through oversized storage pipes, a dry pond facility, and enhanced grass swales
    - Water quality control has been developed through the use of OGS units, permanent erosion control measures, and enhanced grass swales,
    - The minor system has been developed to provide safe conveyance of the required runoff
    - The major system has been developed to illustrate the drainage conditions during such storm events.
- All site outfalls were documented with implications for erosion control and release rates recognized.

David Jackson, P.Eng.
DJ:dj

METRIC



DRAWING NAME: Figure 1 – Pre-Development Flow Conditions.dwg
SAVED BY: jack857638 SAVE DATE: 2/15/2019 10:52 AM PLOT DATE: 2/19/2019 11:41 AM

INTEGRATED PROJECT DELIVERY TEAM: HATCH, SYSTRA INTERNATIONAL BRIDGE TECHNOLOGIES, PKS Kiewit, KINGSTON

No.	DATE	REVISIONS	BY	CHECKED

DESIGN COMPANY: HATCH

DESIGN: EM	KINGSTON THIRD CROSSING		DRAWING NO. 1
DRAWN: DJ	SWM REPORT		SHEET NO.
CHECKED: MD	PRE–DEVELOPMENT CONDITIONS		REVISION
	DATE: 19–02–19	SCALE: N.T.S.	

METRIC

A: WEST SIDE

B: EAST SIDE

INTEGRATED PROJECT DELIVERY TEAM:

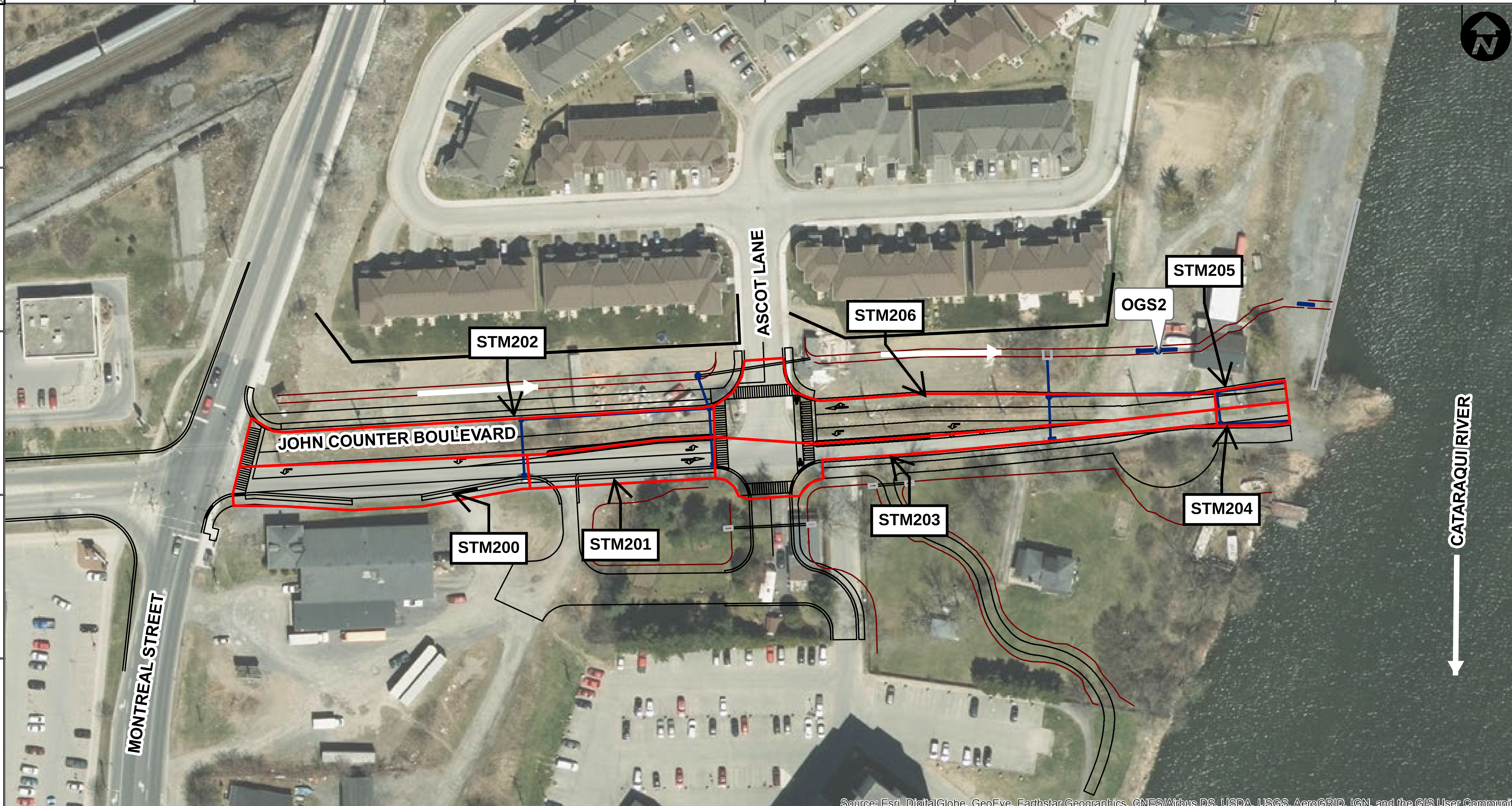
HATCH SYSTRA INTERNATIONAL BRIDGE TECHNOLOGIES Kiewit KINGSTON

No.	DATE	REVISIONS	BY	CHECKED

DESIGN COMPANY: HATCH

DESIGN: EM	KINGSTON THIRD CROSSING		DRAWING NO. 2
DRAWN: DJ	SWM REPORT		SHEET NO.
CHECKED: MD	POST–DEVELOPMENT CONDITIONS		REVISION
	DATE: 19–02–19	SCALE: N.T.S.	

DRAWING NAME: Figure 2 – Post–Development Flow Conditions.dwg PLOT DATE: 2/19/2019 11:54 AM
SAVED BY: jack857638 SAVE DATE: 2/19/2019 11:53 AM



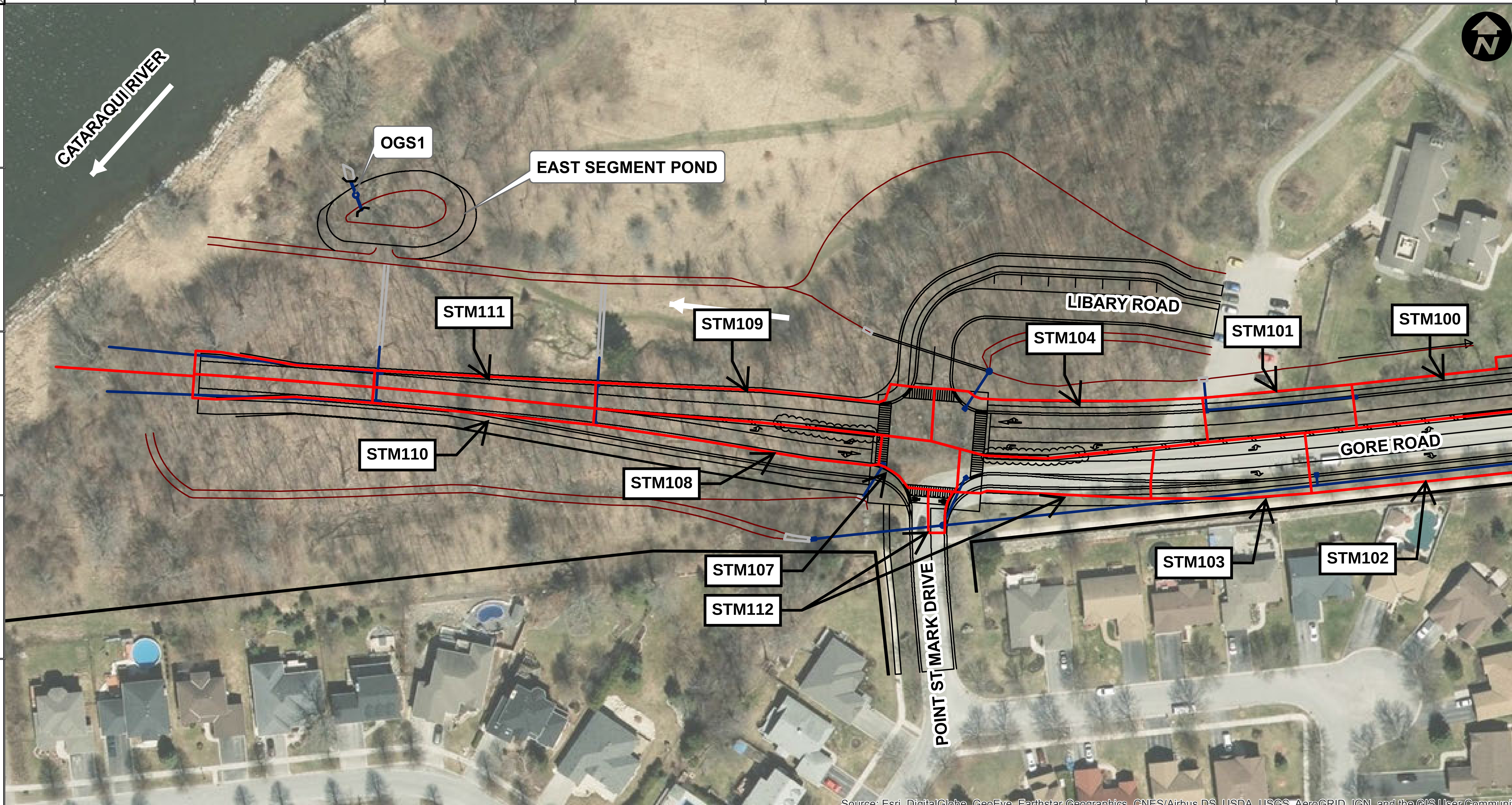
REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR REVIEW	DJ	EM	BR	

DESIGNED BY:	DRAWN BY: DJ
CHECKED BY:	DISC. ENGR.
PROJ. DES. COORD.	PROJ. ENGR.

WEST AND EAST SEGMENTS

KINGSTON THIRD CROSSING

PROPOSED DRAINAGE PLAN



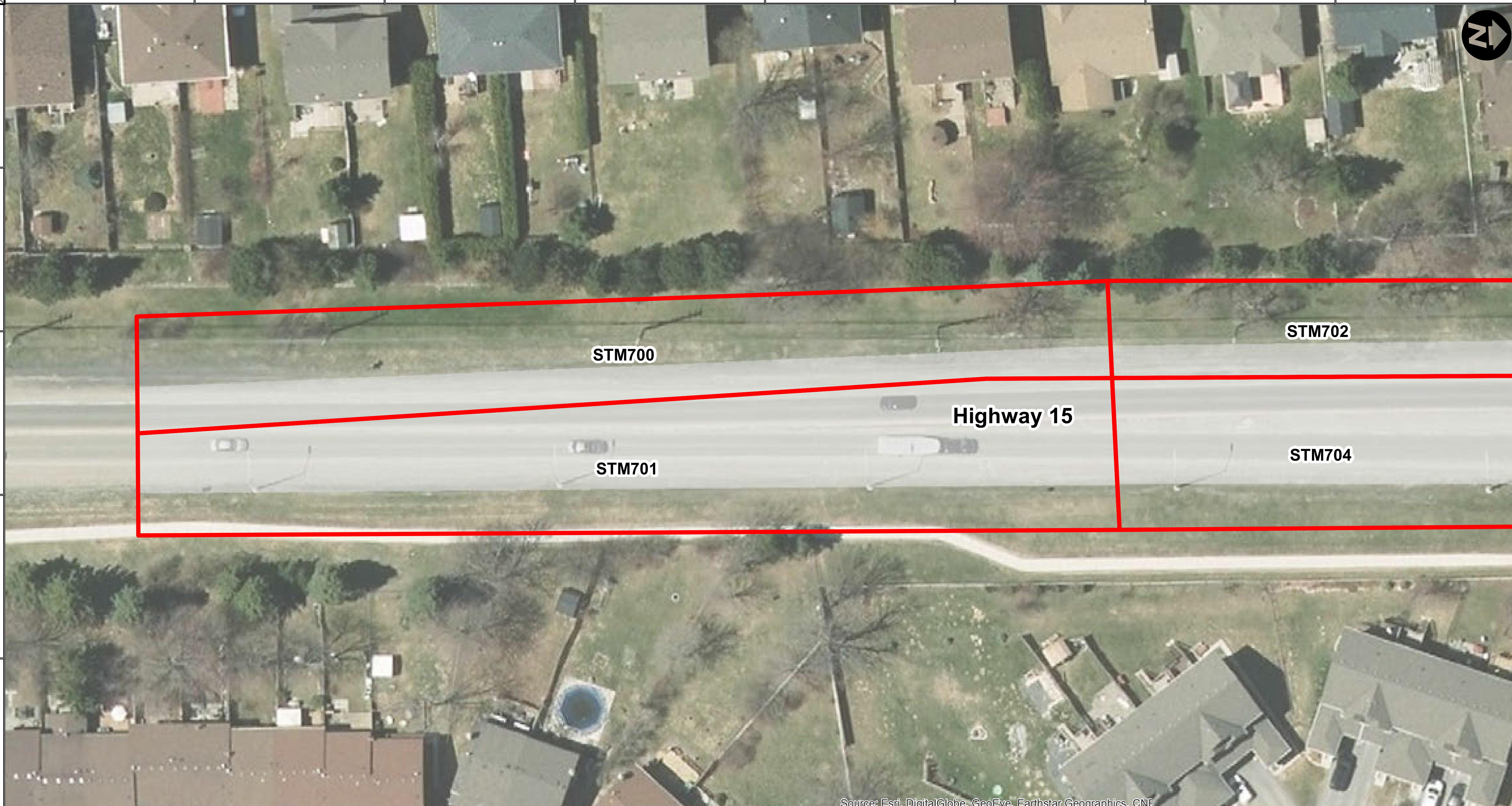
REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR REVIEW	DJ	EM	BR	

DESIGNED BY:	DRAWN BY: DJ
CHECKED BY:	DISC. ENGR.
PROJ. DES. COORD.	PROJ. ENGR.

WEST AND EAST SEGMENTS

KINGSTON THIRD CROSSING

PROPOSED DRAINAGE PLAN



REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR REVIEW	DJ	EM	BR	

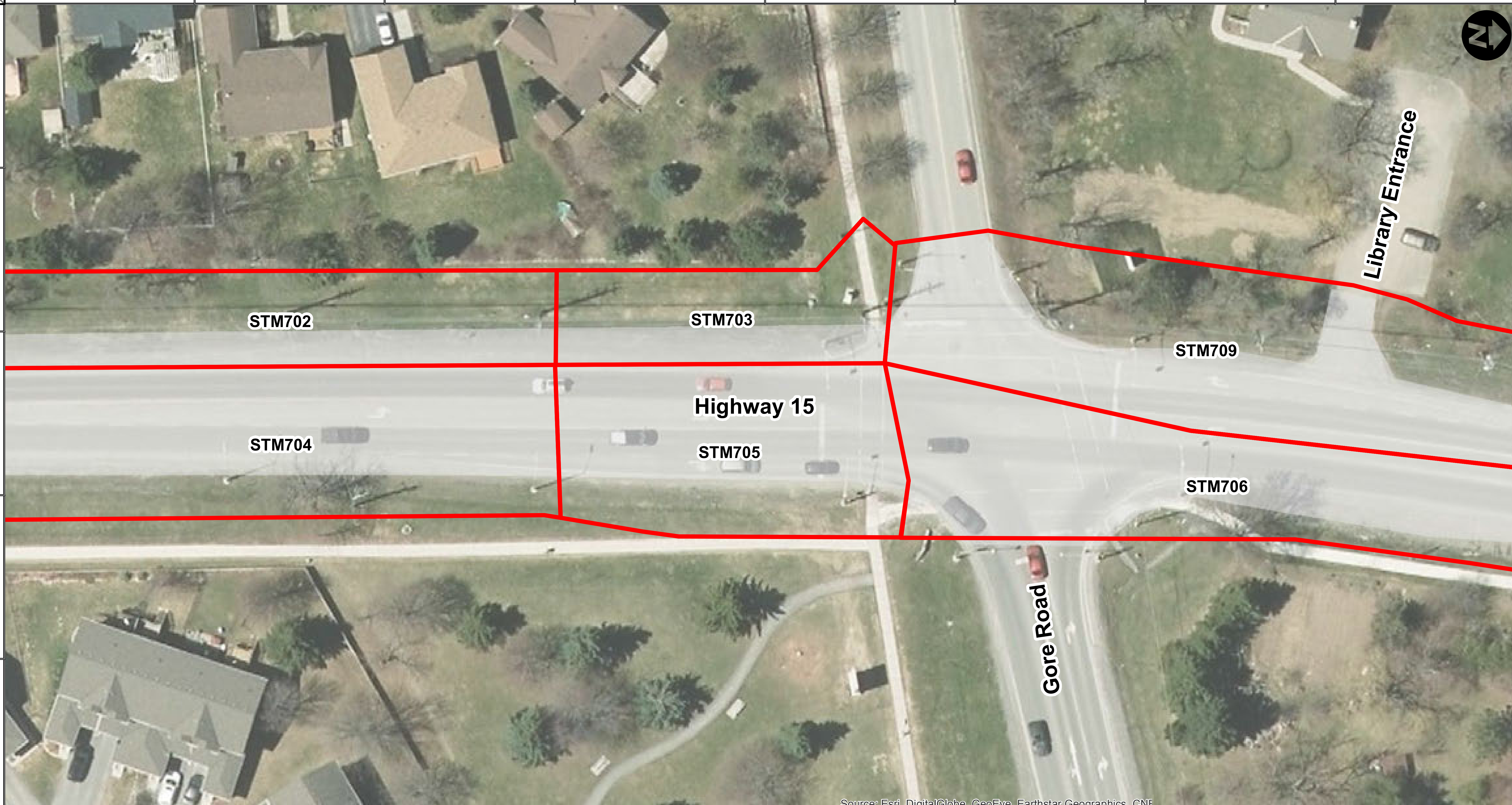
HATCH

DESIGNED BY:	DRAWN BY: DJ
CHECKED BY:	DISC. ENGR.
PROJ. DES. COORD.	PROJ. ENGR.

HIGHWAY 15

KINGSTON THIRD CROSSING

EXISTING DRAINAGE PLAN



HATCH SYSTRA Kiewit KINGSTON

REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR REVIEW	DJ	EM	BR	

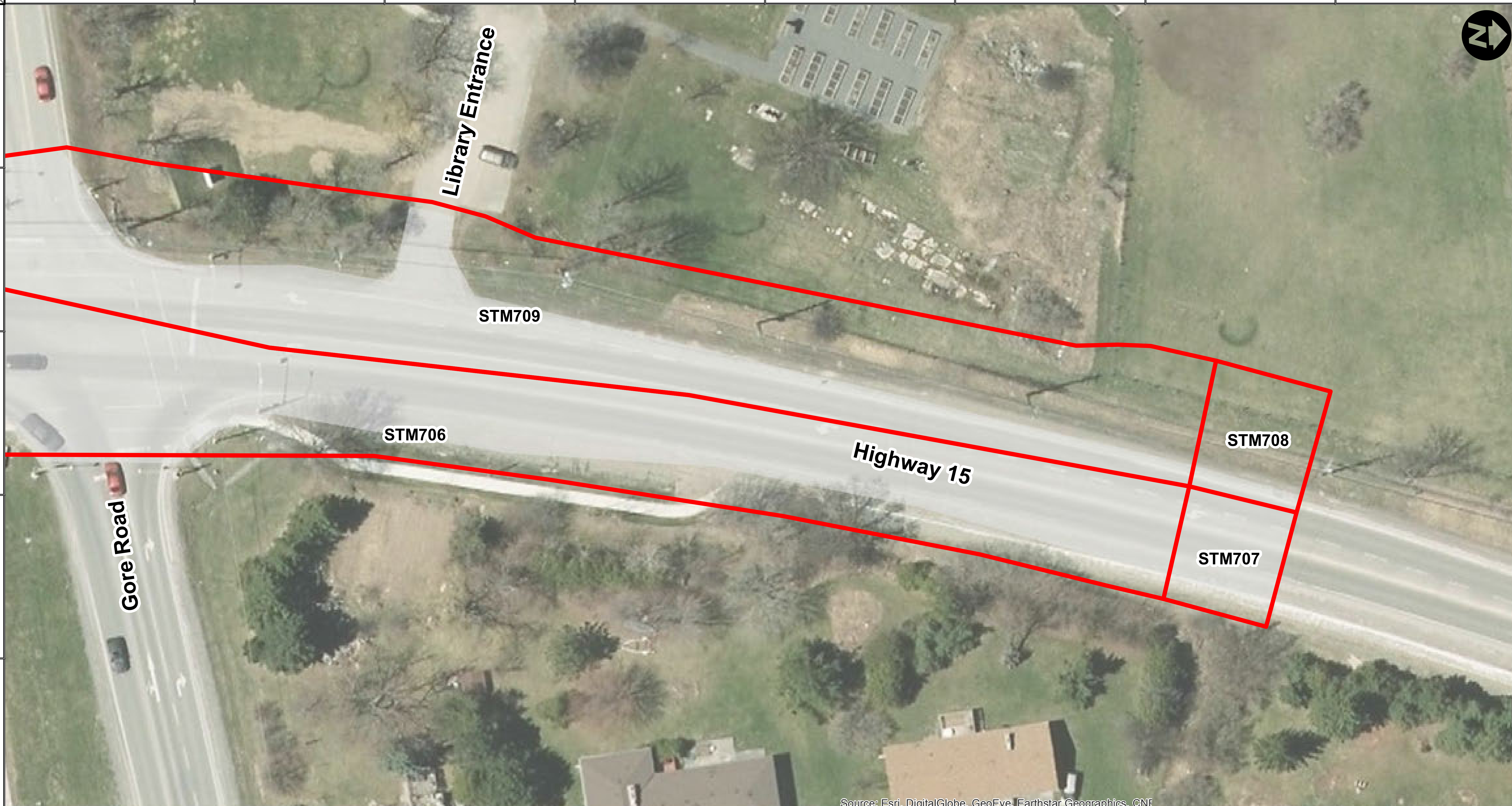
HATCH

DESIGNED BY: | DRAWN BY: DJ
CHECKED BY: | DISC. ENGR.
PROJ. DES. COORD. | PROJ. ENGR.

HIGHWAY 15

KINGSTON THIRD CROSSING

EXISTING DRAINAGE PLAN



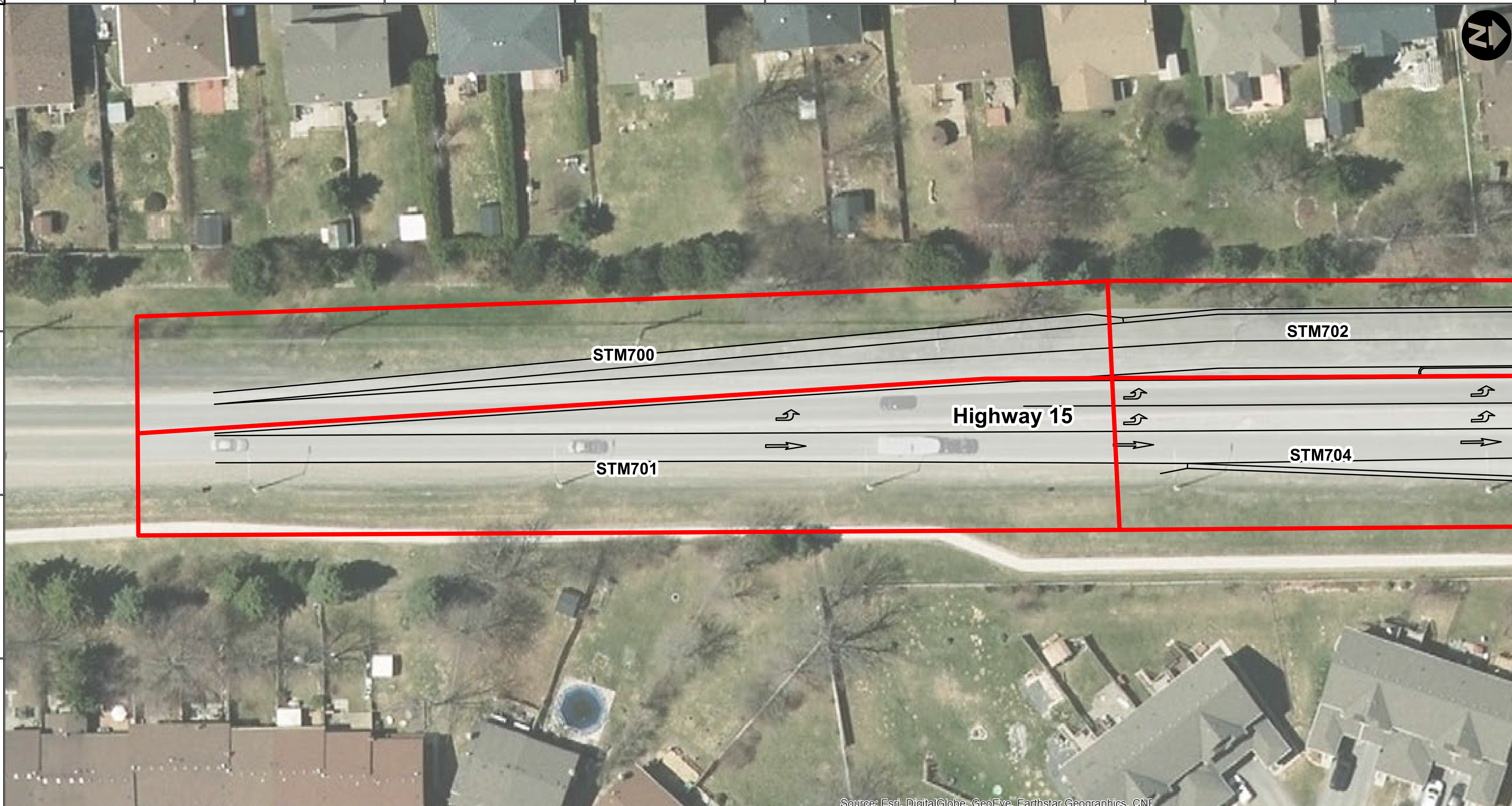
REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR REVIEW	DJ	EM	BR	

DESIGNED BY:	DRAWN BY: DJ
CHECKED BY:	DISC. ENGR.
PROJ. DES. COORD.	PROJ. ENGR.

HIGHWAY 15

KINGSTON THIRD CROSSING

EXISTING DRAINAGE PLAN



HATCH SYSTRA Kiewit KINGSTON

REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR REVIEW	DJ	EM	BR	

HATCH

DESIGNED BY:	DRAWN BY: DJ
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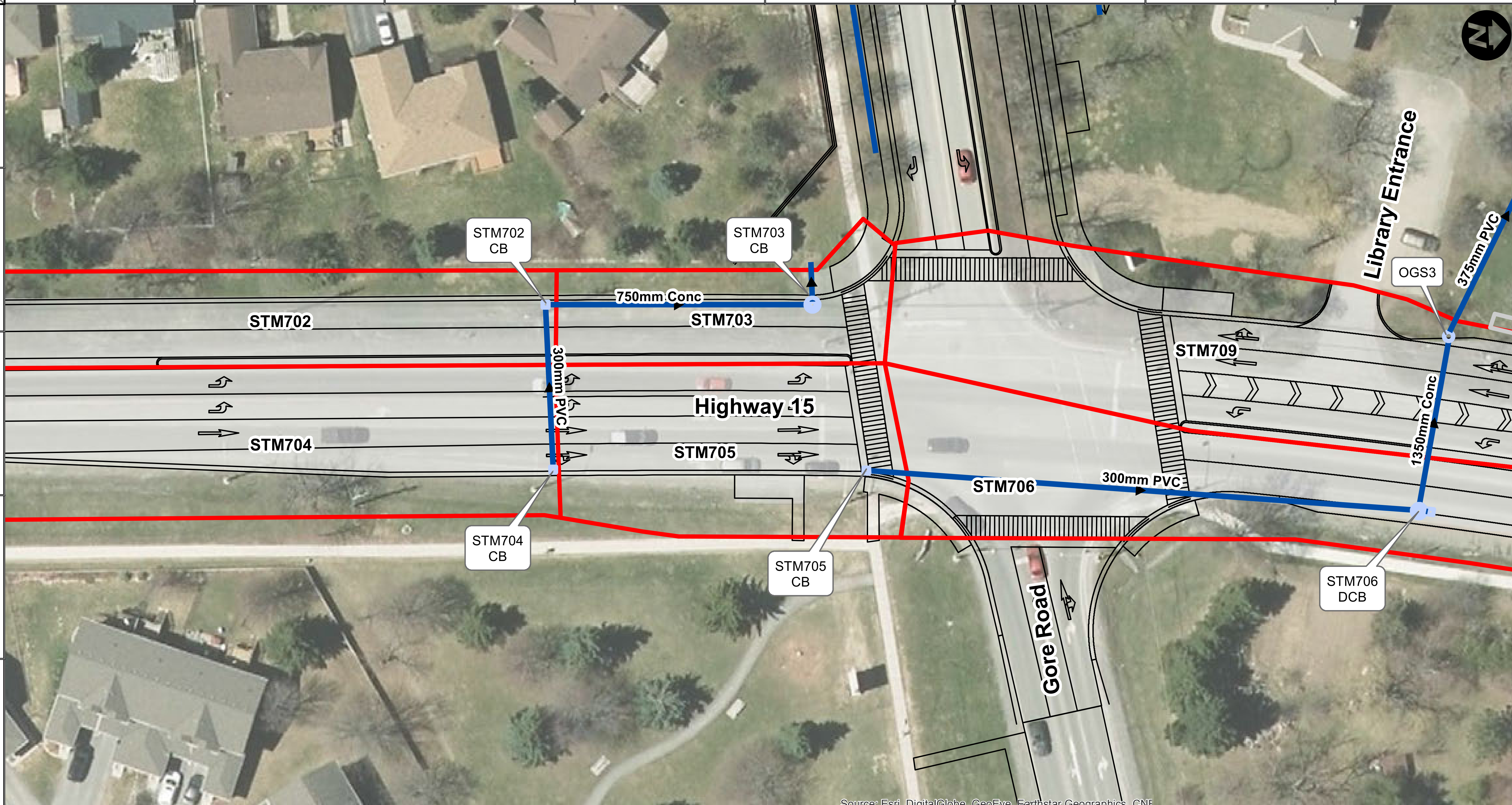
PROJ. DES. COORD.	PROJ. ENGR.

HIGHWAY 15

KINGSTON THIRD CROSSING

PROPOSED DRAINAGE PLAN



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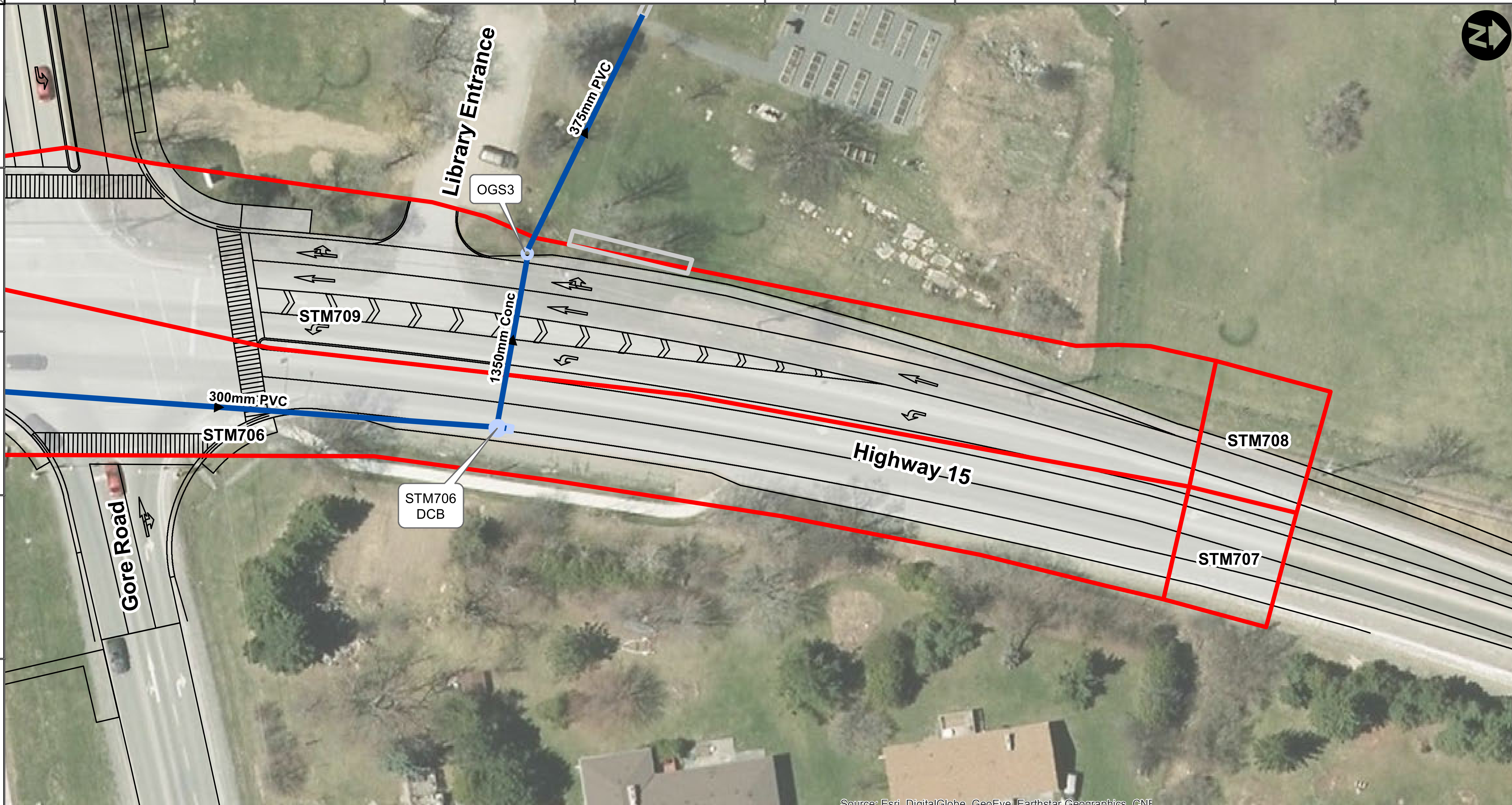
0	FOR REVIEW	DJ	EM	BR	

DESIGNED BY:	DRAWN BY: DJ
CHECKED BY:	DISC. ENGR.
PROJ. DES. COORD.	PROJ. ENGR.

HIGHWAY 15

KINGSTON THIRD CROSSING

PROPOSED DRAINAGE PLAN



HATCH

REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR REVIEW	DJ	EM	BR	

DESIGNED BY:
DRAWN BY: DJ
CHECKED BY:
DISC. ENGR.
PROJ. DES. COORD.
PROJ. ENGR.

HIGHWAY 15

KINGSTON THIRD CROSSING

PROPOSED DRAINAGE PLAN

DRAWING NAME: H357883-20-260-WIP0-0019.dwg SAVE DATE: 2/11/2019 4:45 PM PLOT DATE: 2/12/2019 11:40 AM
SAVED BY: WEST867507

INTEGRATED PROJECT DELIVERY TEAM:

HATCH | SYSTRA INTERNATIONAL BRIDGE TECHNOLOGIES | Kiewit | KINGSTON

No.	DATE	REVISIONS	BY	CHECKED

DESIGN COMPANY: HATCH

DESIGN:

DRAWN:

CHECKED:

KINGSTON THIRD CROSSING

WEST SHORE

SITE PLAN

STA. 9+950 TO STA. 11+370

DATE: 02-11-19

SCALE: 1:500

DRAWING NO. SEG1-0001

SHEET NO. C001

REVISION

DRAWING NAME: H357883-20-260-WIP0-0019.dwg SAVE DATE: 2/12/2019 12:11 PM PLOT DATE: 2/15/2019 10:01 AM
SAVED BY: WEST867507

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No.	DATE	REVISIONS	BY	CHECKED

DESIGN COMPANY: HATCH

DESIGN:

DRAWN:

CHECKED:

KINGSTON THIRD CROSSING

EAST SHORE

SITE PLAN

STA. 11+370 TO STA. 11+770

DATE: 02-15-19

SCALE: 1:500

DRAWING NO. SEG3-0001

SHEET NO. C002

REVISION

INTEGRATED PROJECT DELIVERY TEAM:

HATCH SYSTRA INTERNATIONAL BRIDGE TECHNOLOGIES Kiewit KINGSTON

No.	DATE	REVISIONS	BY	CHECKED

DESIGN COMPANY: HATCH

DESIGN: SG

DRAWN: LW

CHECKED: SM

KINGSTON THIRD CROSSING

HIGHWAY 15

SITE PLAN

STA. 2+000 TO STA. 2+535

DATE: 02-15-19

SCALE: 1:500

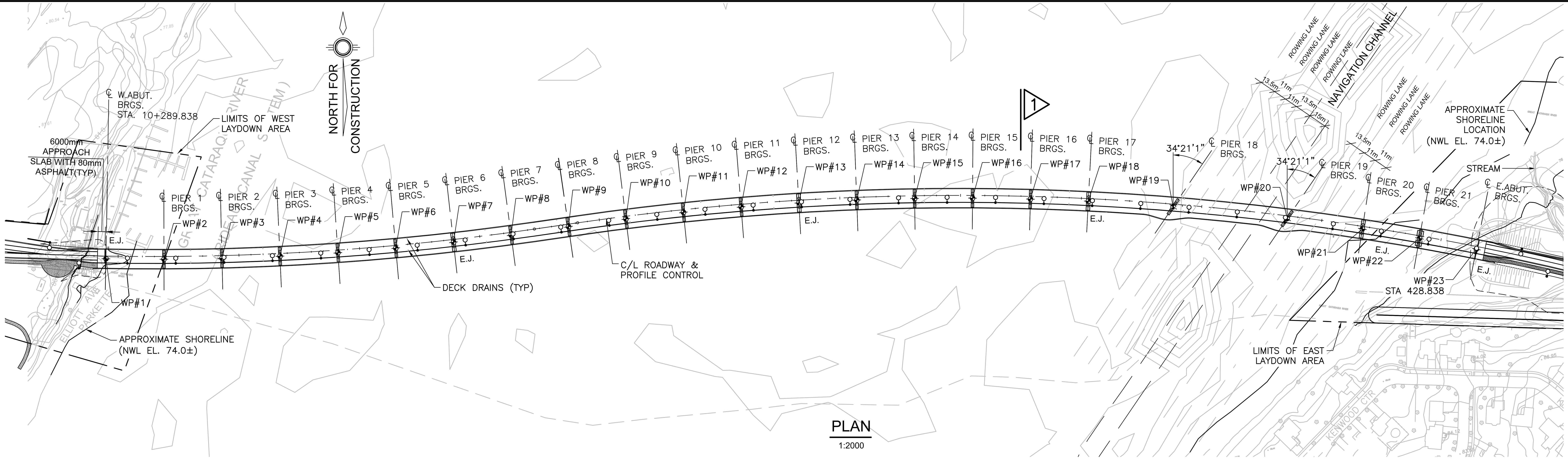
DRAWING NO. SEG3-0002

SHEET NO. C003

REVISION

DRAWING NAME: H357883-20-260-WIP0-0019.dwg SAVE DATE: 2/12/2019 12:11 PM PLOT DATE: 2/15/2019 3:02 PM
SAVED BY: WEST867507

METRIC



PLAN
1:2000

GENERAL NOTES:

DESIGN LOADS

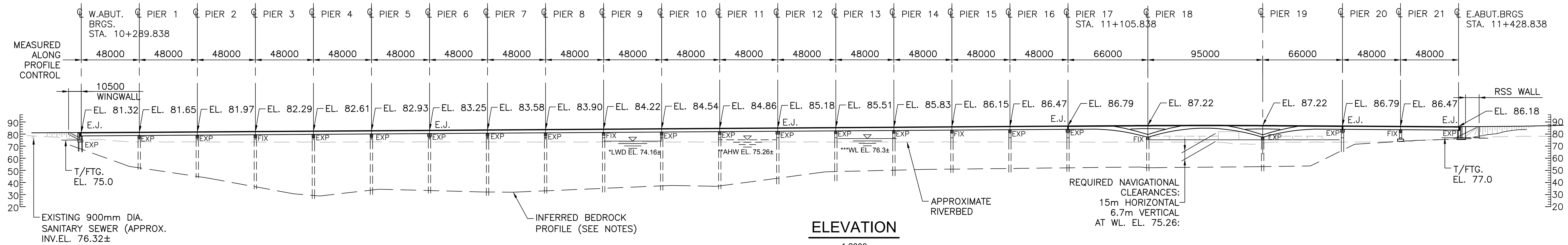
BRIDGE: CL-625-ONT TRUCK LOAD, CL-625-ONT LANE LOAD OF CHBDC.
SIDEWALK: PEDESTRIAN LOADS AND MAINTENANCE VEHICLE OF CHBDC S6-14.

CONSTRUCTION NOTES

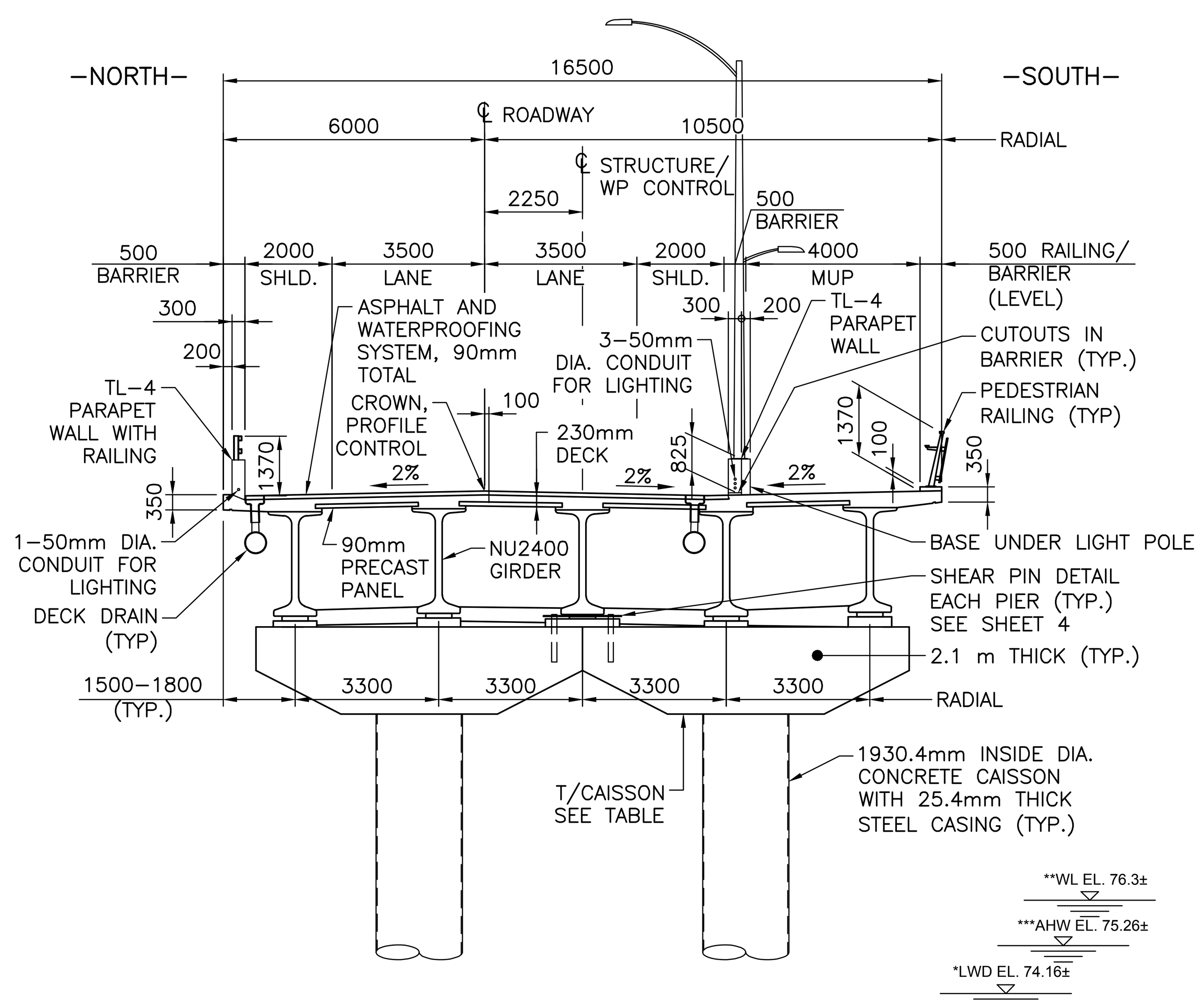
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE. CHAINAGES AND ELEVATIONS ARE IN METRES.
2. MAINTAIN FULL NAVIGATIONAL CLEARANCE THROUGHOUT CONSTRUCTION.
3. INFERRED BEDROCK PROFILE IS BASED ON BOREHOLE LOGS FROM GOLDER ASSOCIATES REPORT ENTITLED "PRELIMINARY GEOTECHNICAL INVESTIGATION – THIRD CROSSING OF CATARAQUI RIVER – JOHN COUNTER BOULEVARD TO GORE ROAD, KINGSTON, ONTARIO", DATED MARCH 2017, REPORT NO. 1541774/2000/003.

LEGEND:

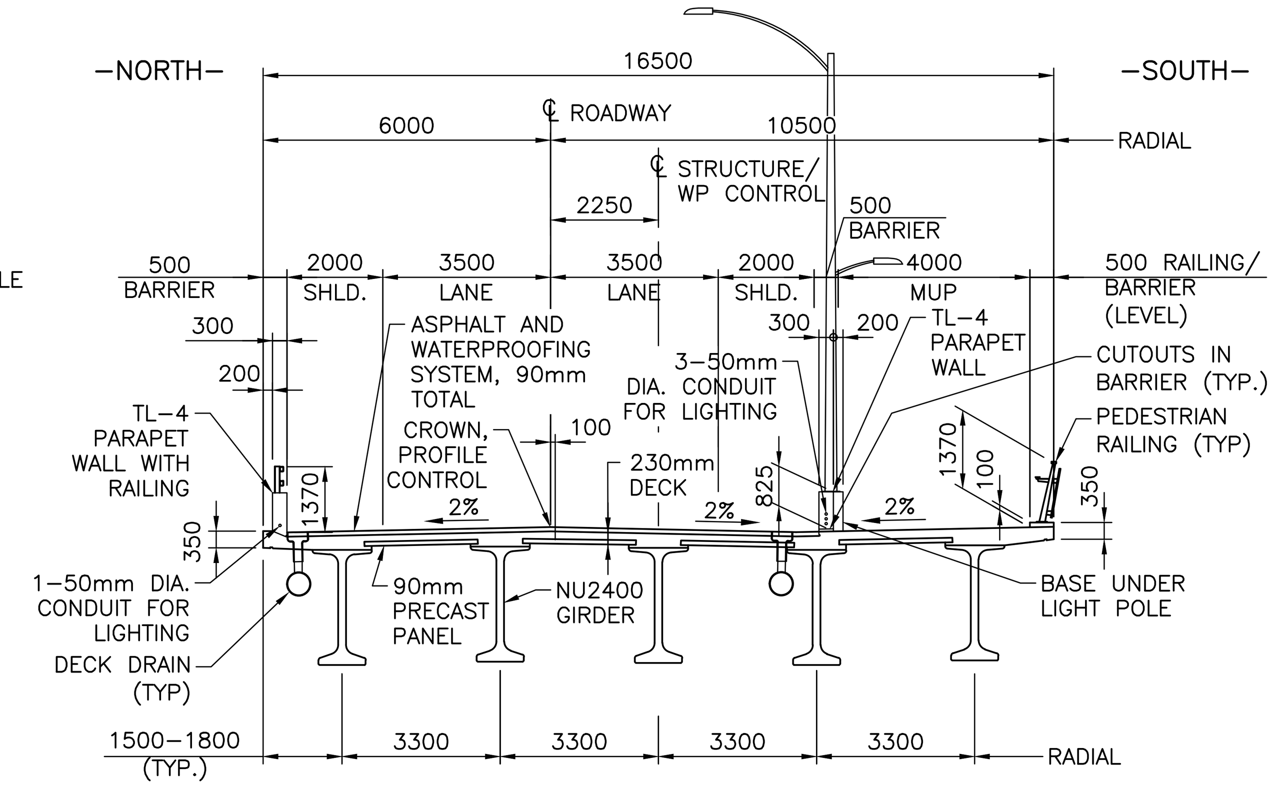
WP	DENOTES WORKING POINT
C/L	DENOTES CENTRELINE
T/A	DENOTES TOP OF ASPHALT
T/FTG.	DENOTES TOP OF FOOTING
T/CAISSON	DENOTES TOP OF CAISSON
– – – –	DENOTES NOISE BARRIER



ELEVATION
1:2000



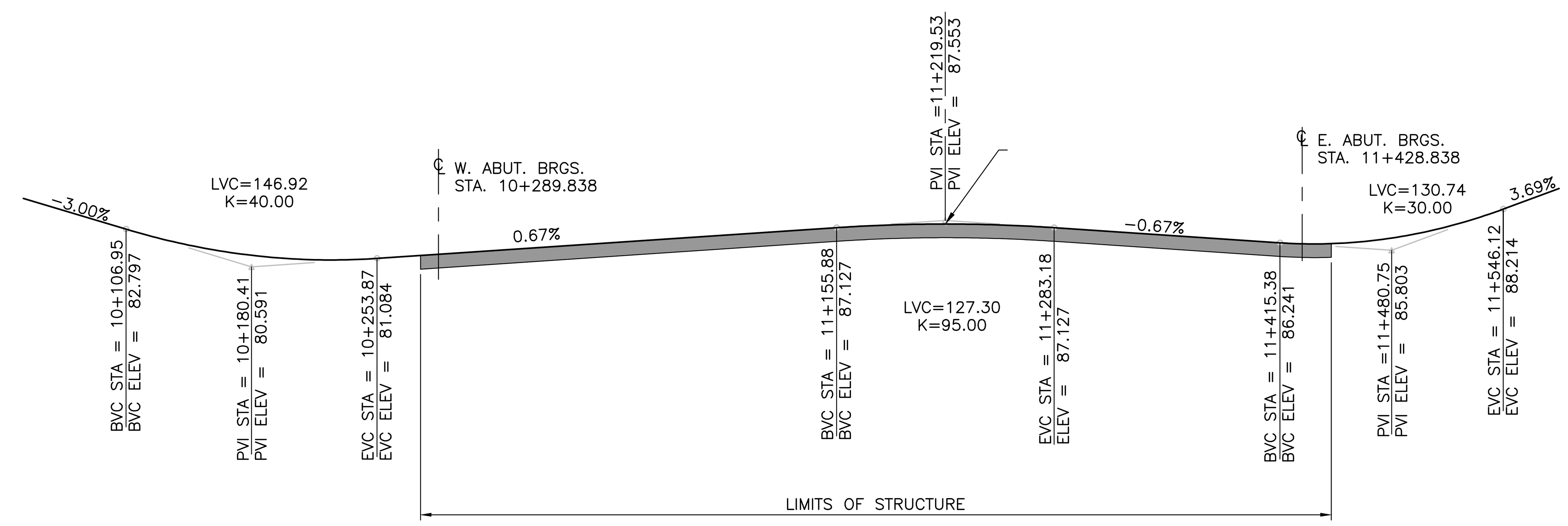
APPROACH SPANS AT PIER
SCALE 1:125



APPROACH SPANS AT MID-SPAN
SCALE 1:125

NOTE:

* LOW WATER DATUM	EL. 74.16	CANADIAN HYDROGRAPHIC SERVICE (LAKE ONTARIO)
** AVERAGE HIGH WATER	EL. 75.26	MINISTRY OF NATURAL RESOURCES (LAKE ONTARIO)
*** REGULATORY WATER LEVEL	EL. 76.3	CATARAQUI REGION CONSERVATION AUTHORITY "REGULATORY LIMIT WITHIN THE STUDY AREA"



PROFILE THIRD CROSSING
N.T.S.

INTEGRATED PROJECT DELIVERY TEAM:

HATCH
SYSTRA INTERNATIONAL BRIDGE TECHNOLOGIES
Kiewit
KINGSTON

No.	DATE	REVISIONS	BY	CHECKED
D	19-01-31	REVISED FOR ESTIMATING PURPOSES	RF	BR
C	19-01-18	DRAINAGE DETAIL IN DECK REVISED	RF	BR
B	19-01-11	REVISED FOR ESTIMATING PURPOSES	RF	BR
A	18-12-17	FOR ESTIMATING PURPOSES	RF	BR

DESIGN COMPANY: HATCH

DESIGN:	RF
DRAWN:	YZ
CHECKED:	BR

KINGSTON THIRD CROSSING

OVERALL GENERAL ARRANGEMENT

DATE: 19-01-31
SCALE: AS SHOWN

DRAWING NO.
SHEET NO. 0001
REVISION D

DRAWING NAME: H357883-03-260-WIP0-1000.dwg
SAVED BY: zhoo857409 SAVE DATE: 2/1/2019 4:18 PM PLOT DATE: 2/1/2019 4:57 PM

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.010)
--------------------------------------------------------------


*************
Element Count
*************
Number of rain gages ...... 2
Number of subcatchments ... 4
Number of nodes ........... 8
Number of links ........... 6
Number of pollutants ...... 0
Number of land uses ....... 0


****************
Raingage Summary
****************
                                                     Data       Recording
Name                 Data Source                     Type       Interval
------------------------------------------------------------------------
KNGSTN-PS_CHI_3hr_100 KNGSTN-PS_CHI_3hr_100          INTENSITY   10 min.
KNGSTN-PS_SCS_24hr_100 KNGSTN-PS_SCS_24hr_100         INTENSITY   15 min.


********************
Subcatchment Summary
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------------------
East_Approach              1.43     68.00     25.00    0.5000 KNGSTN-PS_SCS_24hr_100 Headwall
East_Bank                  4.21    168.25      6.00    3.0000 KNGSTN-PS_SCS_24hr_100 EastBank
East_Upstream             20.46    240.67     20.90    0.5000 KNGSTN-PS_SCS_24hr_100 Ditch
West_Upstream              4.03    134.23     33.00    5.0000 KNGSTN-PS_SCS_24hr_100 WestBank


************
Node Summary
************
                                           Invert      Max.    Ponded    External
Name                 Type                   Elev.     Depth      Area    Inflow
-------------------------------------------------------------------------------
EastBank             OUTFALL                74.77      0.30       0.0
WestBank             OUTFALL                74.61      0.00       0.0
115                  STORAGE                92.71      3.02       0.0
116                  STORAGE                92.25      3.45       0.0
117                  STORAGE                89.66      3.84       0.0
118                  STORAGE                87.28      4.27       0.0
Ditch                STORAGE                93.50      2.50       0.0
Headwall             STORAGE                86.99      4.56       0.0


************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
---------------------------------------------------------------------------------------------
C2               115              116              CONDUIT           16.0    2.6194    0.0130
C3               116              117              CONDUIT           99.9    2.5724    0.0130
C4               117              118              CONDUIT           84.8    2.8067    0.0130
C5               118              Headwall         CONDUIT            4.6    6.3307    0.0130
C6               Headwall         EastBank         CONDUIT          200.1    6.1174    0.0100
DitchInlet       Ditch            115              OUTLET


*********************
Cross Section Summary
*********************
                                    Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape             Depth     Area     Rad.    Width  Barrels     Flow
---------------------------------------------------------------------------------------
C2               CIRCULAR           0.60     0.28     0.15     0.60        1     0.99
C3               CIRCULAR           0.60     0.28     0.15     0.60        1     0.98
C4               CIRCULAR           0.60     0.28     0.15     0.60        1     1.03
C5               CIRCULAR           0.60     0.28     0.15     0.60        1     1.55
C6               TRAPEZOIDAL        0.30     0.57     0.20     2.80        1     4.77


*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Starting Date ............ JAN-01-2000 00:00:00
Ending Date .............. JAN-04-2000 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00
```

```
Routing Time Step ........ 1.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 1
Head Tolerance ........... 0.001500 m

**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         2.924        97.100
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         1.145        38.021
Surface Runoff ...........         1.637        54.340
Final Storage ............         0.145         4.822
Continuity Error (%) .....        -0.085

**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         1.637        16.366
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         1.637        16.366
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.003         0.026
Final Stored Volume ......         0.003         0.032
Continuity Error (%) .....        -0.038

***************************
Time-Step Critical Elements
***************************
Link C5 (28.87%)

********************************
Highest Flow Instability Indexes
********************************
All links are stable.

*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     0.00 sec
Average Time Step           :     0.88 sec
Maximum Time Step           :     1.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
Percent Not Converging      :     0.00

***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff CMS	Runoff Coeff
East_Approach	97.10	0.00	0.00	52.90	42.99	0.61	0.12	0.443
East_Bank	97.10	0.00	0.00	64.08	31.79	1.34	0.14	0.327
East_Upstream	97.10	0.00	0.00	28.67	62.02	12.69	1.46	0.639
West_Upstream	97.10	0.00	0.00	53.01	42.91	1.73	0.43	0.442

```
******************
Node Depth Summary
******************
```

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
EastBank	OUTFALL	0.20	0.20	74.97	0 00:00	0.06
WestBank	OUTFALL	0.00	0.00	74.61	0 00:00	0.00
115	STORAGE	0.08	0.92	93.63	0 12:03	0.28
116	STORAGE	0.08	0.92	93.17	0 12:03	0.28
117	STORAGE	0.08	0.55	90.21	0 11:58	0.17
118	STORAGE	0.07	0.36	87.64	0 11:58	0.11
Ditch	STORAGE	0.06	0.63	94.13	0 12:03	0.19
Headwall	STORAGE	0.02	0.14	87.13	0 11:58	0.04

```
*******************
Node Inflow Summary
*******************
```

Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
EastBank	OUTFALL	0.138	1.289	0 11:58	1.34	14.6	0.000
WestBank	OUTFALL	0.427	0.427	0 12:00	1.73	1.73	0.000
115	STORAGE	0.000	1.156	0 11:58	0	12.7	0.007
116	STORAGE	0.000	1.137	0 11:58	0	12.7	0.006

117	STORAGE	0.000	1.058	0 11:57	0	12.7	-0.013
118	STORAGE	0.000	1.052	0 11:58	0	12.7	0.000
Ditch	STORAGE	1.460	1.460	0 12:00	12.7	12.7	-0.000
Headwall	STORAGE	0.121	1.168	0 11:58	0.614	13.3	-0.000

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
115	STORAGE	0.24	0.320	2.100
116	STORAGE	0.22	0.276	2.534
Ditch	STORAGE	72.00	0.634	1.866

****
Node Flooding Summary
****

No nodes were flooded.

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 m3	Avg Pcnt Full	Evap Pcnt Loss	Exfil Pcnt Loss	Maximum Volume 1000 m3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CMS
115	0.000	3	0	0	0.001	30	0 12:03	1.137
116	0.000	2	0	0	0.001	27	0 12:03	1.058
117	0.000	2	0	0	0.001	14	0 11:58	1.052
118	0.000	2	0	0	0.000	8	0 11:58	1.050
Ditch	0.048	3	0	0	0.475	25	0 12:03	1.156
Headwall	0.000	0	0	0	0.000	3	0 11:58	1.163

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
EastBank	91.99	0.091	1.289	14.638
WestBank	43.74	0.023	0.427	1.728
System	67.86	0.114	1.713	16.366

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
C2	CONDUIT	1.137	0 11:58	4.02	1.14	1.00
C3	CONDUIT	1.058	0 11:57	3.96	1.07	1.00
C4	CONDUIT	1.052	0 11:58	4.73	1.02	0.76
C5	CONDUIT	1.050	0 11:58	9.35	0.68	0.42
C6	CONDUIT	1.163	0 11:58	4.45	0.24	0.57
DitchInlet	DUMMY	1.156	0 11:58			

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	---------- Fraction of Time in Flow Class ----------								
		Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
C2	1.00	0.02	0.00	0.00	0.01	0.00	0.00	0.98	0.00	0.00
C3	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
C4	1.00	0.02	0.00	0.00	0.05	0.93	0.00	0.00	0.06	0.00
C5	1.00	0.02	0.00	0.00	0.03	0.95	0.00	0.00	0.02	0.00
C6	1.00	0.00	0.02	0.00	0.83	0.16	0.00	0.00	0.98	0.00

****
Conduit Surcharge Summary
****

Conduit	--------- Hours Full --------			Hours Above Full Normal Flow	Hours Capacity Limited
	Both Ends	Upstream	Dnstream		
C2	0.24	0.24	0.25	0.23	0.22
C3	0.23	0.23	0.26	0.26	0.23
C4	0.01	0.01	0.01	0.18	0.01

```
Analysis begun on:  Wed Aug 03 11:03:02 2016
Analysis ended on:  Wed Aug 03 11:03:06 2016
Total elapsed time: 00:00:04
```

Cataraqui River, Third Crossing, Kingston - Post-Development Conditions

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.011)
--------------------------------------------------------------

WARNING 03: negative offset ignored for Link 1_1
WARNING 03: negative offset ignored for Link 1_2
WARNING 03: negative offset ignored for Link 1_2
WARNING 03: negative offset ignored for Link 2_3
WARNING 03: negative offset ignored for Link 7
WARNING 03: negative offset ignored for Link C5
WARNING 02: maximum depth increased for Node 1
WARNING 02: maximum depth increased for Node 10
WARNING 02: maximum depth increased for Node EGS1
WARNING 02: maximum depth increased for Node EGS2-CVI
WARNING 02: maximum depth increased for Node EGS3-CVO
WARNING 02: maximum depth increased for Node EGS4-DI

*************
Element Count
*************
Number of rain gages ...... 1
Number of subcatchments ... 18
Number of nodes ........... 38
Number of links ........... 37
Number of pollutants ...... 0
Number of land uses ....... 0


****************
Raingage Summary
****************
                                                    Data       Recording
Name                 Data Source                    Type       Interval
------------------------------------------------------------------------
KNGSTN-PS_SCS_24hr_100 KNGSTN-PS_SCS_24hr_100         INTENSITY   15 min.


********************
Subcatchment Summary
********************
Name                           Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------
Bridge_East                    0.14     12.35    100.00    1.0000 KNGSTN-PS_SCS_24hr_100 East_N_Low
Bridge_West                    1.16     12.13    100.00    1.0000 KNGSTN-PS_SCS_24hr_100 14
BridgeApproach                 0.09     12.76    100.00    0.5000 KNGSTN-PS_SCS_24hr_100 East_N_Low
East_Bank                      3.30     86.97     13.07    3.0000 KNGSTN-PS_SCS_24hr_100 EastBank
Montreal                       1.94     63.13     52.61    2.0000 KNGSTN-PS_SCS_24hr_100 EGS1
S1                            20.29    253.57     20.58    0.5000 KNGSTN-PS_SCS_24hr_100 Ditch
S12                            0.37     36.73     11.55    0.5000 KNGSTN-PS_SCS_24hr_100 EGS5-DO
S19_1                          0.16     34.21     64.73    0.5000 KNGSTN-PS_SCS_24hr_100 117
S19_2                          1.26     34.21     64.73    0.5000 KNGSTN-PS_SCS_24hr_100 3
S2_1                           0.60     35.02     43.00    2.0000 KNGSTN-PS_SCS_24hr_100 1
S2_2                           0.36     35.02     43.00    2.0000 KNGSTN-PS_SCS_24hr_100 2
S2_3                           0.02     35.02     43.00    2.0000 KNGSTN-PS_SCS_24hr_100 14
S3                             0.81     19.34     60.26    0.5000 KNGSTN-PS_SCS_24hr_100 East_S_Low
S4_1                           0.26     31.64     64.00    2.0000 KNGSTN-PS_SCS_24hr_100 CB4
S4_2                           0.48     31.64     64.00    2.0000 KNGSTN-PS_SCS_24hr_100 CB2
S4_3                           0.03     31.64     64.00    2.0000 KNGSTN-PS_SCS_24hr_100 15
S9                             0.50    127.85      3.14    0.5000 KNGSTN-PS_SCS_24hr_100 5
West_Upstream                  2.02     77.77     37.75    5.0000 KNGSTN-PS_SCS_24hr_100 WestBank


************
Node Summary
```

Cataraqui River, Third Crossing, Kingston - Post-Development Conditions

****

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
1	JUNCTION	80.39	1.65	0.0	
10	JUNCTION	76.25	1.65	0.0	
11	JUNCTION	76.00	2.00	0.0	
12	JUNCTION	77.30	2.70	0.0	
13	JUNCTION	79.00	1.90	0.0	
14	JUNCTION	79.42	1.83	0.0	
15	JUNCTION	79.59	1.65	0.0	
2	JUNCTION	78.90	2.00	0.0	
3	JUNCTION	88.30	2.20	0.0	
4	JUNCTION	77.00	6.20	0.0	
5	JUNCTION	88.00	2.50	0.0	
6	JUNCTION	78.00	2.00	0.0	
7	JUNCTION	88.60	1.50	0.0	
8	JUNCTION	75.30	2.04	0.0	
9	JUNCTION	75.17	2.17	0.0	
CB1	JUNCTION	82.40	1.50	0.0	
CB2	JUNCTION	80.53	1.58	0.0	
CB4	JUNCTION	79.27	1.64	0.0	
EastBank	JUNCTION	75.00	0.50	0.0	
EGS1	JUNCTION	83.50	1.65	0.0	
EGS2-CVI	JUNCTION	80.30	1.65	0.0	
EGS3-CVO	JUNCTION	79.80	1.80	0.0	
EGS4-DI	JUNCTION	78.80	1.80	0.0	
EGS5-DO	JUNCTION	78.35	1.65	0.0	
Headwall	JUNCTION	83.02	1.80	0.0	
OF1	OUTFALL	83.40	0.00	0.0	
River_East	OUTFALL	74.77	0.50	0.0	
River_West	OUTFALL	75.50	1.00	0.0	
115	STORAGE	92.71	3.02	0.0	
116	STORAGE	92.25	3.45	0.0	
117	STORAGE	89.66	3.84	0.0	
118	STORAGE	87.28	4.27	0.0	
Ditch	STORAGE	93.50	1.50	0.0	
East_N_Low	STORAGE	91.00	0.65	0.0	
East_S_Low	STORAGE	91.00	0.65	0.0	
SU1	STORAGE	83.50	2.15	0.0	
West_S_Low	STORAGE	81.00	0.65	0.0	
WestBank	STORAGE	75.60	2.15	0.0	

****
Link Summary
****

Name	From Node	To Node	Type	Length	%Slope	Roughness
1	14	13	CONDUIT	39.6	0.8580	0.0100
1_1	EGS1	1	CONDUIT	108.2	2.8728	0.0350
1_2	1	EGS2-CVI	CONDUIT	3.6	2.5572	0.0350
1_3	3	5	CONDUIT	28.6	1.0477	0.0130
10	10	WestBank	CONDUIT	21.3	1.1754	0.0130
2	15	14	CONDUIT	10.5	0.9532	0.0100
2_1	EGS3-CVO	2	CONDUIT	61.3	1.4677	0.0350
2_2	2	EGS4-DI	CONDUIT	7.5	1.3358	0.0350
2_3	Headwall	6	CONDUIT	76.4	6.5825	0.0100
2_4	5	4	CONDUIT	75.5	14.7345	0.0280
2_6	11	8	CONDUIT	22.2	3.1503	0.0350
2_7	6	12	CONDUIT	16.3	4.3082	0.0130
2_9	4	11	CONDUIT	53.7	1.8632	0.0280
3	CB1	CB2	CONDUIT	70.7	2.5478	0.0130
4	CB2	1	CONDUIT	22.0	0.5993	0.0100

5_1	CB4	13	CONDUIT	11.3	1.0170	0.0130
5_2	13	2	CONDUIT	11.3	0.8873	0.0130
6	7	3	CONDUIT	57.3	0.5240	0.0350
7	EGS2-CVI	EGS3-CVO	CONDUIT	24.1	2.0776	0.0130
8	EGS4-DI	EGS5-DO	CONDUIT	22.2	2.0240	0.0130
8_2	EGS5-DO	10	CONDUIT	53.5	3.9296	0.0350
9	8	9	CONDUIT	8.5	1.5858	0.0130
C1	WestBank	River_West	CONDUIT	13.9	0.7198	0.0400
C2	115	116	CONDUIT	16.0	2.6190	0.0130
C3	116	117	CONDUIT	99.9	2.5724	0.0130
C4	117	118	CONDUIT	78.9	3.0188	0.0130
C5	118	Headwall	CONDUIT	81.4	5.2434	0.0130
C6_3	9	EastBank	CONDUIT	28.2	0.5891	0.0350
C7	EastBank	River_East	CONDUIT	7.8	2.9349	0.0400
C8	East_N_Low	11	CONDUIT	19.6	113.1651	0.0100
2_8	12	EastBank	WEIR			
C11	West_S_Low	WestBank	WEIR			
C9	East_S_Low	EastBank	WEIR			
W1	East_S_Low	East_N_Low	WEIR			
W2	West_S_Low	CB4	WEIR			
W3	SU1	OF1	WEIR			
DitchInlet	Ditch	115	OUTLET			

****
Cross Section Summary
****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
1	CIRCULAR	0.53	0.22	0.13	0.53	1	0.52
1_1	TRAPEZOIDAL	1.65	10.64	0.89	11.40	1	47.75
1_2	TRAPEZOIDAL	1.65	10.64	0.89	11.40	1	45.05
1_3	CIRCULAR	0.30	0.07	0.07	0.30	1	0.10
10	CIRCULAR	0.40	0.13	0.10	0.40	1	0.23
2	CIRCULAR	0.45	0.16	0.11	0.45	1	0.36
2_1	TRAPEZOIDAL	1.80	12.42	0.96	12.30	1	41.96
2_2	TRAPEZOIDAL	1.80	12.42	0.96	12.30	1	40.03
2_3	TRAPEZOIDAL	1.50	9.00	0.82	10.50	1	202.19
2_4	TRAPEZOIDAL	1.00	4.50	0.58	7.50	1	42.67
2_6	TRAPEZOIDAL	1.50	9.00	0.82	10.50	1	39.96
2_7	CIRCULAR	0.53	0.22	0.13	0.53	1	0.89
2_9	TRAPEZOIDAL	1.00	4.50	0.58	7.50	1	15.17
3	CIRCULAR	0.30	0.07	0.07	0.30	1	0.15
4	CIRCULAR	0.38	0.11	0.09	0.38	1	0.18
5_1	CIRCULAR	0.45	0.16	0.11	0.45	1	0.29
5_2	CIRCULAR	0.60	0.28	0.15	0.60	1	0.58
6	TRAPEZOIDAL	1.50	9.00	0.82	10.50	1	16.30
7	CIRCULAR	0.38	0.11	0.09	0.38	1	0.25
8	CIRCULAR	0.45	0.16	0.11	0.45	1	0.41
8_2	TRAPEZOIDAL	1.65	10.64	0.89	11.40	1	55.85
9	CIRCULAR	0.23	0.04	0.06	0.23	1	0.06
C1	RECT_OPEN	1.00	10.00	0.83	10.00	1	18.79
C2	CIRCULAR	0.60	0.28	0.15	0.60	1	0.99
C3	CIRCULAR	0.60	0.28	0.15	0.60	1	0.98
C4	CIRCULAR	0.60	0.28	0.15	0.60	1	1.07
C5	CIRCULAR	0.60	0.28	0.15	0.60	1	1.41
C6_3	TRAPEZOIDAL	0.50	1.25	0.30	4.00	1	1.23
C7	TRAPEZOIDAL	0.50	1.25	0.30	4.00	1	2.40
C8	CIRCULAR	1.00	0.79	0.25	1.00	1	33.16

****

Cataraqui River, Third Crossing, Kingston - Post-Development Conditions

```
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Starting Date ............ 01/01/2000 00:00:00
Ending Date .............. 01/04/2000 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00
Routing Time Step ........ 1.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 10
Number of Threads ........ 8
Head Tolerance ........... 0.001500 m


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         3.277        97.100
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         1.124        33.294
Surface Runoff ...........         2.008        59.495
Final Storage ............         0.149         4.426
Continuity Error (%) .....        -0.118


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         2.008        20.079
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         2.007        20.072
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.000         0.000
Continuity Error (%) .....         0.034


***************************
Time-Step Critical Elements
***************************
None
```

****
Highest Flow Instability Indexes
****
All links are stable.

****
Routing Time Step Summary
****

Minimum Time Step	:	0.11 sec
Average Time Step	:	1.00 sec
Maximum Time Step	:	1.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.01
Percent Not Converging	:	0.09

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Total Runoff mm	Total Runoff 10^6 ltr	Pea Runof CM
Bridge_East	97.10	0.00	0.00	0.00	95.96	0.13	0.0
Bridge_West	97.10	0.00	0.00	0.00	95.64	1.11	0.2
BridgeApproach	97.10	0.00	0.00	0.00	95.98	0.09	0.0
East_Bank	97.10	0.00	0.00	57.94	37.93	1.25	0.0
Montreal	97.10	0.00	0.00	35.79	60.13	1.17	0.3
S1	97.10	0.00	0.00	28.79	61.95	12.57	1.4
S12	97.10	0.00	0.00	70.76	25.11	0.09	0.0
S19_1	97.10	0.00	0.00	24.57	71.43	0.11	0.0
S19_2	97.10	0.00	0.00	25.31	70.51	0.89	0.2
S2_1	97.10	0.00	0.00	44.96	50.97	0.30	0.0
S2_2	97.10	0.00	0.00	44.74	51.19	0.18	0.0
S2_3	97.10	0.00	0.00	44.22	51.79	0.01	0.0
S3	97.10	0.00	0.00	25.49	70.33	0.57	0.1
S4_1	97.10	0.00	0.00	28.06	67.92	0.18	0.0
S4_2	97.10	0.00	0.00	28.19	67.80	0.32	0.1
S4_3	97.10	0.00	0.00	27.85	68.13	0.02	0.0
S9	97.10	0.00	0.00	67.88	28.01	0.14	0.0
West_Upstream	97.10	0.00	0.00	48.53	47.40	0.96	0.2

****
Node Depth Summary
****

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
1	JUNCTION	0.01	0.73	81.12	0 12:03	0.72
10	JUNCTION	0.04	1.38	77.63	0 12:16	1.38
11	JUNCTION	0.02	0.75	76.75	0 12:19	0.74
12	JUNCTION	0.02	0.26	77.56	0 12:09	0.26
13	JUNCTION	0.02	0.71	79.71	0 12:04	0.70
14	JUNCTION	0.02	0.27	79.68	0 12:03	0.27
15	JUNCTION	0.00	0.10	79.69	0 12:03	0.10

2	JUNCTION	0.02	0.80	79.70	0	12:05	0.80
3	JUNCTION	0.03	0.60	88.90	0	12:05	0.60
4	JUNCTION	0.01	0.09	77.09	0	12:04	0.09
5	JUNCTION	0.00	0.05	88.05	0	12:03	0.05
6	JUNCTION	0.07	0.83	78.83	0	12:09	0.83
7	JUNCTION	0.00	0.30	88.90	0	12:05	0.30
8	JUNCTION	0.05	1.48	76.78	0	12:19	1.48
9	JUNCTION	0.02	0.23	75.40	0	12:10	0.23
CB1	JUNCTION	0.00	0.00	82.40	0	00:00	0.00
CB2	JUNCTION	0.01	0.62	81.14	0	12:02	0.61
CB4	JUNCTION	0.01	0.44	79.70	0	12:05	0.42
EastBank	JUNCTION	0.05	0.38	75.38	0	12:10	0.38
EGS1	JUNCTION	0.01	0.15	83.65	0	12:00	0.14
EGS2-CVI	JUNCTION	0.03	0.91	81.21	0	12:02	0.85
EGS3-CVO	JUNCTION	0.01	0.18	79.98	0	12:03	0.18
EGS4-DI	JUNCTION	0.03	1.02	79.82	0	12:06	0.99
EGS5-DO	JUNCTION	0.01	0.18	78.53	0	12:03	0.18
Headwall	JUNCTION	0.01	0.11	83.13	0	12:02	0.11
OF1	OUTFALL	0.00	0.00	83.40	0	00:00	0.00
River_East	OUTFALL	0.05	0.38	75.15	0	12:10	0.38
River_West	OUTFALL	0.00	0.07	75.57	0	12:00	0.07
115	STORAGE	0.07	1.44	94.15	0	12:03	1.39
116	STORAGE	0.07	1.28	93.53	0	12:01	1.27
117	STORAGE	0.06	0.55	90.21	0	12:01	0.55
118	STORAGE	0.06	0.50	87.78	0	12:02	0.50
Ditch	STORAGE	0.05	0.61	94.11	0	12:02	0.61
East_N_Low	STORAGE	0.00	0.06	91.06	0	11:57	0.06
East_S_Low	STORAGE	0.11	0.17	91.17	0	12:00	0.16
SU1	STORAGE	0.00	0.00	83.50	0	00:00	0.00
West_S_Low	STORAGE	0.00	0.00	81.00	0	00:00	0.00
WestBank	STORAGE	0.01	0.14	75.74	0	12:00	0.14

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Fl Balan Err Perce
1	JUNCTION	0.083	0.976	0	12:02	0.305	1.83	0.0
10	JUNCTION	0.000	0.566	0	12:04	0	3.38	0.0
11	JUNCTION	0.000	1.030	0	12:08	0	2.43	-0.0
12	JUNCTION	0.000	1.075	0	12:09	0	12.7	0.0
13	JUNCTION	0.000	0.317	0	12:00	0	1.31	-0.0
14	JUNCTION	0.255	0.261	0	11:59	1.12	1.13	0.0
15	JUNCTION	0.007	0.007	0	12:00	0.0173	0.0173	0.0
2	JUNCTION	0.050	1.740	0	12:07	0.183	3.54	-0.1
3	JUNCTION	0.232	0.232	0	12:00	0.886	0.911	-0.0
4	JUNCTION	0.000	0.143	0	12:03	0	1.03	-0.0
5	JUNCTION	0.017	0.143	0	12:02	0.14	1.03	-0.0
6	JUNCTION	0.000	1.133	0	12:02	0	12.7	0.0
7	JUNCTION	0.000	0.047	0	11:59	0	0.0252	0.7
8	JUNCTION	0.000	1.190	0	12:10	0	2.43	0.0
9	JUNCTION	0.000	0.182	0	12:14	0	1.8	-0.0
CB1	JUNCTION	0.000	0.000	0	00:00	0	0	0.0
CB2	JUNCTION	0.099	0.099	0	12:00	0.323	0.323	-0.0
CB4	JUNCTION	0.057	0.057	0	12:00	0.178	0.178	0.0
EastBank	JUNCTION	0.089	1.339	0	12:09	1.25	15.7	0.0
EGS1	JUNCTION	0.326	0.326	0	12:00	1.17	1.17	-0.2
EGS2-CVI	JUNCTION	0.000	1.335	0	12:02	0	1.83	0.2

EGS3-CVO	JUNCTION	0.000	0.343	0	12:02	0	1.79	-0.0
EGS4-DI	JUNCTION	0.000	2.328	0	12:08	0	3.55	0.3
EGS5-DO	JUNCTION	0.014	0.581	0	12:04	0.0922	3.37	-0.0
Headwall	JUNCTION	0.000	1.134	0	12:02	0	12.7	-0.0
OF1	OUTFALL	0.000	0.000	0	00:00	0	0	0.0
River_East	OUTFALL	0.000	1.339	0	12:10	0	15.7	0.0
River_West	OUTFALL	0.000	0.630	0	12:00	0	4.33	0.0
115	STORAGE	0.000	1.442	0	12:02	0	12.6	0.0
116	STORAGE	0.000	1.227	0	11:59	0	12.6	-0.0
117	STORAGE	0.037	1.135	0	12:01	0.113	12.7	0.0
118	STORAGE	0.000	1.134	0	12:02	0	12.7	-0.0
Ditch	STORAGE	1.474	1.474	0	12:00	12.6	12.6	-0.0
East_N_Low	STORAGE	0.075	0.197	0	12:00	0.22	0.779	0.0
East_S_Low	STORAGE	0.140	0.140	0	12:00	0.567	0.567	-0.0
SU1	STORAGE	0.000	0.000	0	00:00	0	0	0.0
West_S_Low	STORAGE	0.000	0.000	0	00:00	0	0	0.0
WestBank	STORAGE	0.217	0.632	0	12:00	0.955	4.33	0.0

****

Node Surcharge Summary

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Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
13	JUNCTION	0.18	0.109	1.191
CB2	JUNCTION	0.25	0.241	0.959

****

Node Flooding Summary

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No nodes were flooded.

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Storage Volume Summary

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Storage Unit	Average Volume 1000 m3	Avg Pcnt Full	Evap Pcnt Loss	Exfil Pcnt Loss	Maximum Volume 1000 m3	Max Pcnt Full	Time of Max Occurrence days	hr:min	Maxi Outf
115	0.000	2	0	0	0.002	48	0	12:03	1.
116	0.000	2	0	0	0.001	37	0	12:01	1.
117	0.000	2	0	0	0.001	14	0	12:01	1.
118	0.000	1	0	0	0.001	12	0	12:02	1.
Ditch	0.034	3	0	0	0.460	41	0	12:02	1.
East_N_Low	0.000	0	0	0	0.000	2	0	11:57	0.
East_S_Low	0.000	7	0	0	0.000	16	0	12:00	0.
SU1	0.000	0	0	0	0.000	0	0	00:00	0.
West_S_Low	0.000	0	0	0	0.000	0	0	00:00	0.
WestBank	0.000	0	0	0	0.003	6	0	12:00	0.

****

Outfall Loading Summary

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Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
OF1	0.00	0.000	0.000	0.000
River_East	89.23	0.069	1.339	15.742
River_West	59.36	0.029	0.630	4.330
System	49.53	0.098	1.900	20.072

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
1	CONDUIT	0.260	0 12:00	2.06	0.50	0.76
1_1	CONDUIT	0.323	0 12:00	0.67	0.01	0.26
1_2	CONDUIT	1.335	0 12:02	0.91	0.03	0.49
1_3	CONDUIT	0.130	0 12:05	3.04	1.31	0.58
10	CONDUIT	0.501	0 12:16	3.98	2.22	1.00
2	CONDUIT	0.009	0 11:58	0.52	0.02	0.32
2_1	CONDUIT	0.339	0 12:03	0.55	0.01	0.27
2_2	CONDUIT	2.328	0 12:08	0.94	0.06	0.49
2_3	CONDUIT	1.133	0 12:02	1.55	0.01	0.31
2_4	CONDUIT	0.143	0 12:03	1.19	0.00	0.07
2_6	CONDUIT	1.190	0 12:10	0.30	0.03	0.72
2_7	CONDUIT	1.075	0 12:09	6.28	1.20	0.74
2_9	CONDUIT	0.143	0 12:04	0.59	0.01	0.42
3	CONDUIT	0.000	0 00:00	0.00	0.00	0.50
4	CONDUIT	0.099	0 12:00	1.35	0.56	1.00
5_1	CONDUIT	0.059	0 12:00	1.36	0.21	0.99
5_2	CONDUIT	0.317	0 12:00	1.65	0.55	1.00
6	CONDUIT	0.047	0 11:59	0.10	0.00	0.30
7	CONDUIT	0.343	0 12:02	3.93	1.36	0.74
8	CONDUIT	0.578	0 12:05	4.85	1.42	0.70
8_2	CONDUIT	0.566	0 12:04	0.59	0.01	0.47
9	CONDUIT	0.182	0 12:14	4.70	3.22	1.00
C1	CONDUIT	0.630	0 12:00	0.60	0.03	0.11
C2	CONDUIT	1.227	0 11:59	4.34	1.23	1.00
C3	CONDUIT	1.107	0 12:01	4.12	1.12	1.00
C4	CONDUIT	1.134	0 12:02	4.39	1.06	0.87
C5	CONDUIT	1.134	0 12:02	7.89	0.81	0.51
C6_3	CONDUIT	0.190	0 12:16	0.44	0.15	0.61
C7	CONDUIT	1.339	0 12:10	1.65	0.56	0.76
C8	CONDUIT	0.197	0 12:00	10.38	0.01	0.24
2_8	WEIR	1.075	0 12:09			0.51
C11	WEIR	0.000	0 00:00			0.00
C9	WEIR	0.017	0 12:00			0.03
W1	WEIR	0.122	0 12:00			0.10
W2	WEIR	0.000	0 00:00			0.00
W3	WEIR	0.000	0 00:00			0.00
DitchInlet	DUMMY	1.442	0 12:02			

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Flow Classification Summary
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Cataraqui River, Third Crossing, Kingston - Post-Development Conditions

Conduit	Adjusted /Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
		---------- Fraction of Time in Flow Class ----------								
1	1.00	0.02	0.00	0.00	0.01	0.00	0.00	0.97	0.00	0.00
1_1	1.00	0.02	0.04	0.00	0.94	0.00	0.00	0.00	0.95	0.00
1_2	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.97	0.00
1_3	1.00	0.02	0.00	0.00	0.33	0.65	0.00	0.00	0.00	0.00
10	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
2	1.00	0.02	0.00	0.00	0.02	0.00	0.00	0.95	0.02	0.00
2_1	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.98	0.00
2_2	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.96	0.00
2_3	1.00	0.02	0.00	0.00	0.91	0.07	0.00	0.00	0.98	0.00
2_4	1.00	0.02	0.01	0.00	0.65	0.32	0.00	0.00	0.97	0.00
2_6	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.96	0.00
2_7	1.00	0.02	0.00	0.00	0.01	0.97	0.00	0.00	0.00	0.00
2_9	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.98	0.00
3	1.00	0.99	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	1.00	0.02	0.00	0.00	0.65	0.33	0.00	0.00	0.08	0.00
5_1	1.00	0.02	0.00	0.00	0.01	0.00	0.00	0.97	0.00	0.00
5_2	1.00	0.02	0.00	0.00	0.42	0.56	0.00	0.00	0.03	0.00
6	1.00	0.02	0.88	0.00	0.10	0.00	0.00	0.00	0.83	0.00
7	1.00	0.02	0.00	0.00	0.37	0.61	0.00	0.00	0.00	0.00
8	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00
8_2	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.97	0.00
9	1.00	0.02	0.00	0.00	0.07	0.91	0.00	0.00	0.02	0.00
C1	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00
C2	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
C3	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
C4	1.00	0.02	0.00	0.00	0.09	0.89	0.00	0.00	0.97	0.00
C5	1.00	0.02	0.00	0.00	0.06	0.92	0.00	0.00	0.02	0.00
C6_3	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.97	0.00
C7	1.00	0.02	0.00	0.00	0.96	0.02	0.00	0.00	0.01	0.00
C8	1.00	0.03	0.00	0.00	0.01	0.00	0.00	0.95	0.01	0.00

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Conduit Surcharge Summary
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Conduit	Hours Full Both Ends	Hours Full Upstream	Hours Full Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
1	0.01	0.01	0.18	0.01	0.01
1_3	0.01	0.58	0.01	0.63	0.01
10	0.60	0.76	0.60	0.80	0.60
2_7	0.01	0.28	0.01	0.33	0.01
4	0.25	0.25	0.33	0.01	0.01
5_1	0.01	0.01	0.18	0.01	0.01
5_2	0.18	0.18	0.27	0.01	0.01
7	0.01	0.39	0.01	0.41	0.01
8	0.01	0.44	0.01	0.50	0.01
9	0.20	1.46	0.20	1.56	0.20
C2	0.23	0.23	0.24	0.21	0.19
C3	0.22	0.22	0.25	0.25	0.22
C4	0.01	0.01	0.01	0.19	0.01

Analysis begun on: Fri Feb 01 09:47:15 2019
Analysis ended on: Fri Feb 01 09:47:25 2019

```
Total elapsed time: 00:00:10
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Assesses storm sewer sizing and capacity to convey flows from sub-catchment:

A. Input Data (Apply for A <10 ha)

Specify "Design Storm" using drop-down (see "Rainfall Data" sheet for reference data) or manual IDF input; Set maximum inlet time and manning's roughness for pipe

Design Storm	IDF Coeff			
	Year	*A*	*B*	*C*
Return Period Storm	**10**	656.95	1.50	0.72
[Optional] User Defined				

Sewer Characteristics	Input Value	
Inlet Time [min]	10	*City of Toronto WWF Guidelines, TTC, MTO Drainage Manual*
Manning's "n"	0.013	*Concrete Pipe*

B. Storm Sewer Calculation Sheet

At minimum, input "Length", "Diameter" and "Slope" of pipe

Sub-Catchment ID	MH Location			Runoff Calculations							Designed Pipe Characteristics					
	From	To	Distance [m]	A [ha]	C	A x C	Total AxC	Tin [min]	i [mm/hr]	Q [cms]	Diameter [mm]	Slope [%]	Q_Full [cms]	V_Full [cms]	Pipe Time [min]	Capacity [%]
STM704	STM704	STM702	39.7	0.178	0.744	0.132	0.132	10.000	112.095	0.041	300	0.5	0.068	0.968	0.683	60%
STM702	STM702	STM703	37.10	0.114	0.802	0.091	0.132	10.683	107.507	0.040	750	0.5	0.788	1.784	0.347	5%
STM703	STM703	EXSTM														
STM705	STM705	STM706	71.1	0.097	0.703	0.068	0.068	10.000	112.095	0.021	375	0.5	0.124	1.124	1.055	17%
STM706	STM706	STM709	19.4	0.227	0.735	0.167	0.235	11.055	105.196	0.069	1350	0.2	2.389	1.669	0.194	3%
STM709	STM709	OF4	30	0.291	0.833	0.242	0.477	11.248	104.036	0.138	375	1	0.176	1.589	0.315	79%

Assesses storm sewer sizing and capacity to convey flows from sub-catchments

A. Input Data (Apply for A <10 ha)

Specify "Design Storm" using drop-down (see "Rainfall Data" sheet for reference data) or manual IDF input; Set maximum inlet time and manning's roughness for pipe

Design Storm	IDF Coeff			
	Year	*A*	*B*	*C*
Return Period Storm	10	656.95	1.50	0.72
[Optional] User Defined				

Sewer Characteristics	Input Value	
Inlet Time [min]	10	*MTO Drainage Manual*
Manning's "n"	0.013	*Concrete Pipe*

B. Storm Sewer Calculation Sheet

At minimum, input "Length", "Diameter" and "Slope" of pipe

EAST SEGMENT

Sub-Catchment ID	MH Location			Runoff Calculations							Designed Pipe Characteristics					
	From	To	Distance [m]	A [ha]	C	A x C	Total AxC	Tin [min]	i [mm/hr]	Q [cms]	Diameter [mm]	Slope [%]	Q_Full [cms]	V_Full [cms]	Pipe Time [min]	Capacity [%]
STM100	STM100	STM101	37.9	0.071	0.900	0.064	0.064	10.000	112.095	0.020	300	2.74	0.160	2.267	0.279	12%
STM101	STM101	OUTFALL	7.4	0.044	0.900	0.040	0.104	10.279	110.169	0.032	375	0.81	0.158	1.430	0.086	20%
STM102	STM102	ExSTM	1.0	0.111	0.900	0.100	0.100	10.000	112.095	0.031	300	2	0.137	1.937	0.009	23%
STM103	STM103	ExSTM	5.5	0.060	0.900	0.054	0.054	10.000	112.095	0.017	300	2	0.137	1.937	0.047	12%
STM112	STM112	ExSTM	5.5	0.052	0.900	0.047	0.047	10.000	112.095	0.015	300	0.5	0.068	0.968	0.095	21%
STM107	STM107	OUTFALL	9.7	0.022	0.900	0.020	0.020	10.000	112.095	0.006	300	1.75	0.128	1.812	0.089	5%
STM104	STM104	STM105	11.1	0.097	0.900	0.087	0.087	10.000	112.095	0.027	300	2	0.137	1.937	0.096	20%
STM108	STM108	STM109	9.5	0.049	0.900	0.044	0.044	10.000	112.095	0.014	300	1.25	0.108	1.531	0.103	13%
STM109	STM109	OUTFALL	6.5	0.076	0.900	0.068	0.113	10.103	111.371	0.035	300	1.26	0.109	1.537	0.070	32%
STM110	STM110	STM111	7.7	0.244	0.900	0.220	0.220	10.000	112.095	0.068	300	1.25	0.108	1.531	0.084	63%
STM111	STM111	OUTFALL	6.5	0.157	0.900	0.141	0.361	10.084	111.507	0.112	450	1.29	0.324	2.038	0.053	34%

WEST SEGMENT

Sub-Catchment ID	MH Location			Runoff Calculations							Designed Pipe Characteristics					
	From	To	Distance [m]	A [ha]	C	A x C	Total AxC	Tin [min]	i [mm/hr]	Q [cms]	Diameter [mm]	Slope [%]	Q_Full [cms]	V_Full [cms]	Pipe Time [min]	Capacity [%]
STM200	STM200	STM201	48.1	0.084	0.900	0.076	0.076	10.000	112.095	0.024	300	2.61	0.156	2.212	0.362	15%
STM201	STM201	STM202	13.9	0.048	0.900	0.043	0.118	10.362	109.605	0.036	375	1.52	0.216	1.959	0.118	17%
STM202	STM202	OUTFALL	7.5	0.108	0.900	0.097	0.216	10.481	108.821	0.065	375	2.49	0.277	2.508	0.050	24%
STM203	STM203	STM206	10.8	0.077	0.900	0.069	0.069	10.000	112.095	0.022	375	3.98	0.350	3.170	0.057	6%
STM204	STM204	STM205	8.3	0.973	0.900	0.876	0.876	10.000	112.095	0.273	600	0.6	0.476	1.684	0.082	57%
STM205	STM205	STM206	43.5	0.557	1.900	1.058	1.934	10.082	111.519	0.599	750	0.61	0.870	1.970	0.368	69%
STM206	STM206	OUTFALL	9.7	0.130	2.900	0.378	2.312	10.450	109.022	0.700	825	1.09	1.500	2.806	0.058	47%

INLET SPACING, SPREAD FLOW DEPTH CALCULATIONS

Kingston 3rd Crossing Spread

BRIDGE	K3C SE			RAINFALL STATION(S)	
SCENARIO		DATE		DESIGN SPREAD	**10 Year - 2.0 m; 100 Year - 3.0 m**
DESIGNED BY	EM	DATE		CURB & GUTTER TYPE	**Concrete Barrier w/ Cutouts; Gutter Type - Triangular shape (Flow on Either Side)**
CHECKED BY	DJ			INLET TYPE	**OPSD Deck Drains**

Design Frequency	LOCATION From Inlet Station	To Inlet Station	DRAINAGE AREA DETAILS Gutter Grade S_o	Distance L	Gutter Crossfall S_w	Road Crossfall S_x	Average Width W	Watershed Area A	Runoff Coeff. C	Time of Conc. T_c	Rainfall Intensity I	FLOW, SPREAD AND INLET SPACING Local Runoff Q_r	Gutter Flow Q_g	Sides of Gutter Flow	Gutter Flow Ea Q_g	Inlet Spacing L	Flow Spread T	Flow Depth at Shoulder d_s	Flow Area A_F	Flow Velocity V	Flow Travel Time t	Lane Spread Encroachment (W_{LSE})	Flow Depth at EOP (d_1)	Inlet Type	No. of Inlets	Inlet Elevation	Inlet Capacity Q_i	Inlet Efficiency Q_i		Carryover Flow Q_c	Remarks
			m/m	m	m/m	m/m	m	ha	-	min	mm/h	m³/s	m³/s	-	m³/s	m	m	mm	m²	m/s	min	m	mm	-	-	m	m³/s			m³/s	
2-yr (Minor system Event)	**Station 11+219.5 to 11+428.8**																**Max Spread Width =**		**2.00**			***0.05m tolerance at this stage of design**									
	11+219.5	11+332.8	0.67%	113.3	2.0%	2.0%	10.50	0.119	0.95	8.66	80.5	0.025	0.02547	2	0.01274	113.3	1.63	32.55	0.0265	0.48	3.93	**0.00**	32.5	SS9-8	2	87.55	0.0327	100%	0.0327	0.0000	Pier 12
	11+332.8	11+380.8	0.67%	48.0	2.0%	2.0%	10.50	0.050	0.95	5.00	118.1	0.016	0.01584	2	0.00792	48.0	1.36	27.24	0.0185	0.43	1.87	**0.00**	27.2	SS9-8	1	86.79	0.0139	100%	0.0139	0.0019	
	11+380.8	11+428.8	0.67%	48.0	2.0%	2.0%	10.50	0.050	0.95	5.00	118.1	0.016	0.01778	2	0.00889	48.0	1.42	28.44	0.0202	0.44	1.82	**0.00**	28.4	SS9-8	1	86.47	0.0145	100%	0.0145	0.0033	
	11+428.8	End	0.67%	0.0	2.0%	2.0%	10.50	0.000	0.95	0.00	0.0	0.000	0.00332	2	0.00166	0.0	0.76	15.16								86.15		100%	0.0000	0.0033	
	End																														
5-yr (Minor system Event)	**Station 11+219.5 to 11+428.8**																**Max Spread Width =**		**2.00**			***0.05m tolerance at this stage of design**									
	11+219.5	11+332.8	0.67%	113.3	2.0%	2.0%	10.50	0.119	0.95	8.66	106.8	0.034	0.03380	2	0.01690	113.3	1.81	36.19	0.0327	0.52	3.66	**0.00**	36.2	SS9-8	2	87.55	0.0359	100%	0.0359	0.0000	Pier 12
	11+332.8	11+380.8	0.67%	48.0	2.0%	2.0%	10.50	0.050	0.95	5.00	156.8	0.021	0.02102	2	0.01051	48.0	1.51	30.29	0.0229	0.46	1.75	**0.00**	30.3	SS9-8	1	86.79	0.0153	100%	0.0153	0.0057	
	11+380.8	11+428.8	0.67%	48.0	2.0%	2.0%	10.50	0.050	0.95	5.00	156.8	0.021	0.02673	2	0.01336	48.0	1.66	33.14	0.0275	0.49	1.64	**0.00**	33.1	SS9-8	1	86.47	0.0166	100%	0.0166	0.0101	
	11+428.8	End	0.67%	0.0	2.0%	2.0%	10.50	0.000	0.95	0.00	0.0	0.000	0.01013	2	0.00506	0.0	1.15	23.03								86.15		100%	0.0000	0.0101	
	End																														
10-yr (Minor system Event)																	**Shoulder Width =**		**2.00**												
	Station 11+219.5 to 11+428.8																**Max Spread Width =**		**2.00**			***0.05m tolerance at this stage of design**									
	11+219.5	11+332.8	0.67%	113.3	2.0%	2.0%	10.50	0.119	0.95	8.66	124.2	0.039	0.03931	2	0.01966	113.3	1.92	38.30	0.0367	0.54	3.52	**0.00**	0.0	SS9-8	2	87.55	0.0377	100%	0.0377	0.0016	Pier 12
	11+332.8	11+380.8	0.67%	48.0	2.0%	2.0%	10.50	0.050	0.95	5.00	182.3	0.024	0.02602	2	0.01301	48.0	1.64	32.81	0.0269	0.48	1.65	**0.00**	0.0	SS9-8	1	86.79	0.0165	100%	0.0165	0.0096	
	11+380.8	11+428.8	0.67%	48.0	2.0%	2.0%	10.50	0.050	0.95	5.00	182.3	0.024	0.03401	2	0.01700	48.0	1.81	36.27	0.0329	0.52	1.55	**0.00**	0.0	SS9-8	1	86.47	0.0180	100%	0.0180	0.0160	
	11+428.8	End	0.67%	0.0	2.0%	2.0%	10.50	0.000	0.95	0.00	0.0	0.000	0.01602	2	0.00801	0.0	1.37	27.35								86.15		100%	0.0000	0.0160	
	End																														
100-year (Major System Event)																	**Shoulder Width =**		**2.00**												
	Station 11+219.5 to 11+428.8																**Max Spread Width =**		**3.00**												
	11+219.5	11+332.8	0.67%	113.3	2.0%	2.0%	10.50	0.119	0.95	8.66	178.4	0.056	0.05646	2	0.02823	113.3	2.19	43.87	0.0481	0.59	3.22	**0.00**	3.9	SS9-8	2	87.55	0.0425	100%	0.0425	0.0140	Pier 12
	11+332.8	11+380.8	0.67%	48.0	2.0%	2.0%	10.50	0.050	0.95	5.00	261.8	0.035	0.04911	2	0.02456	48.0	2.08	41.63	0.0433	0.57	1.41	**0.00**	1.6	SS9-8	1	86.79	0.0203	100%	0.0203	0.0288	
	11+380.8	11+428.8	0.67%	48.0	2.0%	2.0%	10.50	0.050	0.95	5.00	261.8	0.035	0.06392	2	0.03196	48.0	2.30	45.96	0.0528	0.61	1.32	**0.00**	6.0	SS9-8	1	86.47	0.0221	100%	0.0221	0.0418	
	11+428.8	End	0.67%	0.0	2.0%	2.0%	10.50	0.000	0.95	0.00	0.0	0.000	0.04184	2	0.02092	0.0	1.96	39.21								86.15		100%	0.0000	0.0418	
	End																														

Rainfall Parameters

a) Rainfall parameters are based on intensity-duration-frequency curves from MTO IDF Curve Lookup

2-Year Storm: A = **20.800**, B = **-0.699**	**5-Year Storm:** A = **27.600**, B = **-0.699**	**10-Year Storm:** A = **32.100**, B = **-0.699**	**100-Year Storm:** A = **46.100**, B = **-0.699**	Rainfall Intensity: $I = AT^B$ Where, I in mm/hr; T = Time of Concentration in hour

Note: Assumed no existing deck drains.
EOP = Edge of pavement of the travelled lane

Note

Input — **All the figures in blue colour need to be updated by the user for respective project.**

Local Runoff $(Q_r) = 0.0028\,CIA$ (m³/s)

Where, C = Runoff coefficient
A = Watershed area (ha)
I = Rainfall Intensity (mm/hr)

Note: The inlet capacity of SS9-2B type deck drain is taken from MTO Design Chart 4.21.

Time of Concentration by B Time of Concentration by Bransby Williams Method.

$$T_c = 0.057 \times L / \left(S_0^{\,0.20} \times A^{0.10}\right)$$

Where, Where, T_c = Time of concentration (min)
L = Watershed length = Inlet Spacing (m)
S_0 = Watershed Slope (%)
A = Watershed Area (ha)

Spread, **Spread,**

$$(T) = \frac{(1/S_x)\times(Q_g)^{3/8}}{(0.375)^{0.375}\times(1/S_x)^{3/8}\times(1/n)^{3/8}\times S_0^{3/16}}$$

BRIDGE	K3C SE		Deck Thickness (mm)	350
SCENARIO			Mannings n	0.013
DESIGNED BY	EM			
CHECKED BY	DJ			

Design Frequency	LOCATION From Inlet Station	To Inlet	FLOW, SPREAD AND INLET SPACING Pipe Length L	Pipe Diameter Dia	No. of Pipes	Inlet Elevation	U/S Invert	D/S Invert	Pipe Drop	D/S Hanger Depth	Pipe Slope S	Pipe Full Capacity Q_{full}	Pipe Full Velocity V_{full}	Pipe Efficiency $C_{eff.}$	Pipe Capacity w/ Blockage Q_{block}	Inlet Capacity Q_i	Pipe Receiving Capacity Q_i / Q_{block}	Carryover Flow Pipe Q_{cp}	Remarks
			m	mm	-	m	m	m	mm	mm	%					m^3/s		m^3/s	
2-yr (Minor system Event)	**Station 11+219.5 to 11+332.8**																		
	11+219.5	11+332.8																	Pier 20
	11+332.8	11+380.8	48.0	300	1	86.79	85.644	85.322	0	500	0.67%	0.079	1.120	100%	0.079	0.0327	41%	0.000	
	11+380.8	11+428.8	48.0	300	1	86.47	85.322	85.001	0	500	0.67%	0.079	1.120	100%	0.079	0.0466	59%	0.000	
	11+428.8					86.15													Abutment
5-yr (Minor system Event)	**Station 11+219.5 to 0+0**																		
	11+219.5	11+332.8																	Pier 20
	11+332.8	11+380.8	48.0	300	1	86.79	85.644	85.322	0	500	0.67%	0.079	1.120	100%	0.079	0.0359	45%	0.000	
	11+380.8	11+428.8	48.0	300	1	86.47	85.322	85.001	0	500	0.67%	0.079	1.120	100%	0.079	0.0512	65%	0.000	
	11+428.8					86.15													Abutment
10-yr (Minor system Event)	**Station 11+219.5 to 0+0**																		
	11+219.5	11+332.8																	Pier 20
	11+332.8	11+380.8	48.0	300	1	86.79	85.644	85.322	0	500	0.67%	0.079	1.120	100%	0.079	0.0377	48%	0.000	
	11+380.8	11+428.8	48.0	300	1	86.47	85.322	85.001	0	500	0.67%	0.079	1.120	100%	0.079	0.0542	68%	0.000	
	11+428.8					86.15													Abutment
100-year (Major System Event)	**Station 11+219.5 to 0+0**																		
	11+219.5	11+332.8																	
	11+332.8	11+380.8	48.0	300	1	86.79	85.644	85.322	0	500	0.67%	0.079	1.120	100%	0.079	0.0425	54%	0.000	Pier 12
	11+380.8	11+428.8	48.0	300	1	86.47	85.322	85.001	0	500	0.67%	0.079	1.120	100%	0.079	0.0627	79%	0.000	
	11+428.8					86.15													

Road Section Data	
EBL Width (m)	5.5
Lane Width (m)	3.5
Shoulder Width (m)	2.0

Bridge Standard (WC-4 Bridge Deck Drainage)

10 Year Storm	Full lane width clear of any flooding
100 Year Storm	Minimum 2.5 m of Lane width should be clear of any flooding

Spread Requirements	
10 Year Spread	2.0
100 Year Spread	3.0

INLET SPACING, SPREAD FLOW DEPTH CALCULATIONS

Kingston 3rd Crossing Spread

BRIDGE	K3C NE		
SCENARIO		DATE	
DESIGNED BY	EM	DATE	
CHECKED BY	DJ		

RAINFALL STATION(S)	
DESIGN SPREAD	**10 Year - 2.0 m; 100 Year - 3.0 m**
CURB & GUTTER TYPE	**Concrete Barrier w/ Cutouts; Gutter Type - Triangular shape (Flow on Either Side)**
INLET TYPE	**OPSD Deck Drains**

	LOCATION		DRAINAGE AREA DETAILS									FLOW, SPREAD AND INLET SPACING																			
Design Frequency	From Inlet Station	To Inlet Station	Gutter Grade S_o	Distance L	Gutter Crossfall S_w	Road Crossfall S_x	Average Width W	Watershed Area A	Runoff Coeff. C	Time of Conc. T_c	Rainfall Intensity I	Local Runoff Q_r	Gutter Flow Q_g	Sides of Gutter Flow	Gutter Flow Ea Q_g	Inlet Spacing L	Flow Spread T	Flow Depth at Shoulder d_s	Flow Area A_F	Flow Velocity V	Flow Travel Time t	Lane Spread Encroachment (W_{LSE})	Flow Depth at EOP (d_l)	Inlet Type	No. of Inlets	Inlet Elevation	Inlet Capacity Q_i	Inlet Efficiency Q_i		Carryover Flow Q_c	Remarks
			m/m	m	m/m	m/m	m	ha	-	min	mm/h	m^3/s	m^3/s	-	m^3/s	m	m	mm	m^2	m/s	min	m	mm	-	-	m	m^3/s			m^3/s	
2-yr (Minor system Event)	**Station 11+219.5 to 11+428.8**																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**									
	11+219.5	11+332.8	0.67%	113.3	2.0%	2.0%	6.00	0.068	0.95	9.16	77.4	0.014	0.01400	1	0.01400	113.3	1.69	33.72	0.0284	0.49	3.84	**0.00**	33.7	SS9-8	2	87.55	0.0337	100%	0.0337	0.0000	Pier 12
	11+332.8	11+380.8	0.67%	48.0	2.0%	2.0%	6.00	0.029	0.95	5.00	118.1	0.009	0.00905	1	0.00905	48.0	1.43	28.64	0.0205	0.44	1.81	**0.00**	28.6	SS9-8	1	86.79	0.0145	100%	0.0145	0.0000	
	11+380.8	11+428.8	0.67%	48.0	2.0%	2.0%	6.00	0.029	0.95	5.00	118.1	0.009	0.00905	1	0.00905	48.0	1.43	28.64	0.0205	0.44	1.81	**0.00**	28.6	SS9-8	1	86.47	0.0145	100%	0.0145	0.0000	
	11+428.8	End	0.67%	0.0	2.0%	2.0%	6.00	0.000	0.95	0.00	0.0	0.000	0.00000	1	0.00000	0.0	0.00	0.00								86.15		100%	0.0000	0.0000	
	End																														
5-yr (Minor system Event)	**Station 11+219.5 to 11+428.8**																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**									
	11+219.5	11+332.8	0.67%	113.3	2.0%	2.0%	6.00	0.068	0.95	9.16	102.7	0.019	0.01857	1	0.01857	113.3	1.87	37.50	0.0351	0.53	3.57	**0.00**	37.5	SS9-8	2	87.55	0.0370	100%	0.0370	0.0000	Pier 12
	11+332.8	11+380.8	0.67%	48.0	2.0%	2.0%	6.00	0.029	0.95	5.00	156.8	0.012	0.01201	1	0.01201	48.0	1.59	31.84	0.0253	0.47	1.69	**0.00**	31.8	SS9-8	1	86.79	0.0160	100%	0.0160	0.0000	
	11+380.8	11+428.8	0.67%	48.0	2.0%	2.0%	6.00	0.029	0.95	5.00	156.8	0.012	0.01201	1	0.01201	48.0	1.59	31.84	0.0253	0.47	1.69	**0.00**	31.8	SS9-8	1	86.47	0.0160	100%	0.0160	0.0000	
	11+428.8	End	0.67%	0.0	2.0%	2.0%	6.00	0.000	0.95	0.00	0.0	0.000	0.00000	1	0.00000	0.0	0.00	0.00								86.15		100%	0.0000	0.0000	
	End																														
10-yr (Minor system Event)																		**Shoulder Width =**	**2.00**												
	Station 11+219.5 to 11+428.8																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**									
	11+219.5	11+332.8	0.67%	113.3	2.0%	2.0%	6.00	0.068	0.95	9.16	119.5	0.022	0.02160	1	0.02160	113.3	1.98	39.68	0.0394	0.55	3.44	**0.00**	0.0	SS9-8	2	87.55	0.0389	100%	0.0389	0.0000	Pier 12
	11+332.8	11+380.8	0.67%	48.0	2.0%	2.0%	6.00	0.029	0.95	5.00	182.3	0.014	0.01397	1	0.01397	48.0	1.68	33.70	0.0284	0.49	1.63	**0.00**	0.0	SS9-8	1	86.79	0.0168	100%	0.0168	0.0000	
	11+380.8	11+428.8	0.67%	48.0	2.0%	2.0%	6.00	0.029	0.95	5.00	182.3	0.014	0.01397	1	0.01397	48.0	1.68	33.70	0.0284	0.49	1.63	**0.00**	0.0	SS9-8	1	86.47	0.0168	100%	0.0168	0.0000	
	11+428.8	End	0.67%	0.0	2.0%	2.0%	6.00	0.000	0.95	0.00	0.0	0.000	0.00000	1	0.00000	0.0	0.00	0.00								86.15		100%	0.0000	0.0000	
	End																														
100-year (Major System Event)																		**Shoulder Width =**	**2.00**												
	Station 11+219.5 to 11+428.8																	**Max Spread Width =**	**3.00**												
	11+219.5	11+332.8	0.67%	113.3	2.0%	2.0%	6.00	0.068	0.95	9.16	171.6	0.031	0.03102	1	0.03102	113.3	2.27	45.45	0.0516	0.60	3.14	**0.00**	5.4	SS9-8	2	87.55	0.0438	100%	0.0438	0.0000	Pier 12
	11+332.8	11+380.8	0.67%	48.0	2.0%	2.0%	6.00	0.029	0.95	5.00	261.8	0.020	0.02006	1	0.02006	48.0	1.93	38.59	0.0372	0.54	1.49	**0.00**	0.0	SS9-8	1	86.79	0.0190	100%	0.0190	0.0011	
	11+380.8	11+428.8	0.67%	48.0	2.0%	2.0%	6.00	0.029	0.95	5.00	261.8	0.020	0.02112	1	0.02112	48.0	1.97	39.35	0.0387	0.55	1.47	**0.00**	0.0	SS9-8	1	86.47	0.0193	100%	0.0193	0.0018	
	11+428.8	End	0.67%	0.0	2.0%	2.0%	6.00	0.000	0.95	0.00	0.0	0.000	0.00180	1	0.00180	0.0	0.78	15.63								86.15		100%	0.0000	0.0018	
	End																														

Rainfall Parameters

a) Rainfall parameters are based on intensity-duration-frequency curves from MTO IDF Curve Lookup

2-Year Storm:	A = **20.800**	**5-Year Storm:**	A = **27.600**	
	B = **-0.699**		B = **-0.699**	
10-Year Storm:	A = **32.100**	**)-Year Storm:**	A = **46.100**	
	B = **-0.699**		B = **-0.699**	

Rainfall Intensity: $I = AT^B$

Where, I in mm/hr

T = Time of Concentration in hour

Note: Assumed no existing deck drains.
EOP = Edge of pavement of the travelled lane

Note

Input **All the figures in blue colour need to be updated by the user for respective project.**

Local Runoff (Q_r) = 0.0028 CIA (m^3/s)

Where, C = Runoff coefficient
A = Watershed area (ha)
I = Rainfall Intensity (mm/hr)

Note: The inlet capacity of SS9-2B type deck drain is taken from MTO Design Chart 4.21.

Time of Concentration by Bı Time of Concentration by Bransby Williams Method.

$$T_c = 0.057 \times L / \left(S_0^{0.20} \times A^{0.10}\right)$$

Where, Where, T_c = Time of concentration (min)
L = Watershed length = Inlet Spacing (m)
S_0 = Watershed Slope (%)
A = Watershed Area (ha)

Spread, **Spread,**

$$(T) = \frac{(1/S_x)\times(Q_g)^{3/8}}{(0.375)^{0.375}\times(1/S_x)^{3/8}\times(1/n)^{3/8}\times S_0^{3/16}}$$

BRIDGE	K3C NE	Deck Thickness (mm)	350
SCENARIO		Mannings n	0.013
DESIGNED BY	EM		
CHECKED BY	DJ		

	LOCATION		FLOW, SPREAD AND INLET SPACING																
Design Frequency	From Inlet Station	To Inlet	Pipe Length L	Pipe Diameter Dia	No. of Pipes	Inlet Elevation	U/S Invert	D/S Invert	Pipe Drop	D/S Hanger Depth	Pipe Slope S	Pipe Full Capacity Q_{full}	Pipe Full Velocity V_{full}	Pipe Efficency $C_{eff.}$	Pipe Capacity w/ Blockage Q_{block}	Inlet Capacity Q_i	Pipe Receiving Capacity Q_i / Q_{block}	Carryover Flow Pipe Q_{cp}	Remarks
			m	mm	-	m	m	m	mm	mm	%					m^3/s		m^3/s	
	Station 11+219.5 to 11+332.8																		
	11+219.5	11+332.8																	Pier 20
2-yr (Minor system Event)	11+332.8	11+380.8	48.0	300	1	86.79	85.644	85.322	0	500	0.67%	0.079	1.120	100%	0.079	0.0337	43%	0.000	
	11+380.8	11+428.8	48.0	300	1	86.47	85.322	85.001	0	500	0.67%	0.079	1.120	100%	0.079	0.0483	61%	0.000	
	11+428.8					86.15													Abutment
	Station 11+219.5 to 0+0																		
	11+219.5	11+332.8																	Pier 20
5-yr (Minor system Event)	11+332.8	11+380.8	48.0	300	1	86.79	85.644	85.322	0	500	0.67%	0.079	1.120	100%	0.079	0.0370	47%	0.000	
	11+380.8	11+428.8	48.0	300	1	86.47	85.322	85.001	0	500	0.67%	0.079	1.120	100%	0.079	0.0531	67%	0.000	
	11+428.8					86.15													Abutment
	Station 11+219.5 to 0+0																		
	11+219.5	11+332.8																	Pier 20
10-yr (Minor system Event)	11+332.8	11+380.8	48.0	300	1	86.79	85.644	85.322	0	500	0.67%	0.079	1.120	100%	0.079	0.0389	49%	0.000	
	11+380.8	11+428.8	48.0	300	1	86.47	85.322	85.001	0	500	0.67%	0.079	1.120	100%	0.079	0.0558	70%	0.000	
	11+428.8					86.15													Abutment
	Station 11+219.5 to 0+0																		
	11+219.5	11+332.8																	
100-year (Major System Event)	11+332.8	11+380.8	48.0	300	1	86.79	85.644	85.322	0	500	0.67%	0.079	1.120	100%	0.079	0.0438	55%	0.000	Pier 12
	11+380.8	11+428.8	48.0	300	1	86.47	85.322	85.001	0	500	0.67%	0.079	1.120	100%	0.079	0.0627	79%	0.000	
	11+428.8					86.15													

Road Section Data	
EBL Width (m)	**5.5**
Lane Width (m)	**3.5**
Shoulder Width (m)	**2.0**

Bridge Standard (WC-4 Bridge Deck Drainage)

10 Year Storm — Full lane width clear of any flooding

100 Year Storm — Minimum 2.5 m of Lane width should be clear of any flooding

Spread Requirements	
10 Year Spread	2.0
100 Year Spread	3.0

INLET SPACING, SPREAD FLOW DEPTH CALCULATIONS

Kingston 3rd Crossing Spread

BRIDGE	K3C SW	RAINFALL STATION(S)	
SCENARIO		DATE	
		DESIGN SPREAD	**10 Year - 2.0 m; 100 Year - 3.0 m**
DESIGNED BY	EM	DATE	
		CURB & GUTTER TYPE	**Concrete Barrier w/ Cutouts; Gutter Type - Triangular shape (Flow on Either Side)**
CHECKED BY	DJ	INLET TYPE	**OPSD Deck Drains**

Design Frequency	LOCATION From Inlet Station	To Inlet Station	DRAINAGE AREA DETAILS Gutter Grade S_o	Distance L	Gutter Crossfall S_w	Road Crossfall S_x	Average Width W	Watershed Area A	Runoff Coeff. C	Time of Conc. T_c	Rainfall Intensity I	FLOW, SPREAD AND INLET SPACING Local Runoff Q_r	Gutter Flow Q_g	Sides of Gutter Flow	Gutter Flow Ea Q_g	Inlet Spacing L	Flow Spread T	Flow Depth at Shoulder d_s	Flow Area A_F	Flow Velocity V	Flow Travel Time t	Lane Spread Encroachment (W_{LSE})	Flow Depth at EOP (d_l)	Inlet Type	No. of Inlets	Inlet Elevation	Inlet Capacity Q_i	Carryover Flow Q_c	Remarks
			m/m	m	m/m	m/m	m	ha	-	min	mm/h	m^3/s	m^3/s	-	m^3/s	m	m	mm	m^2	m/s	min	m	mm	-	-	m	m^3/s	m^3/s	
																		Shoulder Width =	**2.00**										
	Station 11+219.5 to 10+294																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**							
2-yr (Minor System Event)	11+219.5	11+105.0	0.67%		2.0%	2.0%	10.50	0.120	0.95	8.74	80.0	0.026	0.02558	2	0.01279	114.5	1.63	32.60	0.0266	0.48	3.97	**0.00**	0.0	SS9-8	2	87.58	0.0327	0.0000	Pier 17
	11+105.0	10+994.0	0.67%	100.0	2.0%	2.0%	10.50	0.117	0.95	8.50	81.5	0.025	0.02528	2	0.01264	111.0	1.62	32.46	0.0263	0.48	3.85	**0.00**	0.0	SS9-8	2	86.81	0.0326	0.0000	
	10+994.0	10+894.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	87.1	0.024	0.02432	2	0.01216	100.0	1.60	31.99	0.0256	0.48	3.51	**0.00**	0.0	SS9-8	2	86.07	0.0322	0.0000	
	10+894.0	10+794.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	87.1	0.024	0.02432	2	0.01216	100.0	1.60	31.99	0.0256	0.48	3.51	**0.00**	0.0	SS9-8	2	85.39	0.0322	0.0000	
	10+794.0	10+694.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	87.1	0.024	0.02432	2	0.01216	100.0	1.60	31.99	0.0256	0.48	3.51	**0.00**	0.0	SS9-8	2	84.72	0.0322	0.0000	
	10+694.0	10+594.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	87.1	0.024	0.02432	2	0.01216	100.0	1.60	31.99	0.0256	0.48	3.51	**0.00**	0.0	SS9-8	2	84.05	0.0322	0.0000	
	10+594.0	10+494.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	87.1	0.024	0.02432	2	0.01216	100.0	1.60	31.99	0.0256	0.48	3.51	**0.00**	0.0	SS9-8	2	83.37	0.0322	0.0000	
	10+494.0	10+394.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	87.1	0.024	0.02432	2	0.01216	100.0	1.60	31.99	0.0256	0.48	3.51	**0.00**	0.0	SS9-8	2	82.70	0.0322	0.0000	
	10+394.0	10+294.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	87.1	0.024	0.02432	2	0.01216	100.0	1.60	31.99	0.0256	0.48	3.51	**0.00**	0.0	SS9-8	2	82.03	0.0322	0.0000	
	10+294.0	End	0.67%	0.0	2.0%	2.0%	10.50	0.000	0.95	0.00	0.0	0.000	0.00000	2	0.00000	0.0	0.00	0.00								81.35		0.0000	Abutment
	End																												
																		Shoulder Width =	**2.00**										
	Station 11+219.5 to 10+294																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**							
5-yr (Minor System Event)	11+219.5	11+105.0	0.67%		2.0%	2.0%	10.50	0.120	0.95	8.74	106.1	0.034	0.03394	2	0.01697	114.5	1.81	36.25	0.0328	0.52	3.69	**0.00**	0.0	SS9-8	2	87.58	0.0360	0.0000	Pier 17
	11+105.0	10+994.0	0.67%	100.0	2.0%	2.0%	10.50	0.117	0.95	8.50	108.2	0.034	0.03355	2	0.01677	111.0	1.80	36.09	0.0326	0.52	3.59	**0.00**	0.0	SS9-8	2	86.81	0.0358	0.0000	
	10+994.0	10+894.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	115.5	0.032	0.03227	2	0.01614	100.0	1.78	35.57	0.0316	0.51	3.27	**0.00**	0.0	SS9-8	2	86.07	0.0354	0.0000	
	10+894.0	10+794.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	115.5	0.032	0.03227	2	0.01614	100.0	1.78	35.57	0.0316	0.51	3.27	**0.00**	0.0	SS9-8	2	85.39	0.0354	0.0000	
	10+794.0	10+694.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	115.5	0.032	0.03227	2	0.01614	100.0	1.78	35.57	0.0316	0.51	3.27	**0.00**	0.0	SS9-8	2	84.72	0.0354	0.0000	
	10+694.0	10+594.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	115.5	0.032	0.03227	2	0.01614	100.0	1.78	35.57	0.0316	0.51	3.27	**0.00**	0.0	SS9-8	2	84.05	0.0354	0.0000	
	10+594.0	10+494.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	115.5	0.032	0.03227	2	0.01614	100.0	1.78	35.57	0.0316	0.51	3.27	**0.00**	0.0	SS9-8	2	83.37	0.0354	0.0000	
	10+494.0	10+394.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	115.5	0.032	0.03227	2	0.01614	100.0	1.78	35.57	0.0316	0.51	3.27	**0.00**	0.0	SS9-8	2	82.70	0.0354	0.0000	
	10+394.0	10+294.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	115.5	0.032	0.03227	2	0.01614	100.0	1.78	35.57	0.0316	0.51	3.27	**0.00**	0.0	SS9-8	2	82.03	0.0354	0.0000	
	10+294.0	End	0.67%	0.0	2.0%	2.0%	10.50	0.000	0.95	0.00	0.0	0.000	0.00000	2	0.00000	0.0	0.00	0.00								81.35		0.0000	Abutment
	End																												
																		Shoulder Width =	**2.00**										
	Station 11+219.5 to 10+294																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**							
10-yr (Minor system Event)	11+219.5	11+105.0	0.67%		2.0%	2.0%	10.50	0.120	0.95	8.74	123.4	0.039	0.03947	2	0.01973	114.5	1.92	38.36	0.0368	0.54	3.56	**0.00**	0.0	SS9-8	2	87.58	0.0378	0.0017	Pier 17
	11+105.0	10+994.0	0.67%	100.0	2.0%	2.0%	10.50	0.117	0.95	8.50	125.8	0.039	0.04069	2	0.02035	111.0	1.94	38.80	0.0376	0.54	3.42	**0.00**	0.0	SS9-8	2	86.81	0.0382	0.0025	
	10+994.0	10+894.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	134.4	0.038	0.04005	2	0.02003	100.0	1.93	38.57	0.0372	0.54	3.10	**0.00**	0.0	SS9-8	2	86.07	0.0380	0.0021	
	10+894.0	10+794.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	134.4	0.038	0.03961	2	0.01981	100.0	1.92	38.41	0.0369	0.54	3.10	**0.00**	0.0	SS9-8	2	85.39	0.0378	0.0018	
	10+794.0	10+694.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	134.4	0.038	0.03931	2	0.01966	100.0	1.91	38.30	0.0367	0.54	3.11	**0.00**	0.0	SS9-8	2	84.72	0.0377	0.0016	
	10+694.0	10+594.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	134.4	0.038	0.03910	2	0.01955	100.0	1.91	38.22	0.0365	0.54	3.11	**0.00**	0.0	SS9-8	2	84.05	0.0377	0.0014	
	10+594.0	10+494.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	134.4	0.038	0.03896	2	0.01948	100.0	1.91	38.17	0.0364	0.53	3.12	**0.00**	0.0	SS9-8	2	83.37	0.0376	0.0013	
	10+494.0	10+394.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	134.4	0.038	0.03886	2	0.01943	100.0	1.91	38.14	0.0364	0.53	3.12	**0.00**	0.0	SS9-8	2	82.70	0.0376	0.0013	
	10+394.0	10+294.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	134.4	0.038	0.03880	2	0.01940	100.0	1.91	38.11	0.0363	0.53	3.12	**0.00**	0.0	SS9-8	2	82.03	0.0376	0.0012	
	10+294.0	End	0.67%	0.0	2.0%	2.0%	10.50	0.000	0.95	0.00	0.0	0.000	0.00122	2	0.00061	0.0	0.52	10.41								81.35		0.0012	Abutment
	End																												

INLET SPACING, SPREAD FLOW DEPTH CALCULATIONS

Kingston 3rd Crossing Spread

BRIDGE	K3C SW	RAINFALL STATION(S)	
SCENARIO		DESIGN SPREAD	**10 Year - 2.0 m; 100 Year - 3.0 m**
DESIGNED BY	EM	CURB & GUTTER TYPE	**Concrete Barrier w/ Cutouts; Gutter Type - Triangular shape (Flow on Either Side)**
CHECKED BY	DJ	INLET TYPE	**OPSD Deck Drains**

DATE

DATE

	LOCATION		DRAINAGE AREA DETAILS										FLOW, SPREAD AND INLET SPACING																
Design Frequency	From Inlet Station	To Inlet Station	Gutter Grade S_o	Distance L	Gutter Crossfall S_w	Road Crossfall S_x	Average Width W	Watershed Area A	Runoff Coeff. C	Time of Conc. T_c	Rainfall Intensity I	Local Runoff Q_r	Gutter Flow Q_g	Sides of Gutter Flow	Gutter Flow Ea Q_g	Inlet Spacing L	Flow Spread T	Flow Depth at Shoulder d_s	Flow Area A_F	Flow Velocity V	Flow Travel Time t	Lane Spread Encroachment (W_{LSE})	Flow Depth at EOP (d_l)	Inlet Type	No. of Inlets	Inlet Elevation	Inlet Capacity Q_i	Carryover Flow Q_c	Remarks
			m/m	m	m/m	m/m	m	ha	-	min	mm/h	m^3/s	m^3/s	-	m^3/s	m	m	mm	m^2	m/s	min	m	mm	-	-	m	m^3/s	m^3/s	
																		Shoulder Width =	**2.00**										
																		Max Spread Width =	**3.00**										
	Station 11+219.5 to 10+294																												
	11+219.5	11+105.0	0.67%	0.0	2.0%	2.0%	10.50	0.120	0.95	8.74	177.2	0.057	0.05668	2	0.02834	114.5	2.20	43.93	0.0483	0.59	3.25	**0.00**	3.9	SS9-8	2	87.58	0.0425	0.0142	Pier 17
	11+105.0	10+994.0	0.67%	100.0	2.0%	2.0%	10.50	0.117	0.95	8.50	180.7	0.056	0.07021	2	0.03510	111.0	2.38	47.60	0.0567	0.62	2.99	**0.00**	7.6	SS9-8	2	86.81	0.0455	0.0247	
	10+994.0	10+894.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	193.0	0.054	0.07861	2	0.03931	100.0	2.48	49.66	0.0617	0.64	2.61	**0.00**	9.7	SS9-8	2	86.07	0.0471	0.0315	
100-year (Major System Event)	10+894.0	10+794.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	193.0	0.054	0.09404	2	0.04702	100.0	2.66	53.12	0.0705	0.67	2.50	**0.00**	13.1	SS9-8	2	85.39	0.0498	0.0442	
	10+794.0	10+694.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	193.0	0.054	0.09810	2	0.04905	100.0	2.70	53.97	0.0728	0.67	2.47	**0.00**	14.0	SS9-8	2	84.72	0.0505	0.0476	
	10+694.0	10+594.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	193.0	0.054	0.10152	2	0.05076	100.0	2.73	54.66	0.0747	0.68	2.45	**0.00**	14.7	SS9-8	2	84.05	0.0510	0.0505	
	10+594.0	10+494.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	193.0	0.054	0.12406	2	0.06203	100.0	2.95	58.93	0.0868	0.71	2.33	**0.00**	18.9	SS9-8	2	83.37	0.0542	0.0699	
	10+494.0	10+394.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	193.0	0.054	0.12375	2	0.06188	100.0	2.94	58.88	0.0867	0.71	2.33	**0.00**	18.9	SS9-8	2	82.70	0.0542	0.0696	
	10+394.0	10+294.0	0.67%	100.0	2.0%	2.0%	10.50	0.105	0.95	7.74	193.0	0.054	0.12349	2	0.06174	100.0	2.94	58.83	0.0865	0.71	2.34	**0.00**	18.8	SS9-8	2	82.03	0.0541	0.0694	
	10+294.0	End	0.67%	0.0	2.0%	2.0%	10.50	0.000	0.95	0.00	0.0	0.000	0.06935	2	0.03469	0.0	2.37	47.39								81.35		0.0694	Abutment
	End																												

Rainfall Parameters

a) Rainfall parameters are based on intensity-duration-frequency curves from MTO IDF Curve Lookup

2-Year Storm:	A = **20.800** B = **-0.699**	**2-Year Storm:**	A = **27.600** B = **-0.699**	**10-Year Storm:**	A = **32.100** B = **-0.699**	**100-Year Storm:**	A = **46.100** B = **-0.699**

Rainfall Intensity: $I = AT^B$

Where, I in mm/hr

T = Time of Concentration in hour

Note: Assumed no existing deck drains.

EOP = Edge of pavement of the travelled lane

Note

Input — **All the figures in blue colour need to be updated by the user for respective project.**

Local Runoff (Q_r) = 0.0028 CIA (m^3/s)

Where, C = Runoff coefficient

A = Watershed area (ha)

I = Rainfall Intensity (mm/hr)

Note: The inlet capacity of SS9-2B type deck drain is taken from MTO Design Chart 4.21.

Time of Concentration by B Time of Concentration by Bransby Williams Method.

$$T_c = 0.057 \times L / \left(S_0^{\,0.20} \times A^{0.10}\right)$$

Where, Where, T_c = Time of concentration (min)

L = Watershed length = Inlet Spacing (m)

S_0 = Watershed Slope (%)

A = Watershed Area (ha)

Spread, **Spread,**

$$(T) = \frac{(1/S_x)\times(Q_g)^{3/8}}{(0.375)^{0.375}\times(1/S_x)^{3/8}\times(1/n)^{3/8}\times S_0^{\,3/16}}$$

BRIDGE K3C SW

SCENARIO

DESIGNED BY EM

CHECKED BY DJ

Deck Thickness (mm) 350

Mannings n 0.013

FLOW, SPREAD AND INLET SPACING

Design Frequency	LOCATION From Inlet Station	To Inlet	Pipe Length L	Pipe Diameter Dia	No. of Pipes	Inlet Elevation	U/S Invert	D/S Invert	Pipe Drop	D/S Hanger Depth	Pipe Slope S	Pipe Full Capacity Q_{full}	Pipe Full Velocity V_{full}	Pipe Efficency $C_{eff.}$	Pipe Capacity w/ Blockage Q_{block}	Inlet Capacity Q_i	Pipe Receiving Capacity Q_i / Q_{block}	Carryover Flow Pipe Q_{cp}	Remarks
			m	mm	-	m	m	m	mm	mm	%					m^3/s		m^3/s	
2-yr (Minor System Event)	**Station 11+219.5 to 10+294**																		
	11+219.5	11+105.0																	Pier 17
	11+105.0	10+994.0	111.0	300	1	86.81	85.662	84.915	0	500	0.67%	0.079	1.122	100%	0.079	0.0327	41%	0.000	
	10+994.0	10+894.0	100.0	300	1	86.07	84.915	84.242	0	500	0.67%	0.079	1.122	100%	0.079	0.0653	82%	0.000	
	10+894.0	10+794.0	100.0	375	1	85.39	84.167	83.494	75	500	0.67%	0.144	1.302	100%	0.144	0.0975	68%	0.000	
	10+794.0	10+694.0	100.0	450	1	84.72	83.419	82.646	75	600	0.77%	0.251	1.576	100%	0.251	0.1296	52%	0.000	
	10+694.0	10+594.0	100.0	450	1	84.05	82.646	82.073	0	500	0.57%	0.216	1.357	100%	0.216	0.1618	75%	0.000	
	10+594.0	10+494.0	100.0	525	1	83.37	81.998	81.325	75	500	0.67%	0.353	1.630	100%	0.353	0.1940	55%	0.000	
	10+494.0	10+394.0	100.0	525	1	82.70	81.325	80.652	0	500	0.67%	0.353	1.630	100%	0.353	0.2261	64%	0.000	
	10+394.0	10+294.0	100.0	600	1	82.03	80.577	79.904	75	500	0.67%	0.504	1.782	100%	0.504	0.2583	51%	0.000	
	10+294.0	End				81.35													Abutment
5-yr (Minor System Event)	**Station 11+219.5 to 10+294**																		
	11+219.5	11+105.0																	Pier 17
	11+105.0	10+994.0	111.0	300	1	86.81	85.662	84.915	0	500	0.67%	0.079	1.122	100%	0.079	0.0360	45%	0.000	
	10+994.0	10+894.0	100.0	300	1	86.07	84.915	84.242	0	500	0.67%	0.079	1.122	100%	0.079	0.0718	90%	0.000	
	10+894.0	10+794.0	100.0	375	1	85.39	84.167	83.494	75	500	0.67%	0.144	1.302	100%	0.144	0.1071	74%	0.000	
	10+794.0	10+694.0	100.0	450	1	84.72	83.419	82.646	75	600	0.77%	0.251	1.576	100%	0.251	0.1425	57%	0.000	
	10+694.0	10+594.0	100.0	450	1	84.05	82.646	82.073	0	500	0.57%	0.216	1.357	100%	0.216	0.1778	82%	0.000	
	10+594.0	10+494.0	100.0	525	1	83.37	81.998	81.325	75	500	0.67%	0.353	1.630	100%	0.353	0.2132	60%	0.000	
	10+494.0	10+394.0	100.0	525	1	82.70	81.325	80.652	0	500	0.67%	0.353	1.630	100%	0.353	0.2486	70%	0.000	
	10+394.0	10+294.0	100.0	600	1	82.03	80.577	79.904	75	500	0.67%	0.504	1.782	100%	0.504	0.2839	56%	0.000	
	10+294.0	End				81.35													Abutment
10-yr (Minor system Event)	**Station 11+219.5 to 10+294**																		
	11+219.5	11+105.0																	Pier 17
	11+105.0	10+994.0	111.0	300	1	86.81	85.662	84.915	0	500	0.67%	0.079	1.122	100%	0.079	0.0378	48%	0.000	
	10+994.0	10+894.0	100.0	300	1	86.07	84.915	84.242	0	500	0.67%	0.079	1.122	100%	0.079	0.0760	96%	0.000	
	10+894.0	10+794.0	100.0	375	1	85.39	84.167	83.494	75	500	0.67%	0.144	1.302	100%	0.144	0.1139	79%	0.000	
	10+794.0	10+694.0	100.0	450	1	84.72	83.419	82.646	75	600	0.77%	0.251	1.576	100%	0.251	0.1518	61%	0.000	
	10+694.0	10+594.0	100.0	450	1	84.05	82.646	82.073	0	500	0.57%	0.216	1.357	100%	0.216	0.1895	88%	0.000	
	10+594.0	10+494.0	100.0	525	1	83.37	81.998	81.325	75	500	0.67%	0.353	1.630	100%	0.353	0.2272	64%	0.000	
	10+494.0	10+394.0	100.0	525	1	82.70	81.325	80.652	0	500	0.67%	0.353	1.630	100%	0.353	0.2648	75%	0.000	
	10+394.0	10+294.0	100.0	600	1	82.03	80.577	79.904	75	500	0.67%	0.504	1.782	100%	0.504	0.3024	60%	0.000	
	10+294.0	End				81.35													Abutment

BRIDGE K3C SW
SCENARIO
DESIGNED BY EM
CHECKED BY DJ

Deck Thickness (mm) 350
Mannings n 0.013

	LOCATION		FLOW, SPREAD AND INLET SPACING																
Design Frequency	From Inlet Station	To Inlet	Pipe Length L	Pipe Diameter Dia	No. of Pipes	Inlet Elevation	U/S Invert	D/S Invert	Pipe Drop	D/S Hanger Depth	Pipe Slope S	Pipe Full Capacity Q_{full}	Pipe Full Velocity V_{full}	Pipe Efficency $C_{eff.}$	Pipe Capacity w/ Blockage Q_{block}	Inlet Capacity Q_i	Pipe Receiving Capacity Q_i / Q_{block}	Carryover Flow Pipe Q_{cp}	Remarks
			m	mm	-	m	m	m	mm	mm	%					m^3/s		m^3/s	
	Station 11+219.5 to 10+294																		
	11+219.5	11+105.0																	Pier 17
	11+105.0	10+994.0	111.0	300	1	86.81	85.662	84.915	0	500	0.67%	0.079	1.122	100%	0.079	0.0425	54%	0.000	
	10+994.0	10+894.0	100.0	300	1	86.07	84.915	84.242	0	500	0.67%	0.079	1.122	100%	0.079	0.0880	111%	0.009	
	10+894.0	10+794.0	100.0	375	1	85.39	84.167	83.494	75	500	0.67%	0.144	1.302	100%	0.144	0.1352	94%	0.000	
100-year (Major System Event)	10+794.0	10+694.0	100.0	450	1	84.72	83.419	82.646	75	600	0.77%	0.251	1.576	100%	0.251	0.1850	74%	0.000	
	10+694.0	10+594.0	100.0	450	1	84.05	82.646	82.073	0	500	0.57%	0.216	1.357	100%	0.216	0.2355	109%	0.020	
	10+594.0	10+494.0	100.0	525	1	83.37	81.998	81.325	75	500	0.67%	0.353	1.630	100%	0.353	0.2865	81%	0.000	
	10+494.0	10+394.0	100.0	525	1	82.70	81.325	80.652	0	500	0.67%	0.353	1.630	100%	0.353	0.3407	97%	0.000	
	10+394.0	10+294.0	100.0	600	1	82.03	80.577	79.904	75	500	0.67%	0.504	1.782	100%	0.504	0.3949	78%	0.000	
	10+294.0	End				81.35													Abutment

Road Section Data	
EBL Width (m)	**5.5**
Lane Width (m)	**3.5**
Shoulder Width (m)	**2.0**

Bridge Standard (WC-4 Bridge Deck Drainage)

10 Year Storm Full lane width clear of any flooding
100 Year Storm Minimum 2.5 m of Lane width should be clear of any flooding

Spread Requirements	
10 Year Spread	**2.0**
100 Year Spread	**3.0**

INLET SPACING, SPREAD FLOW DEPTH CALCULATIONS

Kingston 3rd Crossing Spread

BRIDGE	K3C NW	RAINFALL STATION(S)	
SCENARIO		DATE	
DESIGNED BY	EM	DATE	
CHECKED BY	DJ		
DESIGN SPREAD	**10 Year - 2.0 m; 100 Year - 3.0 m**		
CURB & GUTTER TYPE	**Concrete Barrier w/ Cutouts; Gutter Type - Triangular shape (Flow on Either Side)**		
INLET TYPE	**OPSD Deck Drains**		

	LOCATION		DRAINAGE AREA DETAILS									FLOW, SPREAD AND INLET SPACING																	
Design Frequency	From Inlet Station	To Inlet Station	Gutter Grade S_o	Distance L	Gutter Crossfall S_w	Road Crossfall S_x	Average Width W	Watershed Area A	Runoff Coeff. C	Time of Conc. T_c	Rainfall Intensity I	Local Runoff Q_r	Gutter Flow Q_g	Sides of Gutter Flow	Gutter Flow Ea Q_g	Inlet Spacing L	Flow Spread T	Flow Depth at Shoulder d_s	Flow Area A_F	Flow Velocity V	Flow Travel Time t	Lane Spread Encroachment (W_{LSE})	Flow Depth at EOP (d_1)	Inlet Type	No. of Inlets	Inlet Elevation	Inlet Capacity Q_i	Carryover Flow Q_c	Remarks
			m/m	m	m/m	m/m	m	ha	-	min	mm/h	m^3/s	m^3/s	-	m^3/s	m	m	mm	m^2	m/s	min	m	mm	-	-	m	m^3/s	m^3/s	
																		Shoulder Width =	**2.00**										
	Station 11+219.5 to 10+294																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**							
2-yr (Minor System Event)	11+219.5	11+105.0	0.67%		2.0%	2.0%	6.00	0.069	0.95	9.24	76.9	0.014	0.01405	1	0.01405	114.5	1.69	33.77	0.0285	0.49	3.87	**0.00**	0.0	SS9-8	2	87.58	0.0338	0.0000	Pier 17
	11+105.0	10+994.0	0.67%	100.0	2.0%	2.0%	6.00	0.067	0.95	8.99	78.4	0.014	0.01389	1	0.01389	111.0	1.68	33.63	0.0283	0.49	3.76	**0.00**	0.0	SS9-8	2	86.81	0.0336	0.0000	
	10+994.0	10+894.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	83.7	0.013	0.01336	1	0.01336	100.0	1.66	33.14	0.0275	0.49	3.42	**0.00**	0.0	SS9-8	2	86.07	0.0332	0.0000	
	10+894.0	10+794.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	83.7	0.013	0.01336	1	0.01336	100.0	1.66	33.14	0.0275	0.49	3.42	**0.00**	0.0	SS9-8	2	85.39	0.0332	0.0000	
	10+794.0	10+694.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	83.7	0.013	0.01336	1	0.01336	100.0	1.66	33.14	0.0275	0.49	3.42	**0.00**	0.0	SS9-8	2	84.72	0.0332	0.0000	
	10+694.0	10+594.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	83.7	0.013	0.01336	1	0.01336	100.0	1.66	33.14	0.0275	0.49	3.42	**0.00**	0.0	SS9-8	2	84.05	0.0332	0.0000	
	10+594.0	10+494.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	83.7	0.013	0.01336	1	0.01336	100.0	1.66	33.14	0.0275	0.49	3.42	**0.00**	0.0	SS9-8	2	83.37	0.0332	0.0000	
	10+494.0	10+394.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	83.7	0.013	0.01336	1	0.01336	100.0	1.66	33.14	0.0275	0.49	3.42	**0.00**	0.0	SS9-8	2	82.70	0.0332	0.0000	
	10+394.0	10+294.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	83.7	0.013	0.01336	1	0.01336	100.0	1.66	33.14	0.0275	0.49	3.42	**0.00**	0.0	SS9-8	2	82.03	0.0332	0.0000	
	10+294.0	End	0.67%	0.0	2.0%	2.0%	6.00	0.000	0.95	0.00	0.0	0.000	0.00000	1	0.00000	0.0	0.00	0.00								81.35		0.0000	Abutment
	End																												
																		Shoulder Width =	**2.00**										
	Station 11+219.5 to 10+294																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**							
5-yr (Minor System Event)	11+219.5	11+105.0	0.67%		2.0%	2.0%	6.00	0.069	0.95	9.24	102.0	0.019	0.01865	1	0.01865	114.5	1.88	37.55	0.0353	0.53	3.61	**0.00**	0.0	SS9-8	2	87.58	0.0371	0.0000	Pier 17
	11+105.0	10+994.0	0.67%	100.0	2.0%	2.0%	6.00	0.067	0.95	8.99	104.1	0.018	0.01843	1	0.01843	111.0	1.87	37.39	0.0349	0.53	3.51	**0.00**	0.0	SS9-8	2	86.81	0.0370	0.0000	
	10+994.0	10+894.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	111.1	0.018	0.01773	1	0.01773	100.0	1.84	36.85	0.0339	0.52	3.19	**0.00**	0.0	SS9-8	2	86.07	0.0365	0.0000	
	10+894.0	10+794.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	111.1	0.018	0.01773	1	0.01773	100.0	1.84	36.85	0.0339	0.52	3.19	**0.00**	0.0	SS9-8	2	85.39	0.0365	0.0000	
	10+794.0	10+694.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	111.1	0.018	0.01773	1	0.01773	100.0	1.84	36.85	0.0339	0.52	3.19	**0.00**	0.0	SS9-8	2	84.72	0.0365	0.0000	
	10+694.0	10+594.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	111.1	0.018	0.01773	1	0.01773	100.0	1.84	36.85	0.0339	0.52	3.19	**0.00**	0.0	SS9-8	2	84.05	0.0365	0.0000	
	10+594.0	10+494.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	111.1	0.018	0.01773	1	0.01773	100.0	1.84	36.85	0.0339	0.52	3.19	**0.00**	0.0	SS9-8	2	83.37	0.0365	0.0000	
	10+494.0	10+394.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	111.1	0.018	0.01773	1	0.01773	100.0	1.84	36.85	0.0339	0.52	3.19	**0.00**	0.0	SS9-8	2	82.70	0.0365	0.0000	
	10+394.0	10+294.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	111.1	0.018	0.01773	1	0.01773	100.0	1.84	36.85	0.0339	0.52	3.19	**0.00**	0.0	SS9-8	2	82.03	0.0365	0.0000	
	10+294.0	End	0.67%	0.0	2.0%	2.0%	6.00	0.000	0.95	0.00	0.0	0.000	0.00000	1	0.00000	0.0	0.00	0.00								81.35		0.0000	Abutment
	End																												
																		Shoulder Width =	**2.00**										
	Station 11+219.5 to 10+294																	**Max Spread Width =**	**2.00**			***0.05m tolerance at this stage of design**							
10-yr (Minor system Event)	11+219.5	11+105.0	0.67%		2.0%	2.0%	6.00	0.069	0.95	9.24	118.7	0.022	0.02169	1	0.02169	114.5	1.99	39.74	0.0395	0.55	3.47	**0.00**	0.0	SS9-8	2	87.58	0.0390	0.0000	Pier 17
	11+105.0	10+994.0	0.67%	100.0	2.0%	2.0%	6.00	0.067	0.95	8.99	121.0	0.021	0.02144	1	0.02144	111.0	1.98	39.57	0.0391	0.55	3.38	**0.00**	0.0	SS9-8	2	86.81	0.0388	0.0000	
	10+994.0	10+894.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	129.2	0.021	0.02062	1	0.02062	100.0	1.95	39.00	0.0380	0.54	3.07	**0.00**	0.0	SS9-8	2	86.07	0.0383	0.0000	
	10+894.0	10+794.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	129.2	0.021	0.02062	1	0.02062	100.0	1.95	39.00	0.0380	0.54	3.07	**0.00**	0.0	SS9-8	2	85.39	0.0383	0.0000	
	10+794.0	10+694.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	129.2	0.021	0.02062	1	0.02062	100.0	1.95	39.00	0.0380	0.54	3.07	**0.00**	0.0	SS9-8	2	84.72	0.0383	0.0000	
	10+694.0	10+594.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	129.2	0.021	0.02062	1	0.02062	100.0	1.95	39.00	0.0380	0.54	3.07	**0.00**	0.0	SS9-8	2	84.05	0.0383	0.0000	
	10+594.0	10+494.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	129.2	0.021	0.02062	1	0.02062	100.0	1.95	39.00	0.0380	0.54	3.07	**0.00**	0.0	SS9-8	2	83.37	0.0383	0.0000	
	10+494.0	10+394.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	129.2	0.021	0.02062	1	0.02062	100.0	1.95	39.00	0.0380	0.54	3.07	**0.00**	0.0	SS9-8	2	82.70	0.0383	0.0000	
	10+394.0	10+294.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	129.2	0.021	0.02062	1	0.02062	100.0	1.95	39.00	0.0380	0.54	3.07	**0.00**	0.0	SS9-8	2	82.03	0.0383	0.0000	
	10+294.0	End	0.67%	0.0	2.0%	2.0%	6.00	0.000	0.95	0.00	0.0	0.000	0.00000	1	0.00000	0.0	0.00	0.00								81.35		0.0000	Abutment
	End																												

INLET SPACING, SPREAD FLOW DEPTH CALCULATIONS

Kingston 3rd Crossing Spread

BRIDGE	K3C NW			RAINFALL STATION(S)	
SCENARIO		DATE		DESIGN SPREAD	**10 Year - 2.0 m; 100 Year - 3.0 m**
DESIGNED BY	EM	DATE		CURB & GUTTER TYPE	**Concrete Barrier w/ Cutouts; Gutter Type - Triangular shape (Flow on Either Side)**
CHECKED BY	DJ			INLET TYPE	**OPSD Deck Drains**

	LOCATION		DRAINAGE AREA DETAILS										FLOW, SPREAD AND INLET SPACING																
Design Frequency	From Inlet Station	To Inlet Station	Gutter Grade S_o	Distance L	Gutter Crossfall S_w	Road Crossfall S_x	Average Width W	Watershed Area A	Runoff Coeff. C	Time of Conc. T_c	Rainfall Intensity I	Local Runoff Q_r	Gutter Flow Q_g	Sides of Gutter Flow	Gutter Flow Ea Q_g	Inlet Spacing L	Flow Spread T	Flow Depth at Shoulder d_s	Flow Area A_F	Flow Velocity V	Flow Travel Time t	Lane Spread Encroachment (W_{LSE})	Flow Depth at EOP (d_l)	Inlet Type	No. of Inlets	Inlet Elevation	Inlet Capacity Q_i	Carryover Flow Q_c	Remarks
			m/m	m	m/m	m/m	m	ha	-	min	mm/h	m³/s	m³/s	-	m³/s	m	m	mm	m²	m/s	min	m	mm	-	-	m	m³/s	m³/s	
																		Shoulder Width =	**2.00**										
	Station 11+219.5 to 10+294																	**Max Spread Width =**	**3.00**										
100-year (Major System Event)	11+219.5	11+105.0	0.67%	0.0	2.0%	2.0%	6.00	0.069	0.95	9.24	170.4	0.031	0.03115	1	0.03115	114.5	2.28	45.52	0.0518	0.60	3.17	**0.00**	5.5	SS9-8	2	87.58	0.0438	0.0000	Pier 17
	11+105.0	10+994.0	0.67%	100.0	2.0%	2.0%	6.00	0.067	0.95	8.99	173.8	0.031	0.03079	1	0.03079	111.0	2.27	45.32	0.0513	0.60	3.09	**0.00**	5.3	SS9-8	2	86.81	0.0436	0.0000	
	10+994.0	10+894.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	185.6	0.030	0.02962	1	0.02962	100.0	2.23	44.67	0.0499	0.59	2.81	**0.00**	4.7	SS9-8	2	86.07	0.0431	0.0000	
	10+894.0	10+794.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	185.6	0.030	0.03774	1	0.03774	100.0	2.45	48.91	0.0598	0.63	2.64	**0.00**	8.9	SS9-8	2	85.39	0.0466	0.0000	
	10+794.0	10+694.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	185.6	0.030	0.02962	1	0.02962	100.0	2.23	44.67	0.0499	0.59	2.81	**0.00**	4.7	SS9-8	2	84.72	0.0431	0.0000	
	10+694.0	10+594.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	185.6	0.030	0.02962	1	0.02962	100.0	2.23	44.67	0.0499	0.59	2.81	**0.00**	4.7	SS9-8	2	84.05	0.0431	0.0000	
	10+594.0	10+494.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	185.6	0.030	0.03402	1	0.03402	100.0	2.35	47.05	0.0553	0.61	2.71	**0.00**	7.0	SS9-8	2	83.37	0.0451	0.0000	
	10+494.0	10+394.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	185.6	0.030	0.02962	1	0.02962	100.0	2.23	44.67	0.0499	0.59	2.81	**0.00**	4.7	SS9-8	2	82.70	0.0431	0.0000	
	10+394.0	10+294.0	0.67%	100.0	2.0%	2.0%	6.00	0.060	0.95	8.18	185.6	0.030	0.02962	1	0.02962	100.0	2.23	44.67	0.0499	0.59	2.81	**0.00**	4.7	SS9-8	2	82.03	0.0431	0.0000	
	10+294.0	End	0.67%	0.0	2.0%	2.0%	6.00	0.000	0.95	0.00	0.0	0.000	0.00000	1	0.00001	0.0	0.11	2.23								81.35		0.0000	Abutment
	End																												

Rainfall Parameters

a) Rainfall parameters are based on intensity-duration-frequency curves from MTO IDF Curve Lookup

2-Year Storm:	A = **20.800** B = **-0.699**	**2-Year Storm:**	A = **27.600** B = **-0.699**	**10-Year Storm:**	A = **32.100** B = **-0.699**	**100-Year Storm:**	A = **46.100** B = **-0.699**

Rainfall Intensity: $I = AT^B$

Where, I in mm/hr

T = Time of Concentration in hour

Note: Assumed no existing deck drains.

EOP = Edge of pavement of the travelled lane

Note

Input — **All the figures in blue colour need to be updated by the user for respective project.**

Local Runoff (Q_r) = 0.0028 CIA (m³/s)

Where, C = Runoff coefficient

A = Watershed area (ha)

I = Rainfall Intensity (mm/hr)

Note: The inlet capacity of SS9-2B type deck drain is taken from MTO Design Chart 4.21.

Time of Concentration by B Time of Concentration by Bransby Williams Method.

$$T_c = 0.057 \times L / \left(S_o^{0.20} \times A^{0.10}\right)$$

Where, Where, T_c = Time of concentration (min)

L = Watershed length = Inlet Spacing (m)

S_0 = Watershed Slope (%)

A = Watershed Area (ha)

Spread, **Spread,**

$$(T) = \frac{(1/S_x) \times (Q_g)^{3/8}}{(0.375)^{0.375} \times (1/S_x)^{3/8} \times (1/n)^{3/8} \times S_0^{3/16}}$$

BRIDGE	K3C	NW	Deck Thickness (mm)	350
SCENARIO			Mannings n	0.013
DESIGNED BY	EM			
CHECKED BY	DJ			

Design Frequency	LOCATION From Inlet Station	To Inlet	FLOW, SPREAD AND INLET SPACING Pipe Length L	Pipe Diameter Dia	No. of Pipes	Inlet Elevation	U/S Invert	D/S Invert	Pipe Drop	D/S Hanger Depth	Pipe Slope S	Pipe Full Capacity Q_{full}	Pipe Full Velocity V_{full}	Pipe Efficiency $C_{eff.}$	Pipe Capacity w/ Blockage Q_{block}	Inlet Capacity Q_i	Pipe Receiving Capacity Q_i / Q_{block}	Carryover Flow Pipe Q_{cp}	Remarks
			m	mm	-	m	m	m	mm	mm	%					m^3/s		m^3/s	
2-yr (Minor System Event)	**Station 11+219.5 to 10+294**																		
	11+219.5	11+105.0																	Pier 17
	11+105.0	10+994.0	111.0	300	1	86.81	85.662	84.915	0	500	0.67%	0.079	1.122	100%	0.079	0.0338	43%	0.000	
	10+994.0	10+894.0	100.0	300	1	86.07	84.915	84.242	0	500	0.67%	0.079	1.122	100%	0.079	0.0674	85%	0.000	
	10+894.0	10+794.0	100.0	375	1	85.39	84.167	83.494	75	500	0.67%	0.144	1.302	100%	0.144	0.1006	70%	0.000	
	10+794.0	10+694.0	100.0	450	1	84.72	83.419	82.646	75	600	0.77%	0.251	1.576	100%	0.251	0.1338	53%	0.000	
	10+694.0	10+594.0	100.0	450	1	84.05	82.646	82.073	0	500	0.57%	0.216	1.357	100%	0.216	0.1670	77%	0.000	
	10+594.0	10+494.0	100.0	525	1	83.37	81.998	81.325	75	500	0.67%	0.353	1.630	100%	0.353	0.2002	57%	0.000	
	10+494.0	10+394.0	100.0	525	1	82.70	81.325	80.652	0	500	0.67%	0.353	1.630	100%	0.353	0.2334	66%	0.000	
	10+394.0	10+294.0	100.0	600	1	82.03	80.577	79.904	75	500	0.67%	0.504	1.782	100%	0.504	0.2666	53%	0.000	
	10+294.0	End				81.35													Abutment
5-yr (Minor System Event)	**Station 11+219.5 to 10+294**																		
	11+219.5	11+105.0																	Pier 17
	11+105.0	10+994.0	111.0	300	1	86.81	85.662	84.915	0	500	0.67%	0.079	1.122	100%	0.079	0.0371	47%	0.000	
	10+994.0	10+894.0	100.0	300	1	86.07	84.915	84.242	0	500	0.67%	0.079	1.122	100%	0.079	0.0740	93%	0.000	
	10+894.0	10+794.0	100.0	375	1	85.39	84.167	83.494	75	500	0.67%	0.144	1.302	100%	0.144	0.1105	77%	0.000	
	10+794.0	10+694.0	100.0	450	1	84.72	83.419	82.646	75	600	0.77%	0.251	1.576	100%	0.251	0.1470	59%	0.000	
	10+694.0	10+594.0	100.0	450	1	84.05	82.646	82.073	0	500	0.57%	0.216	1.357	100%	0.216	0.1835	85%	0.000	
	10+594.0	10+494.0	100.0	525	1	83.37	81.998	81.325	75	500	0.67%	0.353	1.630	100%	0.353	0.2200	62%	0.000	
	10+494.0	10+394.0	100.0	525	1	82.70	81.325	80.652	0	500	0.67%	0.353	1.630	100%	0.353	0.2565	73%	0.000	
	10+394.0	10+294.0	100.0	600	1	82.03	80.577	79.904	75	500	0.67%	0.504	1.782	100%	0.504	0.2929	58%	0.000	
	10+294.0	End				81.35													Abutment
10-yr (Minor system Event)	**Station 11+219.5 to 10+294**																		
	11+219.5	11+105.0																	Pier 17
	11+105.0	10+994.0	111.0	300	1	86.81	85.662	84.915	0	500	0.67%	0.079	1.122	100%	0.079	0.0390	49%	0.000	
	10+994.0	10+894.0	100.0	300	1	86.07	84.915	84.242	0	500	0.67%	0.079	1.122	100%	0.079	0.0778	98%	0.000	
	10+894.0	10+794.0	100.0	375	1	85.39	84.167	83.494	75	500	0.67%	0.144	1.302	100%	0.144	0.1162	81%	0.000	
	10+794.0	10+694.0	100.0	450	1	84.72	83.419	82.646	75	600	0.77%	0.251	1.576	100%	0.251	0.1545	62%	0.000	
	10+694.0	10+594.0	100.0	450	1	84.05	82.646	82.073	0	500	0.57%	0.216	1.357	100%	0.216	0.1928	89%	0.000	
	10+594.0	10+494.0	100.0	525	1	83.37	81.998	81.325	75	500	0.67%	0.353	1.630	100%	0.353	0.2312	66%	0.000	
	10+494.0	10+394.0	100.0	525	1	82.70	81.325	80.652	0	500	0.67%	0.353	1.630	100%	0.353	0.2695	76%	0.000	
	10+394.0	10+294.0	100.0	600	1	82.03	80.577	79.904	75	500	0.67%	0.504	1.782	100%	0.504	0.3079	61%	0.000	
	10+294.0	End				81.35													Abutment

BRIDGE	K3C NW	Deck Thickness (mm)	350
SCENARIO		Mannings n	0.013
DESIGNED BY	EM		
CHECKED BY	DJ		

	LOCATION		FLOW, SPREAD AND INLET SPACING																
Design Frequency	From Inlet Station	To Inlet	Pipe Length L	Pipe Diameter *Dia*	No. of Pipes	Inlet Elevation	U/S Invert	D/S Invert	Pipe Drop	D/S Hanger Depth	Pipe Slope S	Pipe Full Capacity Q_{full}	Pipe Full Velocity V_{full}	Pipe Efficency $C_{eff.}$	Pipe Capacity w/ Blockage Q_{block}	Inlet Capacity Q_i	Pipe Receiving Capacity Q_i / Q_{block}	Carryover Flow Pipe Q_{cp}	Remarks
			m	mm	-	m	m	m	mm	mm	%					m^3/s		m^3/s	
	Station 11+219.5 to 10+294																		
	11+219.5	11+105.0																	Pier 17
	11+105.0	10+994.0	111.0	300	1	86.81	85.662	84.915	0	500	0.67%	0.079	1.122	100%	0.079	0.0438	55%	0.000	
	10+994.0	10+894.0	100.0	300	1	86.07	84.915	84.242	0	500	0.67%	0.079	1.122	100%	0.079	0.0875	110%	0.008	
100-year (Major System Event)	10+894.0	10+794.0	100.0	375	1	85.39	84.167	83.494	75	500	0.67%	0.144	1.302	100%	0.144	0.1306	91%	0.000	
	10+794.0	10+694.0	100.0	450	1	84.72	83.419	82.646	75	600	0.77%	0.251	1.576	100%	0.251	0.1771	71%	0.000	
	10+694.0	10+594.0	100.0	450	1	84.05	82.646	82.073	0	500	0.57%	0.216	1.357	100%	0.216	0.2202	102%	0.004	
	10+594.0	10+494.0	100.0	525	1	83.37	81.998	81.325	75	500	0.67%	0.353	1.630	100%	0.353	0.2633	75%	0.000	
	10+494.0	10+394.0	100.0	525	1	82.70	81.325	80.652	0	500	0.67%	0.353	1.630	100%	0.353	0.3084	87%	0.000	
	10+394.0	10+294.0	100.0	600	1	82.03	80.577	79.904	75	500	0.67%	0.504	1.782	100%	0.504	0.3515	70%	0.000	
	10+294.0	End				81.35													Abutment

Road Section Data	
EBL Width (m)	5.5
Lane Width (m)	3.5
Shoulder Width (m)	2.0

Bridge Standard (WC-4 Bridge Deck Drainage)

10 Year Storm	Full lane width clear of any flooding
100 Year Storm	Minimum 2.5 m of Lane width should be clear of any flooding

Spread Requirements	
10 Year Spread	2.0
100 Year Spread	3.0

Estimates columetric storage requirements based on Modified Rational Method peak hydrograph and user specified maximum allowable release rate. Use Section A or B as convenient. Copy s

A. Input Data (Apply for A <10 ha)

See "Peak Flow" sheet for desired input values of Area, Runoff Coefficient. Enter Allowable Release Rate, Qr.

Outfall #	Subcatchment Attributes			
	Area [ha]	C	Tc [min]	Qr [cms]
3	0.35	0.78	10	0.09436

A. Volume Based on IDF Data

Maximum required storage in ***Bold Blue*** *for return period storm* **[Ensure Td => Tc!! For Selected Max Storage]**

td [min]	Peak Inflow, Qp [cms]						Qr [cms]	MRM Volume Storage Required, Vstor [m3]					
	2	*5*	*10*	*25*	*50*	*100*		*2*	*5*	*10*	*25*	*50*	*100*
10	0.0544	0.0724	0.0841	0.0991	0.1102	0.1210	0.09	-	-	-	**2.8**	**9.5**	**15.98**
15	0.0419	0.0558	0.0648	0.0763	0.0848	0.0931	0.09	-	-	-	-	5.6	13.05
20	0.0346	0.0460	0.0535	0.0629	0.0700	0.0769	0.09	-	-	-	-	-	7.33
25	0.0298	0.0396	0.0460	0.0541	0.0602	0.0661	0.09	-	-	-	-	-	0.01
30	0.0263	0.0349	0.0406	0.0477	0.0531	0.0583	0.09	-	-	-	-	-	-
35	0.0236	0.0314	0.0364	0.0429	0.0477	0.0524	0.09	-	-	-	-	-	-
40	0.0215	0.0286	0.0332	0.0391	0.0435	0.0477	0.09	-	-	-	-	-	-
45	0.0198	0.0263	0.0306	0.0360	0.0401	0.0439	0.09	-	-	-	-	-	-
50	0.0184	0.0245	0.0284	0.0334	0.0372	0.0408	0.09	-	-	-	-	-	-
55	0.0172	0.0229	0.0266	0.0312	0.0348	0.0382	0.09	-	-	-	-	-	-
60	0.0162	0.0215	0.0250	0.0294	0.0327	0.0359	0.09	-	-	-	-	-	-
120	0.0099	0.0131	0.0153	0.0179	0.0200	0.0219	0.09	-	-	-	-	-	-
180	0.0074	0.0098	0.0114	0.0134	0.0149	0.0164	0.09	-	-	-	-	-	-
240	0.0060	0.0080	0.0093	0.0109	0.0122	0.0133	0.09	-	-	-	-	-	-
300	0.0051	0.0068	0.0079	0.0093	0.0104	0.0113	0.09	-	-	-	-	-	-
360	0.0045	0.0060	0.0069	0.0081	0.0091	0.0099	0.09	-	-	-	-	-	-
480	0.0037	0.0048	0.0056	0.0066	0.0074	0.0081	0.09	-	-	-	-	-	-
600	0.0031	0.0041	0.0048	0.0056	0.0063	0.0069	0.09	-	-	-	-	-	-
720	0.0027	0.0036	0.0042	0.0049	0.0055	0.0060	0.09	-	-	-	-	-	-
1440	0.0017	0.0022	0.0025	0.0030	0.0033	0.0036	0.09	-	-	-	-	-	-

Estimates columetric storage requirements based on Modified Rational Method peak hydrograph and user specified maximum allowable release rate. Use Section A or B as convenient. Copy s

A. Input Data (Apply for A <10 ha)

See "Peak Flow" sheet for desired input values of Area, Runoff Coefficient. Enter Allowable Release Rate, Qr.

Outfall #	Subcatchment Attributes			
	Area [ha]	C	Tc [min]	Qr [cms]
4	0.66	0.77	10	0.19036

A. Volume Based on IDF Data

Maximum required storage in ***Bold Blue*** *for return period storm* **[Ensure Td => Tc!! For Selected Max Storage]**

td [min]	Peak Inflow, Qp [cms]						Qr [cms]	MRM Volume Storage Required, Vstor [m3]					
	2	*5*	*10*	*25*	*50*	*100*		*2*	*5*	*10*	*25*	*50*	*100*
10	0.1028	0.1367	0.1588	0.1870	0.2080	0.2284	0.19	-	-	-	-	**10.6**	**22.84**
15	0.0792	0.1053	0.1223	0.1440	0.1602	0.1758	0.19	-	-	-	-	1.4	15.47
20	0.0654	0.0869	0.1009	0.1188	0.1322	0.1451	0.19	-	-	-	-	-	2.82
25	0.0562	0.0747	0.0868	0.1021	0.1137	0.1247	0.19	-	-	-	-	-	-
30	0.0496	0.0659	0.0766	0.0901	0.1003	0.1100	0.19	-	-	-	-	-	-
35	0.0446	0.0592	0.0688	0.0810	0.0901	0.0989	0.19	-	-	-	-	-	-
40	0.0406	0.0540	0.0627	0.0738	0.0821	0.0901	0.19	-	-	-	-	-	-
45	0.0374	0.0497	0.0577	0.0679	0.0756	0.0830	0.19	-	-	-	-	-	-
50	0.0348	0.0462	0.0536	0.0631	0.0703	0.0770	0.19	-	-	-	-	-	-
55	0.0325	0.0432	0.0502	0.0590	0.0657	0.0720	0.19	-	-	-	-	-	-
60	0.0306	0.0406	0.0472	0.0555	0.0618	0.0677	0.19	-	-	-	-	-	-
120	0.0187	0.0248	0.0288	0.0339	0.0377	0.0413	0.19	-	-	-	-	-	-
180	0.0140	0.0185	0.0215	0.0253	0.0282	0.0309	0.19	-	-	-	-	-	-
240	0.0114	0.0151	0.0175	0.0206	0.0229	0.0251	0.19	-	-	-	-	-	-
300	0.0097	0.0128	0.0149	0.0175	0.0195	0.0214	0.19	-	-	-	-	-	-
360	0.0085	0.0113	0.0131	0.0154	0.0171	0.0188	0.19	-	-	-	-	-	-
480	0.0069	0.0092	0.0106	0.0125	0.0139	0.0152	0.19	-	-	-	-	-	-
600	0.0059	0.0078	0.0090	0.0106	0.0119	0.0130	0.19	-	-	-	-	-	-
720	0.0052	0.0068	0.0079	0.0093	0.0104	0.0114	0.19	-	-	-	-	-	-
1440	0.0031	0.0041	0.0048	0.0056	0.0063	0.0069	0.19	-	-	-	-	-	-

Pipe Storage SWM Design Sheet - Outfall 3 - K3C

A. Design Event — Post Dev. 100-yr Flow to Pre Dev. 100-yr Flow

Pre Dev. 100-yr Flow	0.094	m^3/s
Post Dev. 100-yr Flow	0.121	m^3/s
Vol. Storage Required	16.0	m^3

B. Pipe Data

Upstream Invert	-	
Downstream Invert	-	m
Dia. Of Pipe, d_{pipe}	0.75	m
Area. Of Pipe	0.44	
Length	37.1	m
Pipe Slope	0.002	m/m
Mannings n	0.013	
Full Flow, Q_{full}	0.50	m^3/s

C. Orifice Geometry

Dia. Of Orrifice, $d_{orifice}$	232	mm
Area of Orifice	0.042	m^2
Orifice Coefficient, C_d	0.61	-

$Q_O = C_d A (2 g h)^{1/2}$

Q = the orifice flow discharge

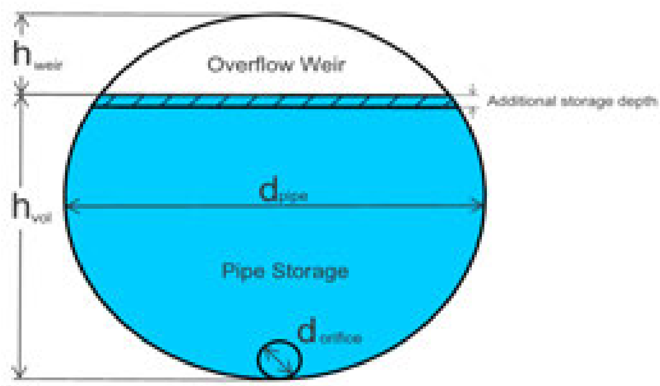
C_d = dimensionless coefficient of discharge

A_0 = cross-sectional area of orifice or pipe

g = acceleration due to gravity

D_o = diameter of orifice or pipe

h = effective head on the orifice, from the center of orifice to the water surface



Pipe Storage SWM Design Sheet

D. Stage Storage Discharge and Volume Control

Stage	Stage	Depth to Middle of Orifice	Orifice Discharge	Inc Cross Section	Total Storage	Inc Time	Cumulative Time
%	m	m	m^3/s	m^2	m^3	(hr)	(hr)
100	0.75	0.75	0.099	0.44	16.4	0.05	0.41
90	0.68	0.68	0.094	0.42	15.5	0.05	0.36
85	0.64	0.64	0.091	0.40	14.8	0.05	0.31
80	0.60	0.60	0.088	0.38	14.1	0.04	0.27
75	0.56	0.56	0.086	0.36	13.2	0.04	0.22
70	0.53	0.53	0.083	0.33	12.3	0.04	0.18
60	0.45	0.45	0.077	0.28	10.3	0.04	0.14
50	0.38	0.38	0.070	0.22	8.2	0.03	0.10
40	0.30	0.30	0.063	0.17	6.1	0.03	0.07
30	0.23	0.23	0.054	0.11	4.1	0.02	0.04
20	0.15	0.15	0.044	0.06	2.3	0.01	0.02
10	0.08	0.08	0.031	0.02	0.9	0.01	0.01

E. Design Outputs

Pipe Full Percentage Required	90%	
Depth in Pipe Required for Volume Control	0.68	m
Additional Storage Depth (Safety Factor)	0.05	m
Depth in Pipe for Volume Control, h_{vol}	0.73	m
Overflow Weir Depth, h_{weir}	0.02	m
Maximum Weir Overflow	0.00	m^3/s
97% Vol. Storage	16.2 >	16.0

Pipe Storage SWM Design Sheet - Outfall 4 - K3C

A. Design Event **Post Dev. 100-yr Flow to Pre Dev. 100-yr Flow**

Pre Dev. 100-yr Flow	0.190	m^3/s
Post Dev. 100-yr Flow	0.228	m^3/s
Vol. Storage Required	22.8	m^3

B. Pipe Data

Upstream Invert	-	
Downstream Invert	-	m
Dia. Of Pipe, d_{pipe}	1.35	m
Area. Of Pipe	1.43	
Length	19.3	m
Pipe Slope	0.002	m/m
Mannings n	0.013	
Full Flow, Q_{full}	2.39	m^3/s

C. Orifice Geometry

Dia. Of Orrifice, $d_{orifice}$	285	mm
Area of Orifice	0.064	m^2
Orifice Coefficient, C_d	0.61	-

$Q_O = C_d A (2 g h)^{1/2}$

Q = the orifice flow discharge

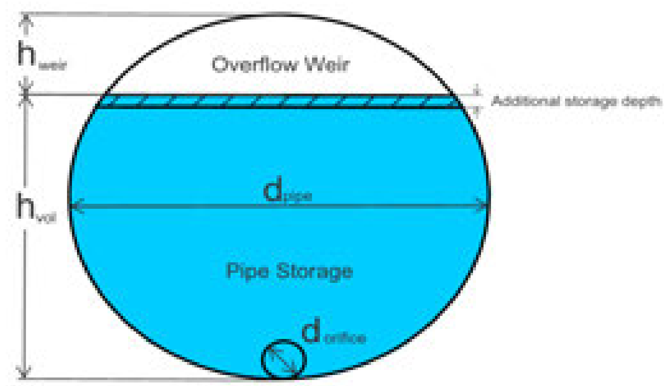
C_d = dimensionless coefficient of discharge

A_0 = cross-sectional area of orifice or pipe

g = acceleration due to gravity

D_o = diameter of orifice or pipe

h = effective head on the orifice, from the center of orifice to the water surface



Pipe Storage SWM Design Sheet

D. Stage Storage Discharge and Volume Control

Stage	Stage	Depth to Middle of Orifice	Orifice Discharge	Inc Cross Section	Total Storage	Inc Time	Cumulative Time
%	m	m	m^3/s	m^2	m^3	(hr)	(hr)
100	1.35	1.35	0.200	1.43	27.6	0.04	0.34
90	1.22	1.22	0.190	1.36	26.2	0.04	0.30
85	1.15	1.15	0.185	1.30	25.0	0.04	0.26
80	1.08	1.08	0.179	1.23	23.7	0.04	0.22
75	1.01	1.01	0.173	1.15	22.2	0.04	0.19
70	0.95	0.95	0.168	1.07	20.7	0.03	0.15
60	0.81	0.81	0.155	0.90	17.3	0.03	0.12
50	0.68	0.68	0.142	0.72	13.8	0.03	0.09
40	0.54	0.54	0.127	0.53	10.3	0.02	0.06
30	0.41	0.41	0.110	0.36	7.0	0.02	0.04
20	0.27	0.27	0.090	0.20	3.9	0.01	0.02
10	0.14	0.14	0.063	0.07	1.4	0.01	0.01

E. Design Outputs

Pipe Full Percentage Required	90%	
Depth in Pipe Required for Volume Control	1.22	m
Additional Storage Depth (Safety Factor)	0.05	m
Depth in Pipe for Volume Control, h_{vol}	1.27	m
Overflow Weir Depth, h_{weir}	0.08	m
Maximum Weir Overflow	0.02	m^3/s
94% Vol. Storage	26.9 >	22.8

Stormceptor®

FORTERRA™

Brief Stormceptor Sizing Report - Bridge Crossing Project

Project Information & Location			
Project Name	Bridge Crossing Project	**Project Number**	7342
City		**State/ Province**	Ontario
Country	Canada	**Date**	1/31/2019
Designer Information		**EOR Information (optional)**	
Name	david Jackson	**Name**	
Company	Hatch	**Company**	
Phone #	905-315-3510	**Phone #**	
Email	david.jackson@hatch.com	**Email**	

Stormwater Treatment Recommendation

The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	
Target TSS Removal (%)	60
TSS Removal (%) Provided	61
Recommended Stormceptor Model	EF6

The recommended Stormceptor Model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

EF Sizing Summary	
EF Model	**% TSS Removal Provided**
EF4	56
EF6	61
EF8	66
EF10	68
EF12	69
Parallel Units / MAX	Custom

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Sizing Details

Drainage Area

Drainage Area	
Total Area (ha)	0.66
Imperviousness %	80.0

Rainfall

Rainfall	
Station Name	KINGSTON PUMPING STATION
State/Province	Ontario
Station ID #	4175
Years of Records	44
Latitude	44°14'N
Longitude	76°29'W

Water Quality Objective

Water Quality Objective	
TSS Removal (%)	60.0
Runoff Volume Capture (%)	
Oil Spill Capture Volume (L)	
Peak Conveyed Flow Rate (L/s)	
Water Quality Flow Rate (L/s)	

Up Stream Storage

Storage (ha-m)	Discharge (cms)
0.000	0.000

Up Stream Flow Diversion

Up Stream Flow Diversion	
Max. Flow to Stormceptor (cms)	

Particle Size Distribution (PSD)
The selected PSD defines TSS removal

CA ETV

Particle Diameter (microns)	Distribution %	Specific Gravity
2.0	5.0	2.65
5.0	5.0	2.65
8.0	10.0	2.65
20.0	15.0	2.65
50.0	10.0	2.65
75.0	5.0	2.65
100.0	10.0	2.65
150.0	15.0	2.65
250.0	15.0	2.65
500.0	5.0	2.65
1000.0	5.0	2.65

Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
- For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

For Stormceptor Specifications and Drawings Please Visit:
http://www.imbriumsystems.com/technical-specifications

STANDARD SPECIFICATION FOR
“OIL GRIT SEPARATOR” (OGS) STORMWATER QUALITY TREAMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, designing, maintaining, and constructing an underground Oil Grit Separator (OGS) device for stormwater quality treatment, with third-party testing results and a Statement of Verification in accordance with ISO 14034 Environmental Management – Environmental Technology Verification (ETV). Work includes supply and installation of concrete bases, precast sections, and the appropriate precast section with OGS internal components correctly installed within the system, watertight sealed to the precast concrete prior to arrival to the project site.

1.2 REFERENCE STANDARDS

1.2.1 For Canadian projects only, the following reference standards apply:

CAN/CSA-A257.4-14: Joints for Circular Concrete Sewer and Culvert Pipe, Manhole Sections, and Fittings Using Rubber Gaskets
CAN/CSA-A257.4-14: Precast Reinforced Circular Concrete Manhole Sections, Catch Basins, and Fittings
CAN/CSA-S6-00: Canadian Highway Bridge Design Code

1.2.2 For ALL projects, the following reference standards apply:

ASTM D-4097:	Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks
ASTM C 478:	Specification for Precast Reinforced Concrete Manhole Sections
ASTM C 443:	Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C 891:	Standard Practice for Installation of Underground Precast Concrete Utility Structures
ASTM D2563:	Standard Practice for Classification of Visual Defects in Reinforced Plastics

1.3 SHOP DRAWINGS

1.3.1 Shop drawings shall be submitted upon request with each order to the contractor then forwarded to the Engineer of Record for review and acceptance. Shop drawings shall detail the precast concrete components and OGS internal components prior to shipment, including the sequence for installation.

1.3.2 Unless directed otherwise by the Engineer of Record, OGS stormwater quality treatment product substitutions or alternatives submitted within ten days prior to project bid shall not be accepted. All alternatives or substitutions submitted shall be based on the exact same criteria detailed in Section 3, in entirety, subject to review and approval by the Engineer of Record. Any and all changes to project cost estimates, bonding amounts, plan check fees for revision of approved documents, or design impacts due to regulatory requirements as a result of a product substitution shall be coordinated by the Contractor with the Engineer of Record.

1.4 HANDLING AND STORAGE

Prevent damage to materials during storage and handling.

1.4.1 OGS internal components supplied by the Manufacturer for attachment to the precast concrete vessel shall be pre-fabricated, bolted to the precast and watertight sealed to the precast vessel surface prior to site delivery to ensure Manufacturer’s internal assembly process and quality control processes are fully adhered to, and to prevent materials damage on site.

1.4.2 Follow all instructions including the sequence for installation in the shop drawings during installation.

PART 2 – PRODUCTS

2.1 <u>GENERAL</u>

2.1.1 The OGS vessel shall be cylindrical and constructed from precast concrete riser and slab components.

2.1.2 The precast concrete OGS internal components shall include a fiberglass insert bolted and watertight sealed inside the precast concrete vessel, prior to site delivery. Primary internal components that are to be anchored and watertight sealed to the precast concrete vessel shall be done so only by the Manufacturer prior to arrival at the job site to ensure product quality.

2.1.3 The OGS shall be allowed to be specified and have the ability to function as a 240-degree bend structure in the stormwater drainage system, or as a junction structure.

2.1.4 The OGS to be specified shall have the capability to accept influent flow from an inlet grate and an inlet pipe.

2.2 <u>PRECAST CONCRETE SECTIONS</u>

All precast concrete components shall be designed and manufactured to meet highway loading conditions per State/Provincial or local requirements.

2.3 <u>GASKETS</u>

Only profile neoprene or nitrile rubber gaskets that are oil resistant shall be accepted. For Canadian projects only, gaskets shall be in accordance to CSA A257.4-14. Mastic sealants, butyl tape/rope or Conseal CS-101 alone are not acceptable gasket materials.

2.4 <u>JOINTS</u>

The concrete joints shall be watertight and meet the design criteria according to ASTM C-990. For projects where joints require gaskets, the concrete joints shall be watertight and oil resistant and meet the design criteria according to ASTM C-443. Mastic sealants or butyl tape/rope alone are not an acceptable alternative.

2.5 <u>FRAMES AND COVERS</u>

Frames and covers shall be manufactured in accordance with State/Provincial or local requirements for inspection and maintenance access purposes. A minimum of one cover, at least 22-inch (560 mm) in diameter, shall be clearly embossed with the OGS manufacturer's product name to properly identify this asset's purpose is for stormwater quality treatment.

2.6 <u>PRECAST CONCRETE</u>

All precast concrete components shall conform to the appropriate CSA or ASTM specifications.

2.7 <u>FIBERGLASS</u>

The fiberglass portion of the OGS device shall be constructed in accordance with ASTM D2563, and in accordance with the PS15-69 manufacturing standard, and shall only be installed, bolted and watertight sealed to the precast concrete by the Manufacturer prior to arrival at the project site to ensure product quality.

2.8 OGS POLLUTANT STORAGE

The OGS device shall include a sump for sediment storage, and a fiberglass insert for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants. The total sediment storage capacity shall be a minimum 40 ft^3 (1.1 m^3). The total petroleum hydrocarbon storage capacity shall be a minimum 50 gallons (189 liters). The access opening to the sump of the OGS device for periodic inspection and maintenance purposes shall be a minimum 16 inches (406 mm) in diameter.

2.9 LADDERS

Ladder rungs shall be provided upon request or to comply with State/Provincial or local requirements.

2.10 INSPECTION

All precast concrete sections shall be level and inspected to ensure dimensions, appearance, integrity of internal components, and quality of the product meets State/Provincial or local specifications and associated standards.

PART 3 – PERFORMANCE & DESIGN

3.1 GENERAL

The OGS stormwater quality treatment device shall be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV). The OGS stormwater quality treatment device shall remove oil, sediment and gross pollutants from stormwater runoff during frequent wet weather events, and retain these pollutants during less frequent high flow wet weather events below the insert within the OGS for later removal during maintenance. The Manufacturer shall have at least ten (10) years of local experience, history and success in engineering design, manufacturing and production and supply of OGS stormwater quality treatment device systems, acceptable to the Engineer of Record.

3.2 HYDROLOGY AND RUNOFF VOLUME

The OGS device shall be engineered, designed and sized to treat a minimum of 90 percent of the average annual runoff volume, unless otherwise stated by the Engineer of Record, using historical rainfall data. Rainfall data sets should be comprised of a minimum 15-years of rainfall data or a longer continuous period if available for a given location, but in all cases a minimum 5-year period of rainfall data.

3.3 ANNUAL (TSS) SEDIMIMENT LOAD AND STORAGE CAPACITY

The OGS device shall be capable of removing and have sufficient storage capacity for the calculated annual total suspended solids (TSS) mass load and volume without scouring previously captured pollutants prior to maintenance being required. The annual (TSS) sediment load and volume transported from the drainage area should be calculated and compared to the OGS device's available storage capacity by the specifying Engineer to ensure adequate capacity between maintenance cycles. Sediment loadings shall be determined by land use and defined as a minimum of 450 kg (992 lb) of sediment (TSS) per impervious hectare of drainage area per year, or greater based on land use, as noted in Table 1 below.

Annual sediment volume calculations shall be performed using the projected average annual treated runoff volume, a typical sediment bulk density of 1602 kg/m^3 (100 lbs/ft^3) and an assumed Event Mean Concentration (EMC) of 125 mg/L TSS in the runoff, or as otherwise determined by the Engineer of Record.

Example calculation for a 1.3-hectares parking lot site:

- 1.28 meters of rainfall depth, per year

- 1.3 hectares of 100% impervious drainage area
- EMC of 125 mg/L TSS in runoff
- Treatment of 90% of the average annual runoff volume
- Target average annual TSS removal rate of 60% by OGS

Annual Runoff Volume:

- 1.28 m rain depth x 1.3 ha x 10,000 m^2/ha= 16,640 m^3 of runoff volume
- 16,640 m^3 x 1000 L/m^3 = 16,640,000 L of runoff volume
- 16,640,000 L x 0.90 = 14,976,000 L to be treated by OGS unit

Annual Sediment Mass and Sediment Volume Load Calculation:

- 14,976,000 L x 125 mg/L x kg/1,000,000 mg = 1,872 kg annual sediment mass
- 1,872 kg x m^3/1602 kg = 1.17 m^3 annual sediment volume
- 1.17 m^3 x 60% TSS removal rate by OGS = 0.70 m^3 minimum expected annual storage requirement in OGS

As a guideline, the U.S. EPA has determined typical annual sediment loads per drainage area for various sites by land use (see Table 1). Certain States, Provinces and local jurisdictions have also established such guidelines.

Table 1 – Annual Mass Sediment Loading by Land Use

	Commercial	Parking Lot	Residential			Highways	Industrial	Shopping Center
			High	Med.	Low			
(lbs/acre/yr)	1,000	400	420	250	10	880	500	440
(kg/hectare/yr)	1,124	450	472	281	11	989	562	494

Source: U.S. EPA Stormwater Best Management Practice Design Guide Volume 1, Appendix D, Table D-1, Burton and Pitt 2002

3.4 SIZING METHODOLOGY

The OGS device shall be engineered, designed and sized to provide stormwater quality treatment based on treating a minimum of 90 percent of the average annual runoff volume and a minimum removal of an annual average 60% of the sediment (TSS) load based on the Particle Size Distribution (PSD) specified in Table 2, Section 3.5, and based on third-party performance testing conducted in accordance with the Canadian Environmental Technology Verification (ETV) Program's **Procedure for Laboratory Testing of Oil-Grit Separators**. Sizing shall be determined using historical rainfall data (as specified in Section 3.2) and a sediment removal performance curve derived from the actual third-party verified laboratory testing data. The OGS device shall also have sufficient annual sediment storage capacity as specified and calculated in Section 3.3.

3.4.1 The Peclet Number is not an approved method or model for calculating TSS removal, sizing, or scaling OGS devices.

3.4.2 If an alternate OGS device is proposed, supporting documentation shall be submitted that demonstrates:

- Canadian ETV or ISO 14034 ETV Verification Statement which verifies third-party performance testing conducted in accordance with the **Procedure for Laboratory Testing of Oil-Grit Separators**
- Equal or better sediment (TSS) removal of the PSD specified in Table 2 at equivalent surface loading rates, as compared to the OGS device specified herein.
- Equal or greater sediment storage capacity, as compared to the OGS device specified herein.
- Supporting documentation shall be signed and sealed by a local registered Professional Engineer. All costs associated with preparing and certifying this documentation shall be born solely by the Contractor.

3.5 PARTICLE SIZE DISTRIBUTION (PSD) FOR SIZING

The OGS device shall be sized to achieve the Engineer-specified average annual percent sediment (TSS) removal based solely on the test sediment used in the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.** This test sediment is comprised of inorganic ground silica with a specific gravity of 2.65, uniformly mixed, and containing a broad range of particle sizes as specified in Table 2. No alternative PSDs or deviations from Table 2 shall be accepted.

Table 2
Canadian ETV Program Procedure for Laboratory Testing of Oil-Grit Separators
Particle Size Distribution (PSD) of Test Sediment

Particle Diameter (Microns)	% by Mass of All Particles	Specific Gravity
1000	5%	2.65
500	5%	2.65
250	15%	2.65
150	15%	2.65
100	10%	2.65
75	5%	2.65
50	10%	2.65
20	15%	2.65
8	10%	2.65
5	5%	2.65
2	5%	2.65

3.6 CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of third-party scour testing conducted in accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators**. This scour testing is conducted with the device pre-loaded with test sediment comprised of the particle size distribution (PSD) illustrated in Table 2.

3.6.1 To be acceptable for on-line installation, the OGS device must demonstrate an average scour test effluent concentration less than 10 mg/L at each surface loading rate tested, up to and including 2600 L/min/m^2.

Data generated from laboratory scour testing performed with an OGS device pre-loaded with a coarser PSD than in Table 2 (i.e. the coarser PSD has no particles in the 1-micron to 50-micron size range, or the D_{50} of the test sediment exceeds 75 microns) shall not be acceptable for the determination of the device's suitability for on-line installation.

3.7 DESIGN ACCOUNTING FOR BYPASS

3.7.1 The OGS device shall be specified to achieve the TSS removal performance and water quality objectives without washout of previously captured pollutants. The OGS device shall also have sufficient hydraulic conveyance capacity to convey the peak storm event, in accordance with hydraulic conditions per the Engineer of Record. To ensure this is achieved, there are two design options with associated requirements:

3.7.1.1 The OGS device shall be placed **off-line** with an upstream diversion structure (typically in an upstream manhole) that only allows the water quality volume to be diverted to the OGS device, and excessive flows diverted downstream around the OGS device to prevent high flow washout of pollutants previously captured. This design typically incorporates a triangular layout including an upstream bypass manhole with an appropriately engineered weir wall, the OGS device, and a downstream junction manhole, which is connected to both the OGS device and bypass structure. In this case with an external bypass required, the OGS device manufacturer must provide calculations and designs for all structures, piping and any other required material applicable to the proper functioning of the system, stamped by a Professional Engineer.

3.7.1.2 Alternatively, OGS devices in compliance with Section 3.6 shall be acceptable for an **on-line** design configuration, thereby eliminating the requirement for an upstream bypass manhole and downstream junction manhole.

3.7.2 The OGS device shall also have sufficient hydraulic conveyance capacity to convey the peak storm event, in accordance with hydraulic conditions per the Engineer of Record. If an alternate OGS device is proposed, supporting documentation shall be submitted that demonstrates equal or better hydraulic conveyance capacity as compared to the OGS device specified herein. This documentation shall be signed and sealed by a local registered Professional Engineer. All costs associated with preparing and certifying this documentation shall be born solely by the Contractor.

3.8 PETROLEUM HYDROCARBONS AND FLOATABLES STORAGE CAPACITY

Petroleum hydrocarbons and floatables storage capacity in the OGS device shall be a minimum 50 gallons (189 Liters), or more as specified.

3.8.1 The OGS device shall have gasketed precast concrete joints that are watertight, and oil resistant and meet the design criteria according to ASTM C-443 to provide safe oil and other hydrocarbon materials storage and ground water protection. Mastic sealants or butyl tape/rope alone are not an acceptable alternative.

3.9 SURFACE LOADING RATE SCALING OF DIFFERENT MODEL SIZES

The reference device for scaling shall be an OGS device that has been third-party tested in accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators**. Other model sizes of the tested device shall only be scaled such that the claimed TSS removal efficiency of the scaled device shall be no greater than the TSS removal efficiency of the tested device at identical **surface loading rates** (flow rate divided by settling surface area). The depth of other model sizes of the tested device shall be scaled in accordance with the depth scaling provisions within Section 6.0 of the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators**.

3.9.1 The Peclet Number and volumetric scaling are not approved methods for scaling OGS devices.

PART 4 – INSPECTION & MAINTENANCE

The OGS manufacturer shall provide an Owner's Manual upon request.

4.1 A Quality Assurance Plan that provides inspection and maintenance for a minimum of 5 years shall be included with the OGS stormwater quality device, and written into the Environmental Compliance Approval (ECA) or the appropriate State/Provincial or local approval document.

4.2 OGS device inspection shall include determination of sediment depth and presence of petroleum hydrocarbons and floatables below the insert. Inspection shall be easily conducted from finished grade through a Frame and Cover of at least 22 inch (560 mm) in diameter.

4.3 Inspection and pollutant removal from below the OGS's insert shall be conducted as a periodic maintenance practice using a standard maintenance truck and vacuum apparatus, and shall be easily conducted from finished grade through a Frame and Cover of at least 22-inches (560 mm) in diameter, and through an access opening to the OGS device's sump with a minimum 16-inches diameter (406 mm).

4.4 No confined space for sediment removal or inspection of internal components shall be required for normal operation, annual inspection or maintenance activity.

PART 5 – EXECUTION

5.1 PRECAST CONCRETE INSTALLATION

The installation of the precast concrete OGS stormwater quality treatment device shall conform to ASTM C 891, ASTM C 478, ASTM C 443, CAN/CSA-A257.4-14, CAN/CSA-A257.4-14, CAN/CSA-S6-00 and all highway, State/Provincial, or local specifications for the construction of manholes. Selected sections of a general specification that are applicable are summarized below. The Contractor shall furnish all labor, equipment and materials necessary to offload, assemble as needed the OGS internal components as specified in the Shop Drawings.

5.2 EXCAVATION

5.2.1 Excavation for the installation of the OGS stormwater quality treatment device shall conform to highway, State/Provincial or local specifications. Topsoil that is removed during the excavation for the OGS stormwater quality treatment device shall be stockpiled in designated areas and not be mixed with subsoil or other materials. Topsoil stockpiles and the general site preparation for the installation of the OGS stormwater quality device shall conform to highway, State/Provincial or local specifications.

5.2.2 The OGS device shall not be installed on frozen ground. Excavation shall extend a minimum of 12 inch (300 mm) from the precast concrete surfaces plus an allowance for shoring and bracing where required. If the bottom of the excavation provides an unsuitable foundation additional excavation may be required.

5.2.3 In areas with a high water table, continuous dewatering shall be provided to ensure that the excavation is stable and free of water.

5.3 BACKFILLING

Backfill material shall conform to highway, State/Provincial or local specifications. Backfill material shall be placed in uniform layers not exceeding 12 inches (300 mm) in depth and compacted to highway, State/Provincial or local specifications.

5.4 OGS WATER QUALITY DEVICE CONSTRUCTION SEQUENCE

5.4.1 The precast concrete OGS stormwater quality treatment device is installed and leveled in sections in the following sequence:

- aggregate base
- base slab, or base
- riser section(s) (if required)
- riser section w/ pre-installed fiberglass insert
- upper riser section(s)
- internal OGS device components
- connect inlet and outlet pipes
- riser section, top slab and/or transition (if required)
- frame and access cover

5.4.2 The precast concrete base shall be placed level at the specified grade. The entire base shall be in contact with the underlying compacted granular material. Subsequent sections, complete with oil resistant, watertight joint seals, shall be installed in accordance with the precast concrete manufacturer’s recommendations.

5.4.3 Adjustment of the OGS stormwater quality treatment device can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections.

Stormceptor

FORTERRA

Detailed Stormceptor Sizing Report – West Bank

Project Information & Location			
Project Name	Third Crossing - West Bank	**Project Number**	27143
City	Kingston	**State/ Province**	Ontario
Country	Canada	**Date**	8/2/2016
Designer Information		**EOR Information (optional)**	
Name	Bobby Pettigrew	**Name**	
Company	J.L. Richards	**Company**	
Phone #	613-728-3571	**Phone #**	
Email	bpettigrew@jlrichards.ca	**Email**	

Stormwater Treatment Recommendation

The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	West Bank
Recommended Stormceptor Model	OSR 2000
Target TSS Removal (%)	80.0
TSS Removal (%) Provided	80
PSD	Roads/Hardstand
Rainfall Station	KINGSTON PUMPING STATION

The recommended Stormceptor model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

Stormceptor Sizing Summary	
OSR Model	**% TSS Removal Provided**
OSR 300	62
OSR 750	74
OSR 2000	80
OSR 4000	85
OSR 6000	87
OSR 9000	90
OSR 14000	92
Stormceptor MAX	Custom

Stormceptor

The Stormceptor oil and sediment separator is sized to treat stormwater runoff by removing pollutants through gravity separation and flotation. Stormceptor's patented design generates positive TSS removal for each rainfall event, including large storms. Significant levels of pollutants such as heavy metals, free oils and nutrients are prevented from entering natural water resources and the re-suspension of previously captured sediment (scour) does not occur.
Stormceptor provides a high level of TSS removal for small frequent storm events that represent the majority of annual rainfall volume and pollutant load. Positive treatment continues for large infrequent events, however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

Design Methodology

Stormceptor is sized using PCSWMM for Stormceptor, a continuous simulation model based on US EPA SWMM. The program calculates hydrology using local historical rainfall data and specified site parameters. With US EPA SWMM's precision, every Stormceptor unit is designed to achieve a defined water quality objective. The TSS removal data presented follows US EPA guidelines to reduce the average annual TSS load. The Stormceptor's unit process for TSS removal is settling. The settling model calculates TSS removal by analyzing:

- Site parameters
- Continuous historical rainfall data, including duration, distribution, peaks & inter-event dry periods
- Particle size distribution, and associated settling velocities (Stokes Law, corrected for drag)
- TSS load
- Detention time of the system

Hydrology Analysis

PCSWMM for Stormceptor calculates annual hydrology with the US EPA SWMM and local continuous historical rainfall data. Performance calculations of Stormceptor are based on the average annual removal of TSS for the selected site parameters. The Stormceptor is engineered to capture sediment particles by treating the required average annual runoff volume, ensuring positive removal efficiency is maintained during each rainfall event, and preventing negative removal efficiency (scour).
Smaller recurring storms account for the majority of rainfall events and average annual runoff volume, as observed in the historical rainfall data analyses presented in this section.

Rainfall Station

State/Province	Ontario	**Total Number of Rainfall Events**	5285
Rainfall Station Name	KINGSTON PUMPING STATION	**Total Rainfall (mm)**	22574.7
Station ID #	4175	**Average Annual Rainfall (mm)**	513.1
Coordinates	44°14'N, 76°29'W	**Total Evaporation (mm)**	1505.2
Elevation (ft)	251	**Total Infiltration (mm)**	7626.1
Years of Rainfall Data	44	**Total Rainfall that is Runoff**	13443.4

Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
- For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

Stormceptor FORTERRA

Drainage Area	
Total Area (ha)	3.84
Imperviousness %	66.2

Up Stream Storage	
Storage (ha-m)	Discharge (cms)
0.000	0.000

Water Quality Objective	
TSS Removal (%)	80.0
Runoff Volume Capture (%)	
Oil Spill Capture Volume (L)	
Peak Conveyed Flow Rate (L/s)	440.00
Water Quality Flow Rate (L/s)	

Up Stream Flow Diversion	
Max. Flow to Stormceptor (cms)	

Design Details	
Stormceptor Inlet Invert Elev (m)	77.50
Stormceptor Outlet Invert Elev (m)	76.90
Stormceptor Rim Elev (m)	78.50
Normal Water Level Elevation (m)	76.90
Pipe Diameter (mm)	750
Pipe Material	RCP - concrete
Multiple Inlets (Y/N)	Yes
Grate Inlet (Y/N)	No

Particle Size Distribution (PSD)

Removing the smallest fraction of particulates from runoff ensures the majority of pollutants, such as metals, hydrocarbons and nutrients are captured. The table below identifies the Particle Size Distribution (PSD) that was selected to define TSS removal for the Stormceptor design.

Roads/Hardstand		
Particle Diameter (microns)	Distribution %	Specific Gravity
0.2	0.1	2.65
22.6	9.9	2.65
99.9	40.0	2.65
340.7	40.0	2.65
1000.0	9.9	2.65
2000.0	0.1	2.65

Site Name	West Bank

Site Details

Drainage Area	
Total Area (ha)	3.84
Imperviousness %	66.2

Surface Characteristics	
Width (m)	392.00
Slope %	2
Impervious Depression Storage (mm)	0.508
Pervious Depression Storage (mm)	5.08
Impervious Manning's n	0.015
Pervious Manning's n	0.25

Maintenance Frequency	
Maintenance Frequency (months) >	12

Infiltration Parameters	
Horton's equation is used to estimate infiltration	
Max. Infiltration Rate (mm/hr)	61.98
Min. Infiltration Rate (mm/hr)	10.16
Decay Rate (1/sec)	0.00055
Regeneration Rate (1/sec)	0.01

Evaporation	
Daily Evaporation Rate (mm/day)	2.54

Dry Weather Flow	
Dry Weather Flow (lps)	0

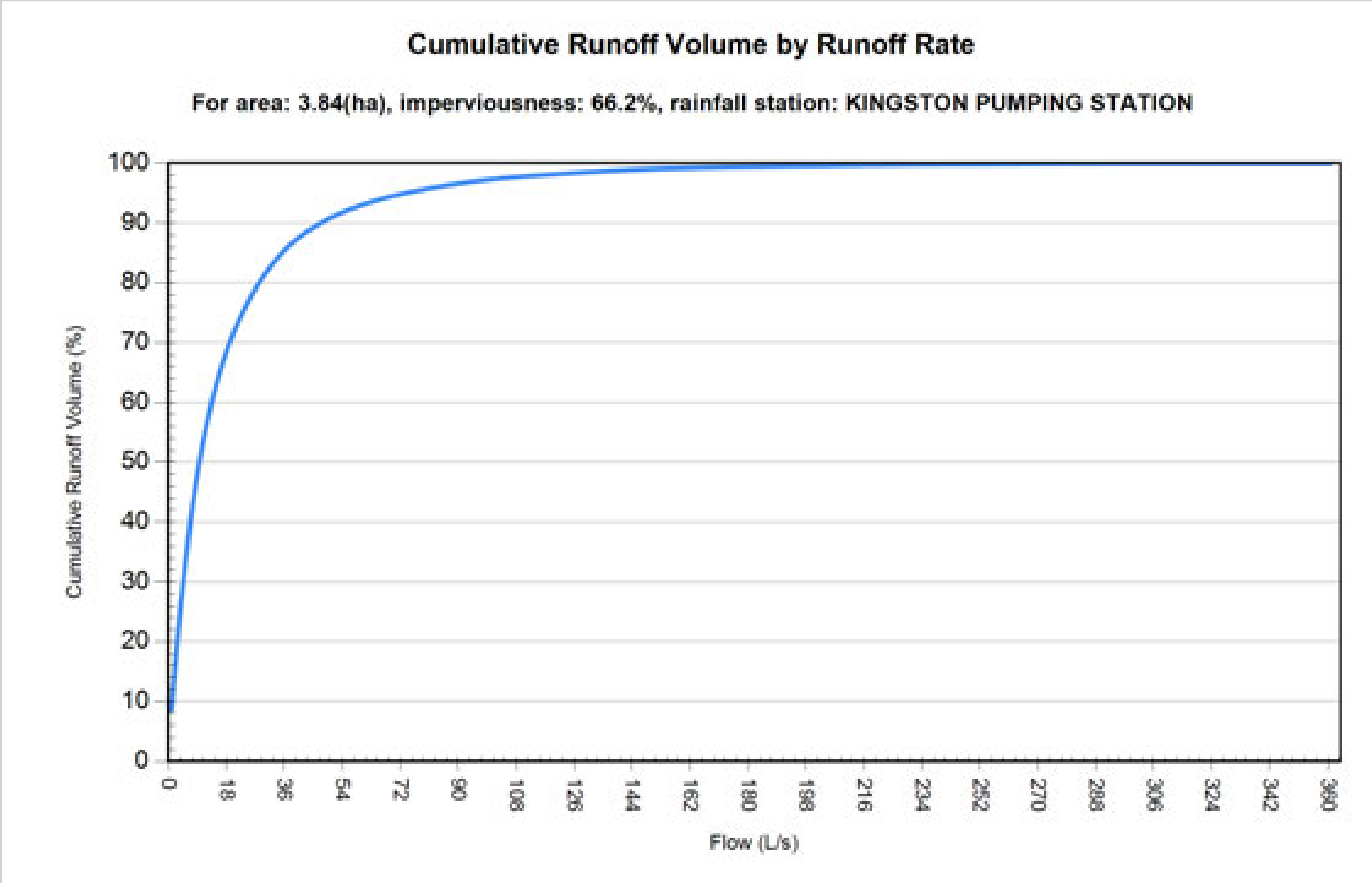
Winter Months	
Winter Infiltration	0

TSS Loading Parameters	
TSS Loading Function	

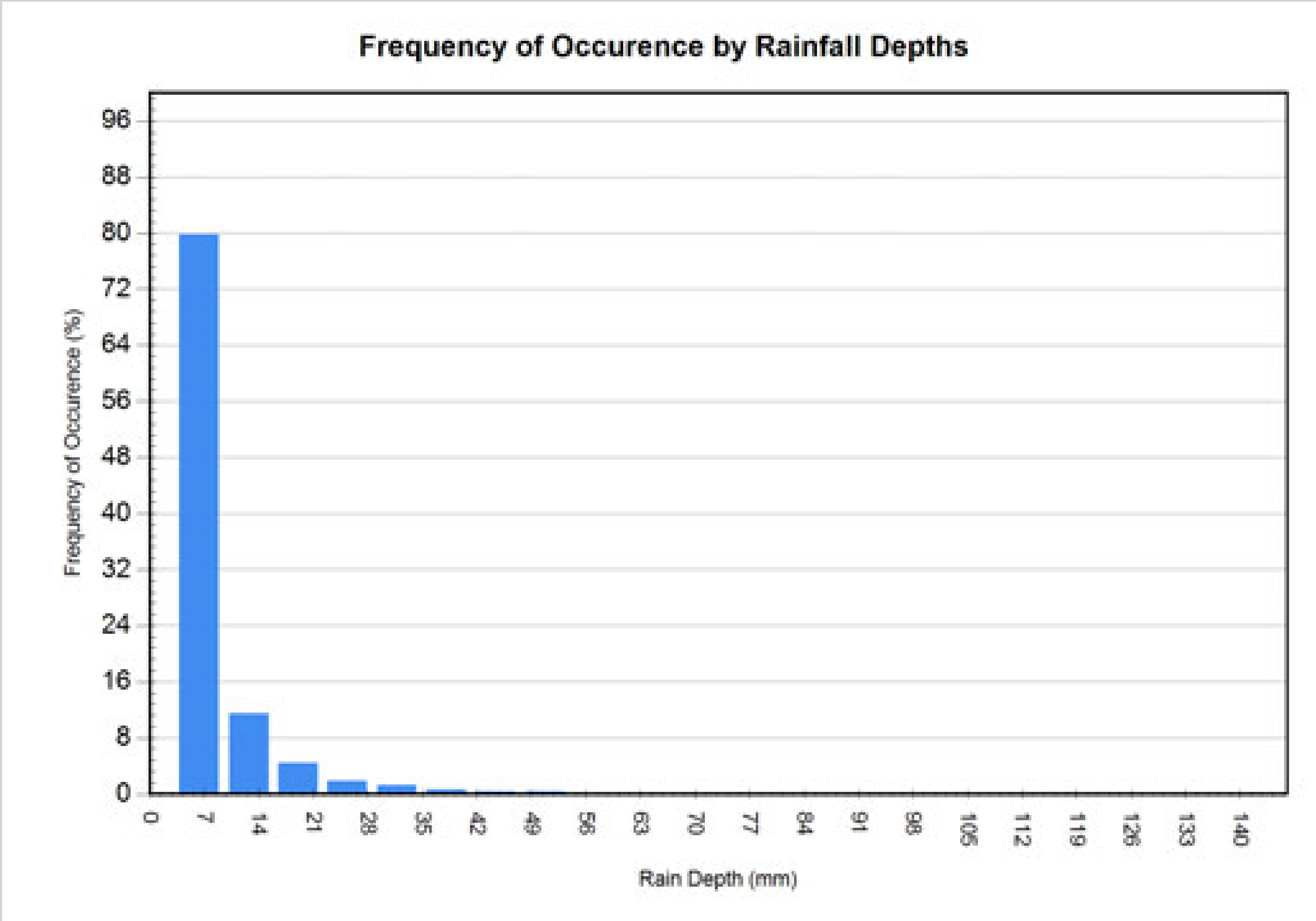
Buildup/Wash-off Parameters	
Target Event Mean Conc. (EMC) mg/L	
Exponential Buildup Power	
Exponential Washoff Exponent	

TSS Availability Parameters	
Availability Constant A	
Availability Factor B	
Availability Exponent C	
Min. Particle Size Affected by Availability (micron)	

Cumulative Runoff Volume by Runoff Rate			
Runoff Rate (L/s)	Runoff Volume (m³)	Volume Over (m³)	Cumulative Runoff Volume (%)
1	44.855	474.191	8.6
4	139.603	379.446	26.9
9	249.845	269.347	48.1
16	337.779	181.26	65.1
25	400.188	118.816	77.1
36	443.008	76.072	85.4
49	469.969	49.041	90.5
64	486.425	32.603	93.7
81	497.39	21.633	95.8
100	504.816	14.219	97.3
121	509.788	9.238	98.2
144	513.277	5.752	98.9
169	515.351	3.676	99.3
196	516.591	2.438	99.5
225	517.412	1.616	99.7
256	517.995	1.033	99.8
289	518.369	0.658	99.9
324	518.604	0.424	99.9
361	518.747	0.281	99.9


Cumulative Runoff Volume by Runoff Rate
For area: 3.84(ha), imperviousness: 66.2%, rainfall station: KINGSTON PUMPING STATION
Cumulative Runoff Volume (%)
0
10
20
30
40
50
60
70
80
90
100
0
18
36
54
72
90
108
126
144
162
180
198
216
234
252
270
288
306
324
342
360
Flow (L/s)

Rainfall Event Analysis				
Rainfall Depth (mm)	No. of Events	Percentage of Total Events (%)	Total Volume (mm)	Percentage of Annual Volume (%)
6.35	4215	79.8	6465	28.6
12.70	603	11.4	5520	24.5
19.05	234	4.4	3602	16.0
25.40	100	1.9	2240	9.9
31.75	63	1.2	1775	7.9
38.10	31	0.6	1085	4.8
44.45	16	0.3	642	2.8
50.80	15	0.3	692	3.1
57.15	3	0.1	161	0.7
63.50	1	0.0	58	0.3
69.85	2	0.0	132	0.6
76.20	0	0.0	0	0.0
82.55	1	0.0	78	0.3
88.90	0	0.0	0	0.0
95.25	0	0.0	0	0.0
101.60	0	0.0	0	0.0
107.95	0	0.0	0	0.0
114.30	0	0.0	0	0.0
120.65	0	0.0	0	0.0
127.00	1	0.0	124	0.5
133.35	0	0.0	0	0.0
139.70	0	0.0	0	0.0



For Stormceptor Specifications and Drawings Please Visit:
http://www.imbriumsystems.com/technical-specifications

Stormceptor

FORTERRA

Detailed Stormceptor Sizing Report – East Bank

Project Information & Location			
Project Name	Third Crossing - East Bank	**Project Number**	27143
City	Kingston	**State/ Province**	Ontario
Country	Canada	**Date**	8/2/2016
Designer Information		**EOR Information (optional)**	
Name	Bobby Pettigrew	**Name**	
Company	J.L. Richards	**Company**	
Phone #	613-728-3571	**Phone #**	
Email	bpettigrew@jlrichards.ca	**Email**	

Stormwater Treatment Recommendation

The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	East Bank
Recommended Stormceptor Model	STC 2000
Target TSS Removal (%)	80.0
TSS Removal (%) Provided	80
PSD	Roads/Hardstand
Rainfall Station	KINGSTON PUMPING STATION

The recommended Stormceptor model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

Stormceptor Sizing Summary	
Stormceptor Model	**% TSS Removal Provided**
STC 300	60
STC 750	74
STC 1000	75
STC 1500	76
STC 2000	80
STC 3000	81
STC 4000	85
STC 5000	86
STC 6000	88
STC 9000	91
STC 10000	91
STC 14000	93
Stormceptor MAX	Custom

Stormceptor

The Stormceptor oil and sediment separator is sized to treat stormwater runoff by removing pollutants through gravity separation and flotation. Stormceptor's patented design generates positive TSS removal for each rainfall event, including large storms. Significant levels of pollutants such as heavy metals, free oils and nutrients are prevented from entering natural water resources and the re-suspension of previously captured sediment (scour) does not occur.
Stormceptor provides a high level of TSS removal for small frequent storm events that represent the majority of annual rainfall volume and pollutant load. Positive treatment continues for large infrequent events, however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

Design Methodology

Stormceptor is sized using PCSWMM for Stormceptor, a continuous simulation model based on US EPA SWMM. The program calculates hydrology using local historical rainfall data and specified site parameters. With US EPA SWMM's precision, every Stormceptor unit is designed to achieve a defined water quality objective. The TSS removal data presented follows US EPA guidelines to reduce the average annual TSS load. The Stormceptor's unit process for TSS removal is settling. The settling model calculates TSS removal by analyzing:

- Site parameters
- Continuous historical rainfall data, including duration, distribution, peaks & inter-event dry periods
- Particle size distribution, and associated settling velocities (Stokes Law, corrected for drag)
- TSS load
- Detention time of the system

Hydrology Analysis

PCSWMM for Stormceptor calculates annual hydrology with the US EPA SWMM and local continuous historical rainfall data. Performance calculations of Stormceptor are based on the average annual removal of TSS for the selected site parameters. The Stormceptor is engineered to capture sediment particles by treating the required average annual runoff volume, ensuring positive removal efficiency is maintained during each rainfall event, and preventing negative removal efficiency (scour).
Smaller recurring storms account for the majority of rainfall events and average annual runoff volume, as observed in the historical rainfall data analyses presented in this section.

Rainfall Station

State/Province	Ontario	**Total Number of Rainfall Events**	5285
Rainfall Station Name	KINGSTON PUMPING STATION	**Total Rainfall (mm)**	22574.7
Station ID #	4175	**Average Annual Rainfall (mm)**	513.1
Coordinates	44°14'N, 76°29'W	**Total Evaporation (mm)**	1081.1
Elevation (ft)	251	**Total Infiltration (mm)**	11374.8
Years of Rainfall Data	44	**Total Rainfall that is Runoff**	10118.8

Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
- For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

Stormceptor FORTERRA

Drainage Area	
Total Area (ha)	3.42
Imperviousness %	49.6

Up Stream Storage	
Storage (ha-m)	Discharge (cms)
0.000	0.000

Water Quality Objective	
TSS Removal (%)	80.0
Runoff Volume Capture (%)	
Oil Spill Capture Volume (L)	
Peak Conveyed Flow Rate (L/s)	370.00
Water Quality Flow Rate (L/s)	

Up Stream Flow Diversion	
Max. Flow to Stormceptor (cms)	

Design Details	
Stormceptor Inlet Invert Elev (m)	77.50
Stormceptor Outlet Invert Elev (m)	76.90
Stormceptor Rim Elev (m)	78.00
Normal Water Level Elevation (m)	76.90
Pipe Diameter (mm)	750
Pipe Material	RCP - concrete
Multiple Inlets (Y/N)	Yes
Grate Inlet (Y/N)	No

Particle Size Distribution (PSD)

Removing the smallest fraction of particulates from runoff ensures the majority of pollutants, such as metals, hydrocarbons and nutrients are captured. The table below identifies the Particle Size Distribution (PSD) that was selected to define TSS removal for the Stormceptor design.

Roads/Hardstand		
Particle Diameter (microns)	Distribution %	Specific Gravity
0.2	0.1	2.65
22.6	9.9	2.65
99.9	40.0	2.65
340.7	40.0	2.65
1000.0	9.9	2.65
2000.0	0.1	2.65

Stormceptor

FORTERRA

Site Name	East Bank

Site Details

Drainage Area	
Total Area (ha)	3.42
Imperviousness %	49.6

Surface Characteristics	
Width (m)	370.00
Slope %	2
Impervious Depression Storage (mm)	0.508
Pervious Depression Storage (mm)	5.08
Impervious Manning's n	0.015
Pervious Manning's n	0.25

Maintenance Frequency	
Maintenance Frequency (months) >	12

Infiltration Parameters	
Horton's equation is used to estimate infiltration	
Max. Infiltration Rate (mm/hr)	61.98
Min. Infiltration Rate (mm/hr)	10.16
Decay Rate (1/sec)	0.00055
Regeneration Rate (1/sec)	0.01

Evaporation	
Daily Evaporation Rate (mm/day)	2.54

Dry Weather Flow	
Dry Weather Flow (lps)	0

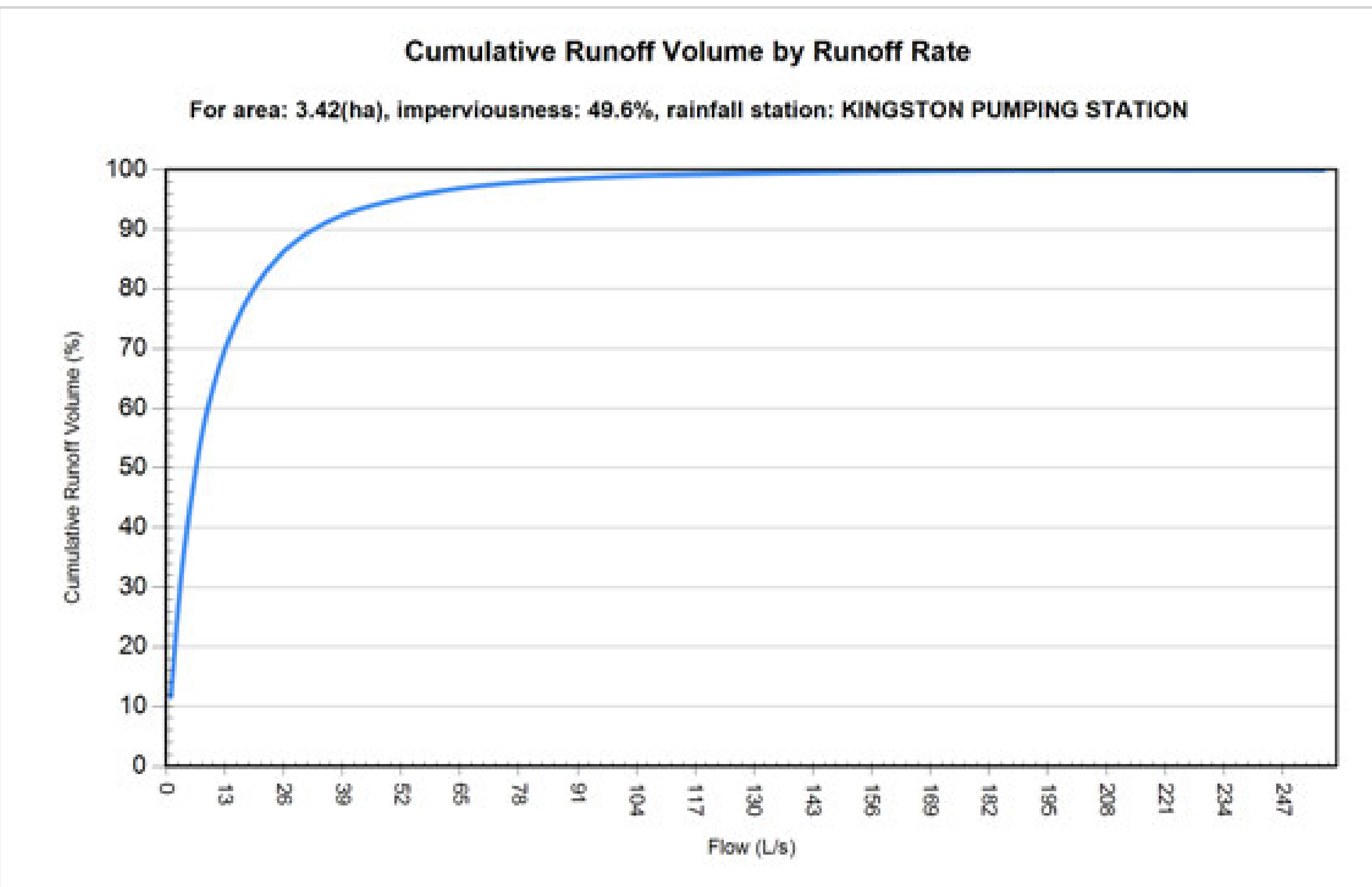
Winter Months	
Winter Infiltration	0

TSS Loading Parameters	
TSS Loading Function	

Buildup/Wash-off Parameters	
Target Event Mean Conc. (EMC) mg/L	
Exponential Buildup Power	
Exponential Washoff Exponent	

TSS Availability Parameters	
Availability Constant A	
Availability Factor B	
Availability Exponent C	
Min. Particle Size Affected by Availability (micron)	

Cumulative Runoff Volume by Runoff Rate			
Runoff Rate (L/s)	Runoff Volume (m³)	Volume Over (m³)	Cumulative Runoff Volume (%)
1	40.34	307.919	11.6
4	125.777	222.489	36.1
9	206.863	141.494	59.4
16	262.394	85.842	75.3
25	297.786	50.485	85.5
36	318.233	30.036	91.4
49	329.86	18.406	94.7
64	337.012	11.255	96.8
81	341.52	6.75	98.1
100	344.387	3.886	98.9
121	345.971	2.301	99.3
144	346.871	1.401	99.6
169	347.451	0.822	99.8
196	347.794	0.478	99.9
225	347.982	0.291	99.9
256	348.097	0.176	99.9



Rainfall Event Analysis				
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101.60	0	0.0	0	0.0
107.95	0	0.0	0	0.0
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120.65	0	0.0	0	0.0
127.00	1	0.0	124	0.5
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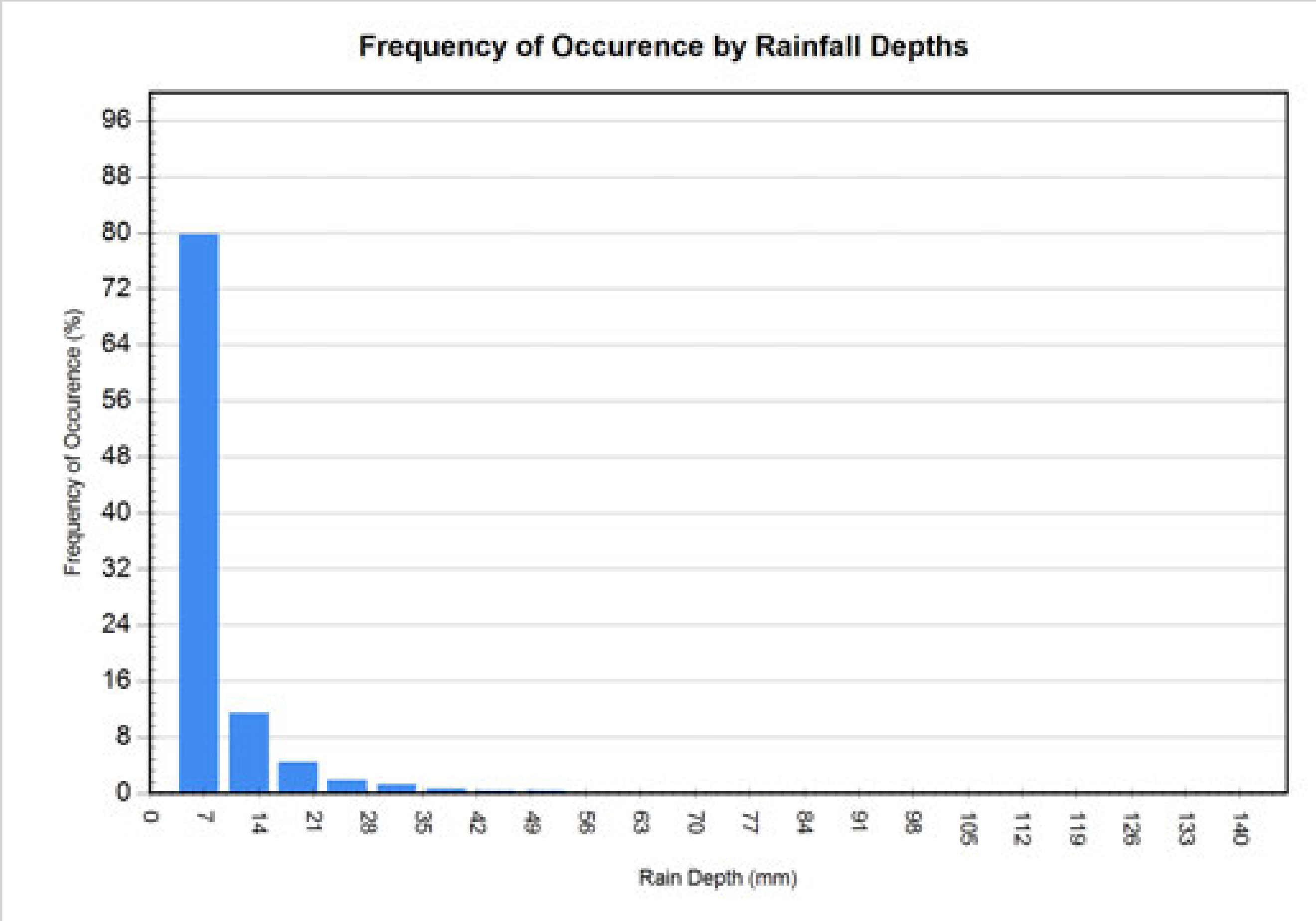
139.70	0	0.0	0	0.0



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Damaged sections and gaskets shall be repaired or replaced as necessary. Once the OGS stormwater quality treatment device has been constructed, any lift holes must be plugged with mortar.

5.5 DROP PIPE AND OIL INSPECTION PIPE

Once the upper precast concrete riser has been attached to the lower precast concrete riser section, the OGS device Drop Pipe and Oil Inspection Pipe must be attached, and watertight sealed to the fiberglass insert using Sikaflex 1a. Installation instructions and required materials shall be provided by the OGS manufacturer.

5.6 INLET AND OUTLET PIPES

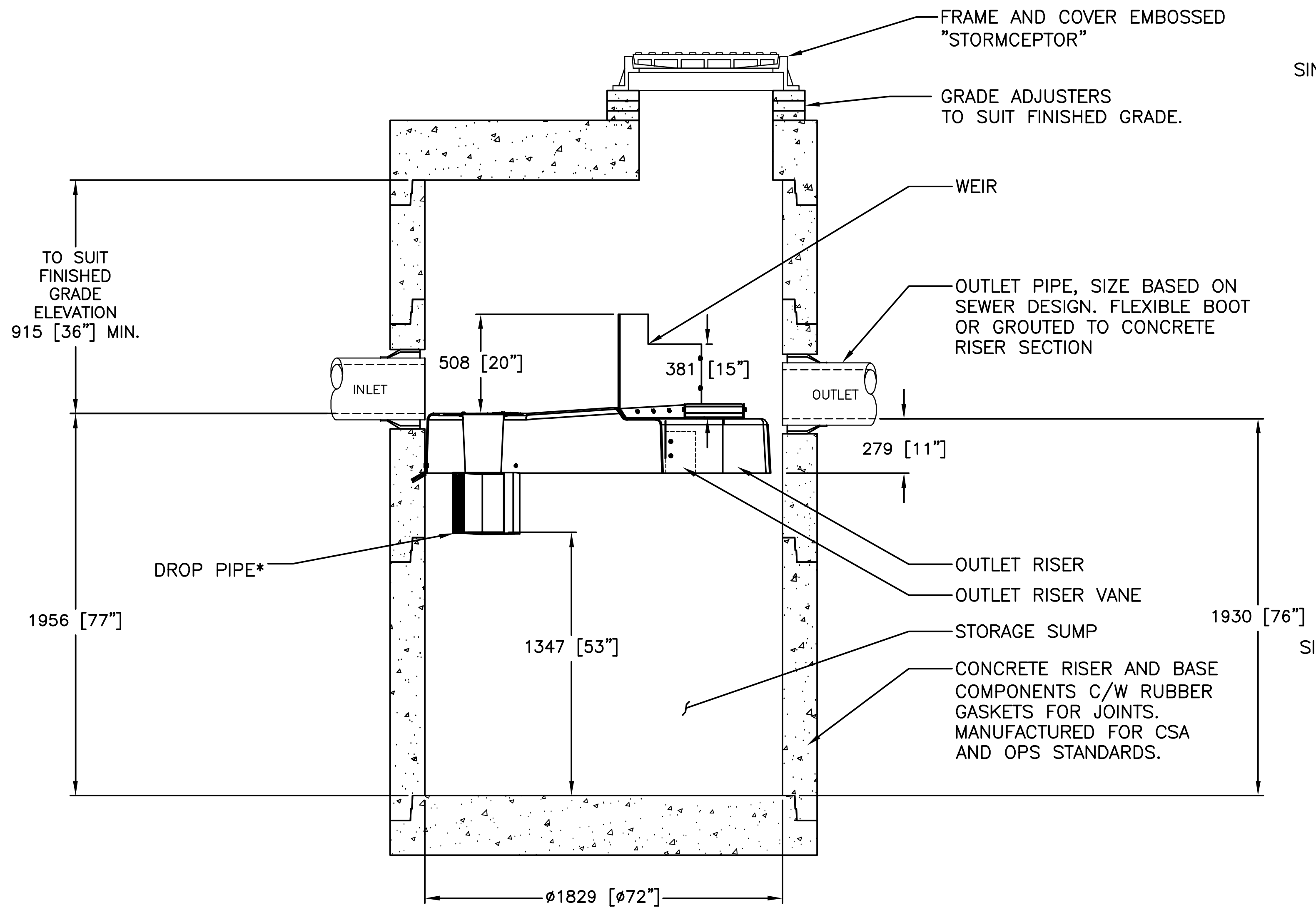
Inlet and outlet pipes shall be securely set using grout or approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight. Non-secure inlets and outlets will result in improper performance.

5.7 FRAME AND COVER OR FRAME AND GRATE INSTALLATION

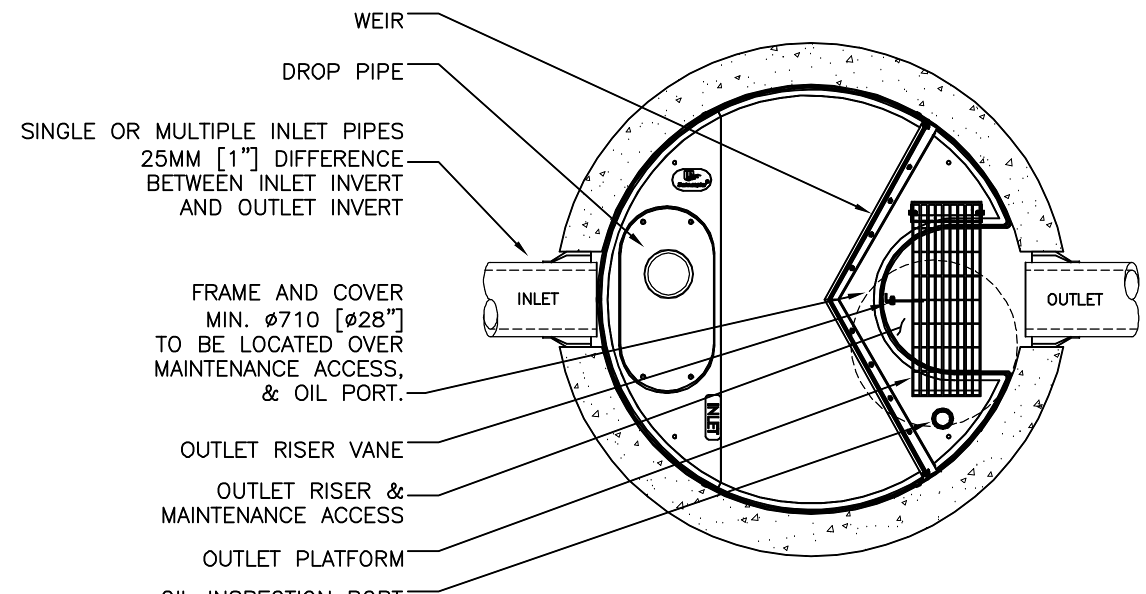
Precast concrete adjustment units shall be installed to set the frame and cover/grate at the required elevation. The adjustment units shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover/grate should be set in a full bed of mortar at the elevation specified.

5.7.1 A minimum of one cover, at least 22-inch (560 mm) in diameter, shall be clearly embossed with the OGS device brand or product name to properly identify this asset’s purpose is for stormwater quality treatment.

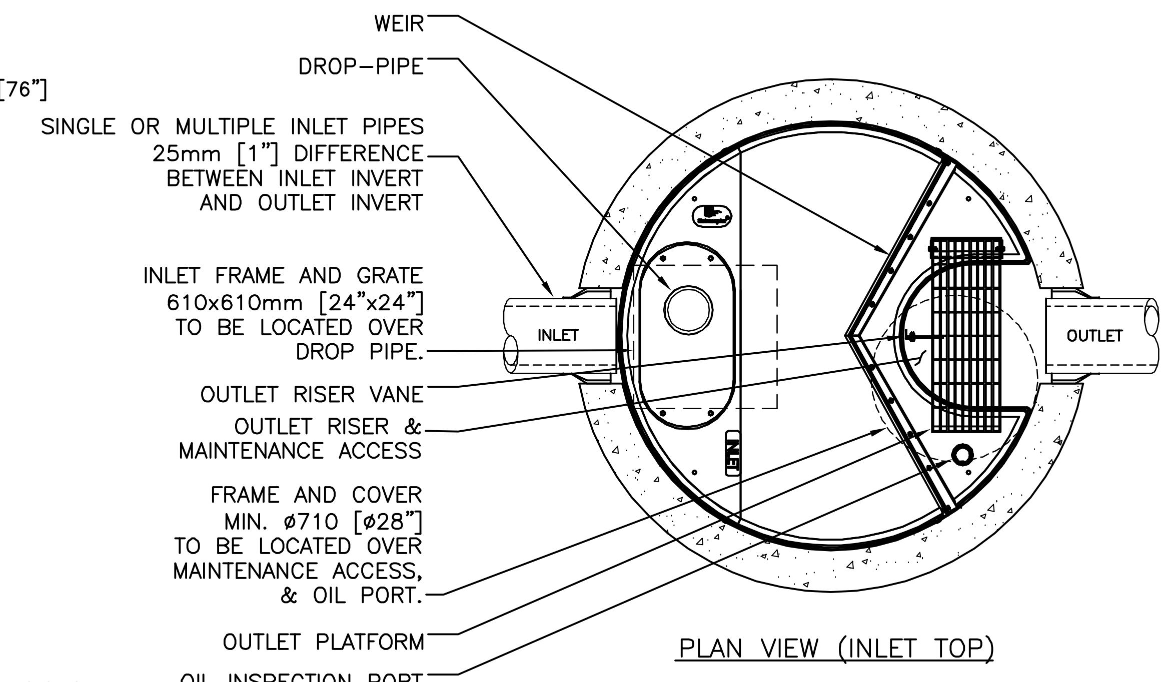
DRAWING NOT TO BE USED FOR CONSTRUCTION



SECTION VIEW



PLAN VIEW (STANDARD)



PLAN VIEW (INLET TOP)

GENERAL NOTES:

* MAXIMUM SURFACE LOADING RATE (SLR) INTO LOWER CHAMBER THROUGH DROP PIPE IS 1135 L/min/m^2 (27.9 gpm/ft^2) FOR STORMCEPTOR EF6 AND 535 L/min/m^2 (13.1 gpm/ft^2) FOR STORMCEPTOR EFO6 (OIL CAPTURE CONFIGURATION).

1. ALL DIMENSIONS INDICATED ARE IN MILLIMETERS (INCHES) UNLESS OTHERWISE SPECIFIED.
2. STORMCEPTOR STRUCTURE INLET AND OUTLET PIPE SIZE AND ORIENTATION SHOWN FOR INFORMATIONAL PURPOSES ONLY.
3. UNLESS OTHERWISE NOTED, BYPASS INFRASTRUCTURE, SUCH AS ALL UPSTREAM DIVERSION STRUCTURES, CONNECTING STRUCTURES, OR PIPE CONDUITS CONNECTING TO COMPLETE THE STORMCEPTOR SYSTEM SHALL BE PROVIDED AND ADDRESSED SEPARATELY.
4. DRAWING FOR INFORMATION PURPOSES ONLY. REFER TO ENGINEER'S SITE/UTILITY PLAN FOR STRUCTURE ORIENTATION.
5. NO PRODUCT SUBSTITUTIONS SHALL BE ACCEPTED UNLESS SUBMITTED 10 DAYS PRIOR TO PROJECT BID DATE, OR AS DIRECTED BY THE ENGINEER OF RECORD.

FOR SITE SPECIFIC DRAWINGS PLEASE CONTACT YOUR LOCAL STORMCEPTOR REPRESENTATIVE. SITE SPECIFIC DRAWINGS ARE BASED ON THE BEST AVAILABLE INFORMATION AT THE TIME. SOME FIELD REVISIONS TO THE SYSTEM LOCATION OR CONNECTION PIPING MAY BE NECESSARY BASED ON AVAILABLE SPACE OR SITE CONFIGURATION REVISIONS. ELEVATIONS SHOULD BE MAINTAINED EXCEPT WHERE NOTED ON BYPASS STRUCTURE (IF REQUIRED).

INSTALLATION NOTES

A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE STRUCTURE (LIFTING CLUTCHES PROVIDED)
C. CONTRACTOR WILL INSTALL AND LEVEL THE STRUCTURE, SEALING THE JOINTS, LINE ENTRY AND EXIT POINTS (NON-SHRINK GROUT WITH APPROVED WATERSTOP OR FLEXIBLE BOOT)
D. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO PROTECT THE DEVICE FROM CONSTRUCTION-RELATED EROSION RUNOFF.
E. DEVICE ACTIVATION, BY CONTRACTOR, SHALL OCCUR ONLY AFTER SITE HAS BEEN STABILIZED AND THE STORMCEPTOR UNIT IS CLEAN AND FREE OF DEBRIS.

STANDARD DETAIL
NOT FOR CONSTRUCTION

SITE SPECIFIC DATA REQUIREMENTS

STORMCEPTOR MODEL	EF6				
STRUCTURE ID					*
WATER QUALITY FLOW RATE (L/s)					*
PEAK FLOW RATE (L/s)					*
RETURN PERIOD OF PEAK FLOW (yrs)					*
DRAINAGE AREA (HA)					*
DRAINAGE AREA IMPERVIOUSNESS (%)					*
PIPE DATA:	I.E.	MAT'L	DIA	SLOPE %	HGL
INLET #1	*	*	*	*	*
INLET #2	*	*	*	*	*
OUTLET	*	*	*	*	*

* PER ENGINEER OF RECORD

MARK	DATE	REVISION DESCRIPTION	BY
0	05/26/17	INITIAL RELEASE	JSK
1	6/8/18	OUTLET PLATFORM	JSK
####	####	####	####
####	####	####	####
####	####	####	####

SCALE = NTS

Stormceptor® EF

imbrium

7937 RIDGE ROAD, SUITE 350, HANOVER, MD 21076

DATE: 5/26/2017
DESIGNED: JSK | DRAWN: JSK
CHECKED: BSF | APPROVED: SP
PROJECT No.: EF6 | SEQUENCE No.: *
SHEET: 1 OF 1

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