## WATERLOO SANITARY MASTER PLAN VOLUME 2

## **APPENDIX G**

TECHNICAL MEMORANDUM #3

#### City-wide Sanitary Servicing Master Plan Update: FINAL Technical Memorandum 3

Task 2: Hydraulic Model Needs Assessment



Prepared for: City of Waterloo

Prepared by: Stantec Consulting Ltd.

#### November 1, 2013

Revision Record								
Revision	Description	Prepared	By	Checked	By	Approved	l By	
1	Initial Draft	NS		DE		AC		
2	Final	NS		DE		AC		

### Sign-off Sheet

This document entitled City-wide Sanitary Servicing Master Plan Update: FINAL Technical Memorandum 3 was prepared by Stantec Consulting Ltd. for the account of City of Waterloo. The material in it reflects Stantec's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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## CITY-WIDE SANITARY SERVICING MASTER PLAN UPDATE: FINAL TECHNICAL MEMORANDUM 3

SOFTWARE EVALUATION November 1, 2013

#### 4.0 SOFTWARE EVALUATION

#### 4.1 AVAILABLE MODEL SOFTWARE

All potential sanitary collection system software alternatives commonly used in the industry were identified and vendors were contacted to obtain the product information necessary to evaluate the software with respect to the needs of the City. Table 1 summarizes the software considered and the associated contact.

**Table 1: Summary of Software Alternatives and Vendor Contacts** 

Vendor	Software	Contact			
Environmental Protection Agency (EPA)	EPASWMM 5	Website: http://www.epa.gov/nrmrl/wswrd/wq/models/swmm/			
XPSolutions	XPSWMM	Neil Vollen Phone: 888-554-5022 Email: neil.vollen@xpsolutions.com			
Computational Hydraulics Int. (CHI)	PCSWMM	Meghan Korman Phone: 519-767-0197 ext. 1001 Email: meghan@chiwater.com			
DHI	MIKE URBAN/MOUSE	Patrick Delaney Phone: ### Email: pad@dhigroup.com			
Bentley	SewerGEMS	Bruce Thomas Phone: 403-221-9370 ext. 817814 Email: Bruce.Thomas@bentley.com			
	InfoWorks CS				
	InfoSewer Pro	Christopher W. Baxter			
Innovyze	H2OMap Sewer Pro	Phone: 604-639-7167			
	INFO-SWMM	Email: cwbaxter@hydrannt.com			
	H2OMap SWMM	_			



## CITY-WIDE SANITARY SERVICING MASTER PLAN UPDATE: FINAL TECHNICAL MEMORANDUM 3

SOFTWARE EVALUATION November 1, 2013

#### 4.2 SHORT-LISTED SOFTWARE

In accordance with RFP 13-04, three (3) software packages that meet the objectives of the City are to be reviewed in detail. A total of 10 common software packages, available from 5 different suppliers and currently utilized within Ontario, were reviewed as part of a preliminary screening. The screening was based on the following criteria:

- 1. Ability to conduct dynamic and static modeling as per City's needs;
- 2. Prevalence of software use locally, incorporating municipal experience;
- 3. Adequacy of vendor software support; and
- 4. Potential for future regional and inter-municipal coordination.

Short-list screening is provided in Table 2.

**Table 2: Software Short-Listing** 

Software	Fully Dynamic	Local Municipal Use	Vendor Support	Other	Carry Forward
EPASWMM 5	Yes	Low	None	Software engine basis for all SWMM-based models	No
XPSWMM	Yes	Low	Yes	Formally used by Waterloo	No
PCSWMM	Yes	Moderate	Yes	Local provider (Guelph); used by Cambridge and Guelph	Yes
MIKE URBAN/ MOUSE	Yes	Low	Yes	Limited use in Ontario	No
SewerGEMS	Yes	Low	Yes	Limited use in Ontario	No
InfoWorks CS	Yes	High	Yes	Used extensively in GTA	Yes
InfoSewer/H2O Map Pro	No	Moderate	Yes	Static model only; H2OMap used in Core Area Assessment	No
InfoSWMM/H2O Map SWMM	Yes	High	Yes	Used by Kitchener	Yes

Of the models, only the Info/H2OMap Sewer Pro software packages are not fully dynamic and have therefore been screened out. Similarly, all provide vendor support, except EPASWMM5. Of the remaining, PCSWMM, InfoWorks CS and InfoSWMM are widely used locally with positive feedback from municipal staff. These three (3) packages thus form the short-list for further consideration.



## CITY-WIDE SANITARY SERVICING MASTER PLAN UPDATE: FINAL TECHNICAL MEMORANDUM 3

Recommended Software November 1, 2013

#### 5.0 Recommended Software

This section is to be completed after Meeting 5b. For discussion purposes, a preliminary recommendation is provided.

Based on the evaluation presented in the previous sections, the recommended software platform is PC-SWMM, based on the following:

- Exceeds the base needs identified by the City for a dynamic modeling platform
- Superior calibration and advanced topological tools built-in to the base cost
- Local software provider to support training and implementation needs
- Excellent vendor availability and extent of customer/technical support
- Least expensive fee structure, with subscription-based approach allowing annual review of needs





October 21, 2013 File: 1611 11191

#### **CHI SOFTWARE INFORMATION**

Computational Hydraulics Int. (CHI) www.chiwater.com

#### Operation requirements

PCSWMM requires the Microsoft 7, Vista, XP (SP2), or 2000 operating system, with the Microsoft .NET 4.0 framework installed. In addition, it requires a minimum screen resolution of 1600x768 pixels (XGA), a minimum of 2GB of physical memory and 100MB of disk space.

#### Licensing

All licenses are subscription based and can be purchased in 12 month periods only. Each license include support for unlimited model sizes (number of nodes/entities), as well as telephone and email support by professional engineers and software updates for the duration of the subscription. Update and support subscriptions are renewed in 12 month periods by purchasing a new subscription. Updates include both major and minor releases as and when they are made available.

#### Single user license

The single user licenses (PCSWMM Professional and PCSWMM Professional 2D) allows for one designated individual (licensee/named-user) to use the software, and for the software to be installed on a maximum of two computers (e.g. one desktop and one laptop), for the use of the licensee only. The software license is owned by the purchasing entity (company), however the licensee within the company/organization is the designated user of the software and is the one that qualifies for technical support.

#### **Enterprise license**

An enterprise license is granted to a company/organization/government agency and permits an unlimited number of named users at that organization to use the software. The enterprise license becomes cost effective if you have 3 or more users of the software.

CHI registers each user and provides software activation codes for those users. Additional/new users can be designated at any time by the company during the subscription period. When it is time to renew, the company can review the list of users, determine the users going forward and purchase their subscription for the next 12 months.

#### On Site training

CHI would be pleased to work with your company to provide an in-house workshop where one of our qualified instructor's would travel to your location and lead the workshop.



#### **CHI SOFTWARE INFORMATION**

Some advantages to an In-house workshop include:

- The context and length of the workshop may be customized to fit your company's needs
- You may select a date and location that is suitable to your company's schedule and workload
- Licensees will have an opportunity to improve their knowledge of PCSWMM and become proficient with the modeling packages just as they would at any of our regularly-scheduled workshops

The cost for in-house workshops can vary depending on the number of attendees and travel costs. For an idea for a 1-day training for a maximum of 10 attendees you would be looking at \$3500 plus the cost of travel and material. We also have regular training workshops all over Ontario during the course of the year that anyone can attend. Rob James (CEO) also hosts free webinar sessions bi-weekly to go allow for remote training on specific topics, for example one topic is Basic introduction to PCSWMM.

#### PCSWMM technical support

- Free and immediate email and direct telephone technical support with our staff of knowledgeable professional engineers
- Extensive, searchable documentation with comprehensive reference tables for parameter values
- Searchable PCSWMM Frequently Asked Questions database
- Comprehensive searchable US EPA SWMM5 knowledge base (3400+ topics and growing)
- Free SWMM-USERS list server (800+ participants around the world)
- Library of peer-reviewed case studies available through our publications
- Cost-effective and timely model review services available
- Professional consulting engineering services available
- Software customization services available

#### **Details**

PCSWMM is a fully featured urban drainage system modeling package, with no limitations on model size or complexity. PCSWMM contains a complete GIS system (no third party software required) tailored to urban drainage modeling which supports most projections, datums, and ellipsoids, provides interaction with a large number of GIS formats, as well as topological operations and querying.

PCSWMM provides advanced versions of all of the standard urban drainage modeling visualization techniques, including animated hydraulic grade line and energy grade line profiles, plan-view static and animated thematic rendering, powerful plotting tools, as well as on-the-fly statistical, calibration and error analysis.

PCSWMM automatically maintains standard US EPA SWMM5 models from GIS data and synchronizes in both directions, thus providing complete data compatibility with any other SWMM5 GUI (including the US EPA GUI). Highlighted below are some of the more prominent features of PCSWMM.

#### Next generation interface

Windows 7 interface (also compatible with Windows Vista, XP, and 2000 operating system)

Multi-threaded application with support for multiple cores (dual-core, quad-core and greater) for significant speed improvements

Written from the ground up in C# for .NET, utilizing many new technologies (e.g. Google Earth<sup>tm</sup>, web documentation, etc.)

#### Open standards based

SWMM model natively stored in your choice of open GIS format (e.g. Shape file, Personal Geodatabase, OpenGIS SQL, GML, etc) \*

Hydrology / Hydraulics engine is public domain (official US EPA SWMM5)- well written and well documented object -oriented C+ code

Standard US EPA SWMM5 input file automatically maintained at all times - models are editable by both interfaces (SWMM5 GUI and PCSWMM)

Standard US EPA SWMM5 reporting and time series files produced

Open standard GIS layers populated with computed SWMM5 results for analysis, thematic rendering, reporting and exporting

Comprehensive support for GIS layer types (over 30 formats)

Flexible importing from Microsoft Excel<sup>tm</sup>, CSV and virtually all database formats, incl. Access<sup>tm</sup>, SQL Server<sup>tm</sup>, Oracle<sup>tm</sup>, MySQL<sup>tm</sup>, XML, OLE DB and ODBC sources, plus direct importing from 17 common GIS/CAD vector formats

Straight-forward conversion of older SWMM models to SWMM5 format

Flexible exporting to most common GIS/CAD formats

#### Complete support for all USEPA SWMM5 engine capabilities

Dynamic wave, kinematic wave, or steady state modeling

Natural river/stream modeling and macro-scale watershed modeling

Sanitary sewer, storm sewer, and/or combined sewer modeling

Backwater effects, surcharging, gravity and pressure flow modeling

Branched, dendritic and looped pipe network modeling

Natural channels, pumps, orifices, weirs, storage pond/tanks modeling

Inflatable dams, valves, gates, bendable weirs, leaping weirs and other complex flow structures

Fixed, variable, free and tidally-influenced outfalls, with or without flap gates

Culvert modeling under dynamically varying inlet and outlet control

Dual drainage (major/minor) system modeling, including dynamic interaction

Rainfall-runoff modeling via non-linear reservoir routing and/or triangular unit hydrograph methods

Dry weather flow (DWF), rainfall derived inflow and infiltration (RDII), and/or direct inflow modeling

Continuous and/or single event modeling

<u>Low Impact Development (LID)</u> modeling: permeable pavers, bio-retention areas (rain gardens, green roofs), vegetative swales and buffer strips, cisterns, infiltration trenches, etc.

Snow accumulation, relocation and melting

Pollutant modeling (land-use based build-up and wash-off, including treatment)

Global optimal and/or passive real time control (GO RTC) modeling, including modulated controls and PID controllers

#### Unlimited model sizes and unrestricted modeling

No limits on number of entities (e.g. model 100,000 entities or more)

No limits on number of non-visual model objects (i.e. rain gages, pollutants, land uses, real-time control rules, unit hydrographs, transects, etc.)

No limits on the size or number of time series, with optimized graphing and analysis of millions of data points

Scalable GIS engine supports <u>fast editing</u> of extremely large data sets - real-world speed comparison tests suggest that some of PCSWMM's geospatial operations run 5 - 50 times faster than competitive GIS products

All common projections, units and GIS formats supported, with infinite zoom ability

Up to 50 character entity and object names

#### **Smart GIS engine**

Stand alone, fully functional GIS (no third party software/licensing needed)

Direct support for opening/editing/saving ESRI ArcGIS data

Model data can be simultaneously edited and shared by PCSWMM and third party GIS/CAD software (ArcView, ArcInfo, ArcGIS, MapInfo, Microstation, AutoCAD, etc) and third party SWMM5 software (USEPA SWMM5 interface, etc.)

Streamlined GIS operations for efficient urban drainage modeling

Support for most projections, datums, and ellipsoids

Topological operation engine (intersections, unions, joining, splitting, area weighting, buffering, etc.)

Digital Elevation Model (DEM) support

Full SQL querying (incl. query builder) of any layer (model or other layer)

Thematic rendering of any layer (model or other layer), incl. plan view pie and bar charts

Animated thematic plan view rendering of any computed time series

Advanced label placement, overlap avoidance, styles, fonts

Transparency support for all raster and vector layers

Raster (pixel) layer operations, such as histograms equalizations, color coding

Full editing capability provided for a large number of vector layer GIS formats (see feature list below for supported formats)

Efficient handling of large raster and vector files (e.g. 2 Gigabyte shape files)

#### Importing / exporting

Conversion of existing older SWMM models to SWMM5 format

Flexible entity/attribute importing from all common GIS, CAD, spreadsheet and database data source formats (direct support for over 50 formats)

Time series importing/exporting to/from MS Excel and other graphing/analysis utilities.

HEC RAS importing of cross-sections and river reaches

Read/write time series support for HEC-DSS, NCDC 3240/3260, AES, database, spreadsheet, CSV, data-logger, NEXRAD products, user-defined formats, etc.

Model merging (combining smaller models to form a larger 'macro' model)

Model splitting (extracting a portion of a model for separate editing/running/analysis)

Model packaging/unpackaging for compressed, single file model sharing (e.g. emailing) and/or archiving

Exporting of model layers (and/or other layers) to most common destination formats (GIS, CAD, SQL, KML, etc.)

#### Automated model input development and quality assurance/control (QA/QC)

Data entry error checking, advanced error detection and consistency checks

Automatic assignment of select entity attributes from GIS topological operations

Automatically create model connectivity (i.e. assign inlet and outlet nodes for links) for imported entities based on node proximity and relative node invert elevations

Model-wide validation and reporting on attributes outside of expected ranges

Frequency distribution analysis and graphing for all input and result attributes

Compute inlet and outlet offsets from conduit invert elevations and connected node invert elevations

Compute max depth attributes from node ground (rim) elevations

Compute subcatchment width attributes from user-defined overland flow paths

Design utility to create drainage networks meeting minimum slope requirements

Find orphans (nodes, links and subcatchments not connected to drainage system)

Calculate and fill in missing data (e.g. manhole invert or rim elevations)

Compute area and length attributes from map (any map units supported, incl. degrees)

Identify conduits with negative or low slopes, and more

Identify confidence (or uncertainty) for all applicable numeric input attributes (both for model entities and non-visual model objects) and color-render table cells to illustrate the level of data uncertainty

#### Tables

Table editing of all applicable visual entities and non-visual model objects as well as background vector (GIS/CAD) layers

All computed results for all model entities included as attribute data in entity tables

Attribute uncertainty (or confidence) displayed/editable in tables - cell colors thematically rendered to show uncertainty

Table sorting by attribute, synchronizing map extent with table selection, etc.

Full query support with query builder

Multi-entity attribute editing, incl. mathematical operations (add, subtract, multiply, divide, apportion, etc.)

#### Dynamic Hydraulic Grade Line (HGL) plots

Plots and animates both the hydraulic grade line (HGL) and quasi-energy grade line (EGL)

Animates HGL for multiple scenarios on a single profile for comparison

Displays input profile plots (i.e. before model run) and provides full entity selection and attribute editing capabilities for model development or 'what if' scenarios

Allows graphical drag-and-drop editing of entities in the profile plot (conduit depths, offsets, node inverts, max. depths, etc.)

Displays and animates observed head/depth data along with computed head

Displays cross connections, natural channel overbanks and user-defined labels

Provides full zoom and pan control with intelligent label overlap prevention

Saves profiles for quick recall

#### Comprehensive and customizable attribute sets

All applicable model data (input and computed results) is stored as GIS layer attributes to support GIS operations, querying and thematic rendering

Both SWMM5 and background GIS/CAD layers can be restructured (attribute fields defined, edited or deleted)

Support for any number of additional user-defined attributes for SWMM5 layers and other vector layers, with full editing, querying, thematic rendering and data analysis support

#### Scenario management tools

Multiple event / design storm analysis

"What-if" scenario analysis and comparison

Compare/animate multiple scenario HGLs on the same profile

Scenario manager for creating, deleting and switching between scenarios

Dynamic hydraulic grade line (HGL) animations of multiple scenario results on the same profile

Scenario comparison graphs for all SWMM5 time series

Statistical comparison of any scenario time series (i.e. compare objective functions, with the same time period and event selection tools as before)

Scenario comparison tables for model inputs and computed results

Support for multi-core processors and computational grids (i.e. local network of computers) when running scenarios, cutting computational time by approx. 1/n where n = number of cores utilized

#### **Dual drainage creation wizard**

Streamline major/minor system modeling with new Dual Drainage Creator

Editor for managing, creating, graphically editing, importing and assigning street cross-sections and other major system conveyance channels

Inlet controls modeled with SWMM5 outlet entities, with inflow/head relationship and modulated control

Automatic roughing out of the major system, based on minor system to streamline model development

Solve both systems simultaneously with dynamic interaction of flows between the major and minor systems

#### Radar-rainfall tools

Automated NEXRAD radar acquisition, archiving and processing (rainfall-reflectivity conversion, bias removal, etc.) Synthetic individual hyetograph generation for every subcatchment/sewershed from radar cells (area weighted) Storm dynamics analysis and modeling (speed and direction can affect peak flow by up to 25% depending on catchment drainage orientation).

#### Rainfall disaggregation

Disaggregation tool for the generation high temporal-resolution continuous rainfall time series from coarse historical records (e.g. NCDC 3240, etc.) for model inference studies

#### **Design storm creation tools**

SCS, Huff, AES and Chicago design storm generation automated

Regional design storms (e.g. Hurricane Hazel, Timmins, SA SCS) with areal reduction computed

Your local design storms added upon request (free service)

#### Dry weather flow (DWF) pattern creation and DWF allocation

Automated hourly, daily and monthly pattern creation from observed flow

Dry weather event identification for pattern creation

Tools for assigning patterns and apportioning DWF to model nodes, based on topological assigning of meter records, and/or observed flows.

Reports generated on pattern derivation and apportioning

#### Automated pipe sizing

Sizing method uses Manning's formula calculated using hydraulic slope under peak computed flow for circular pipes

#### Pond, storage and LID design

Model extended detention (wet/dry) ponds, constructed wetlands, marshes

Model <u>Low Impact Development (LID)</u> practices: permeable pavers, bio-retention areas (rain gardens, green roofs), vegetative swales and buffer strips, cisterns, infiltration trenches

Model underground tanks, arched pipes, large diameter storage pipes (superpipes)

Compute storage volume required to meet peak flow reduction objectives

Compare pre and post hydrology conditions

Pond infiltration (exfiltration)

Multiple interconnected ponds, treatment trains, with backwater effects

Support for multiple inlets and outlets, complex outflow structures with or without tailwater submergence

Pollutant routing and removal

Surface evaporation

#### Graphical time series manager

Manipulation / statistics / error analysis

#### Parameter uncertainty / confidence tracking

Parameter uncertainty estimation available for all numeric model input parameters (both entity attributes such as subcatchment parameters and non-visual object parameters such as RDII parameters, pollutant build-up and wash -off parameters, DWF patterns, etc.)

Thematic color rendering of table cells to visually display uncertainty / confidence

#### Sensitivity, Calibration and Error Analysis (SCEA)

Sensitivity-based radio tuning calibration (SRTC) for any number of SWMM5 parameters

SRTC calibration tool provides fast calibration for any model size or model complexity and calibrates to multiple objective or response functions simultaneously

Genetic algorithm calibration tool for any SWMM5 parameter (requires PCSWMM 2006)

GA calibration tool calibrates either to a specified objective function or to entire response function (e.g. hydrograph shape - requires PCSWMM 2006)

Observed vs computed error analysis on objective functions and/or response functions

#### Project documentation and presentation

Support for embedding external resources (e.g. spreadsheets, CCTV, photos, notes) into the modeling environment, either as general notes & documents, or as geo-referenced points of interest (POIs) on the map.

Embedded external resources can include locally stored (on LAN) documents, images, video, as well as Internet resources such as images, video, documents, web pages from HTTP sites, secured FTP servers, or from Internet storage services like Flickr<sup>tm</sup>, YouTube<sup>tm</sup>, etc.)

Full Google Earth<sup>tm</sup> presentation support for 3D visualization, thematic rendering and even results animation of your complete model, including all SWMM5 entities and attributes, as well as background layers

#### **Technical Support**

Free and immediate email and direct telephone technical support with our staff of knowledgeable professional engineers

Extensive, searchable documentation with comprehensive reference tables for parameter values

Searchable PCSWMM Frequently Asked Questions database

Comprehensive searchable US EPA SWMM5 knowledge base (3400+ topics and growing)

Free SWMM-USERS list server (800+ participants around the world)

Web-based and classroom workshops available at locations across North America and overseas.

Library of peer-reviewed case studies available through our publications

Cost-effective and timely model review services available

Professional consulting engineering services available

Software customization services available

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<sup>\*</sup> multi-format SWMM5 layer coming soon. Current GIS format for SWMM5 layers is the open standard ArcView shape file format.

# 1611-11191: Waterloo Sanitary Master Plan (2013) Table 1a: Hydraulic Software Model Evaluation Criteria Weighting Factors Pair Wise Comparison

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Much less important	1

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	48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88	Is the Simulation Time/Stability more important than the Calibration Capabilities?  Is the Simulation Time/Stability more important than the Scenario Management?  Is the Simulation Time/Stability more important than the GIS Data Exchange?  Is the Simulation Time/Stability more important than the Database Management?  Is the Simulation Time/Stability more important than the Database Management?  Is the Simulation Time/Stability more important than the Capital Costs?  Is the Simulation Time/Stability more important than the Capital Costs?  Is the Simulation Time/Stability more important than the Maintenance Costs?  Is the Simulation Time/Stability more important than the Capital Costs?  Is the Hydrology/Flow Generation more important than the Scenario Management?  Is the Hydrology/Flow Generation more important than the Scenario Management?  Is the Hydrology/Flow Generation more important than the Base of Use / Training Need?  Is the Hydrology/Flow Generation more important than the Ease of Use / Training Need?  Is the Hydrology/Flow Generation more important than the Capital Costs?  Is the Hydrology/Flow Generation more important than the Training Costs?  Is the Hydrology/Flow Generation more important than the Maintenance Costs?  Is the Hydrology/Flow Generation more important than the Training Costs?  Is the Calibration Capabilities more important than the Scenario Management?  Is the Calibration Capabilities more important than the Database Management?  Is the Calibration Capabilities more important than the Database Management?  Is the Calibration Capabilities more important than the Database Management?  Is the Calibration Capabilities more important than the Database Management?  Is the Calibration Capabilities more important than the Base of Use / Training Need?  Is the Scenario Management more important than the Base of Use / Training Need?  Is the Scenario Management more important than the Database Management?  Is the Scenario Management more important than the Database Management?  Is the Scenario Man	Equal Importance Much more important Equal Importance Somewhat less important Equal Importance Equal Importance Somewhat less important Equal Importance Somewhat more important Equal Importance Somewhat more important Equal Importance Somewhat more important Equal Importance Much more important Equal Importance Somewhat less important Equal Importance Somewhat less important Equal Importance Somewhat less important Somewhat less important Equal Importance Somewhat more important Equal Importance Somewhat less important Equal Importance Somewhat less important Equal Importance Somewhat less important Equal Importance Much more important Equal Importance Much more important Equal Importance Much more important Equal Importance Somewhat more important Equal Important Equal Importance Somewhat more important Equal Importance	3 3 3 3 3 3 3 3 3 3 3 3 5 5 3 2 2 2 3 4 3 4 3 4 3 5 5 5 3 2 4 3 4 5 5 2 3 1 1 3 5 3 4 4 5 4 5 4 4 5 3 4 5 3 4 4 5 5 3 4 4 5 5 3 4 4 5 5 3 8 4 4 5 5 3 8 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8

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Table 1b: Hydraulic Software Model Evaluation Criteria Weighting Factors
Pair Wise Comparison

Criterion	Hardware Requirements	Graphics Capabilities	Data Review/Validation	Model Support	Simulation Time/Stability	Hydrology/Flow Generation	Calibration Capabilities	Scenario Management	GIS Data Exchange	Database Management	Ease of Use / Training Need	Capital Costs	Maintenance Costs	Training Costs	Total	Weighted	Rank
Hardware Requirements		2	2	2	2	2	2	2	2	2	2	3	3	5	31.0	5.7%	13
Graphics Capabilities	4		2	3	3	4	3	3	2	3	3	2	3	5	40.0	7.3%	9
Data Review/Validation	4	4		3	2	3	3	3	3	3	3	3	4	5	43.0	7.9%	6
Model Support	4	3	3		3	5	3	3	3	3	3	4	3	5	45.0	8.2%	3
Simulation Time/Stability	4	3	4	3		4	3	3	3	3	3	3	3	5	44.0	8.1%	4
Hydrology/Flow Generation	4	2	3	1	2		3	2	3	3	2	2	3	4	34.0	6.2%	12
Calibration Capabilities	4	3	3	3	3	3		3	4	3	4	3	5	5	46.0	8.4%	1
Scenario Management	4	3	3	3	3	4	3		3	2	4	3	4	5	44.0	8.1%	4
GIS Data Exchange	4	4	3	3	3	3	2	3		2	3	1	3	5	39.0	7.1%	10
Database Management	4	3	3	3	3	3	3	4	4		3	4	4	5	46.0	8.4%	1
Ease of Use / Training Need	4	3	3	3	3	4	2	2	3	3		4	4	5	43.0	7.9%	6
Capital Costs	3	4	3	2	3	4	3	3	5	2	2		3	5	42.0	7.7%	8
Maintenance Costs	3	3	2	3	3	3	1	2	3	2	2	3		5	35.0	6.4%	11
Training Costs	1	1	1	1	1	2	1	1	1	1	1	1	1		14.0	2.6%	14

In order to establish the relative importance of each criterion, and assign weights to each, the pair-wise comparison analysis of the criteria is conducted. The pair-wise comparison is based on successively comparing each pair of criteria and assessing their relative importance against one another on the basis of a total score of 6 where the following scores are assigned:

- 5 vs. 1 if one criterion is deemed to be much more important than the other;
- 4 vs. 2 if one criterion is deemed to be somewhat more important than the other; and;
- 3 and 3 if both criteria are deemed to be equally important.

Summing the scores for each criterion provides a measure of the relative importance of the criteria and provides the basis for establishing the relative weights to be applied for each criterion in the evaluation alternatives.

## 1611-11191: Waterloo Sanitary Master Plan (2013) Table 2: Rating for Each Criterion

Higher Score is More Favourable

Hardware Requirements	High Degree	Moderate Degree	Low Degree			
5.7%	1	2	3			
Graphics Capabilities	Limited	Average	Excellent			
7.3%	1	2	3			
Data Review/Validation	Few Tools	Average Tools	Many Tools and Graphics			
7.9%	1	2	3			
Model Support	US Supplier; Slow to Implement User Feedback	US Supplier; Implements User Feedback	Local Supplier; Implements User Feedback			
8.2%	1	2	3			
Simulation Time/Stability	Slow - Unstable	Average - More Stable	Fast - Robust			
8.1%	1	2	3			
Hydrology/Flow Generation	Average Tools	Advanced Tools as Extra Option	Advanced Tools Included			
6.2%	1	2	3			
Calibration	Cumbersome Interface - Manual	Good Interface - Manual Tools	Good Interface - Automated Tools			
Capabilities	Tools					
Capabilities 8.4%	100ls 1	2	3			
	1 None	2 Hierarchal Structure for Data Only	3 Hierarchal Structure for Data and Scenarios			
8.4% Scenario	1	_	Hierarchal Structure for Data and			
8.4% Scenario Management	1	_	Hierarchal Structure for Data and Scenarios			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1%	None  1  Basic Data Exchange; Average Analytical Tools 1	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools 2	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database	None  1  Basic Data Exchange; Average Analytical Tools  1  Individual Model Files - No File	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File	Hierarchal Structure for Data and Scenarios  3  Good Data Exchange; Good Analytical Tools  3  Database Structure - Built-in			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management	None  1 Basic Data Exchange; Average Analytical Tools 1 Individual Model Files - No File Tracking	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3 Database Structure - Built-in Tracking			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management 8.4%	None  1 Basic Data Exchange; Average Analytical Tools  1 Individual Model Files - No File Tracking 1	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking  2	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3 Database Structure - Built-in Tracking  3			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management	None  1 Basic Data Exchange; Average Analytical Tools 1 Individual Model Files - No File Tracking	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3 Database Structure - Built-in Tracking  3 Easy to Use - Moderate Need for Training			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management 8.4% Ease of Use / Training Need 7.9%	None  1 Basic Data Exchange; Average Analytical Tools 1 Individual Model Files - No File Tracking 1 Difficult to Use - High Need for Training 1	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking  2 Easy to Use - High Need for Training  2	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3 Database Structure - Built-in Tracking  3 Easy to Use - Moderate Need for Training  3			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management 8.4% Ease of Use / Training Need 7.9% Capital Costs	None  1 Basic Data Exchange; Average Analytical Tools 1 Individual Model Files - No File Tracking 1 Difficult to Use - High Need for	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking  2 Easy to Use - High Need for Training  2 Moderate Expense	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3 Database Structure - Built-in Tracking  3 Easy to Use - Moderate Need for Training  3 Least Expensive			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management 8.4% Ease of Use / Training Need 7.9% Capital Costs 7.7%	1 None  1 Basic Data Exchange; Average Analytical Tools 1 Individual Model Files - No File Tracking 1 Difficult to Use - High Need for Training 1 Most Expensive 1	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking  2 Easy to Use - High Need for Training  2 Moderate Expense  2	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3 Database Structure - Built-in Tracking  3 Easy to Use - Moderate Need for Training  3 Least Expensive  3			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management 8.4% Ease of Use / Training Need 7.9% Capital Costs 7.7% Maintenance Costs	None  1  Basic Data Exchange; Average Analytical Tools  1  Individual Model Files - No File Tracking 1  Difficult to Use - High Need for Training 1  Most Expensive 1  Most Expensive	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking  2 Easy to Use - High Need for Training  2 Moderate Expense  Moderate Expense	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools 3 Database Structure - Built-in Tracking 3 Easy to Use - Moderate Need for Training 3 Least Expensive 3 Least Expensive			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management 8.4% Ease of Use / Training Need 7.9% Capital Costs 7.7% Maintenance Costs 6.4%	None  1  Basic Data Exchange; Average Analytical Tools  1  Individual Model Files - No File Tracking  1  Difficult to Use - High Need for Training  1  Most Expensive 1  Most Expensive 1	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking  2 Easy to Use - High Need for Training  2 Moderate Expense  2 Moderate Expense  2	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3 Database Structure - Built-in Tracking  3 Easy to Use - Moderate Need for Training  3 Least Expensive  3 Least Expensive  3			
8.4% Scenario Management 8.1% GIS Data Exchange 7.1% Database Management 8.4% Ease of Use / Training Need 7.9% Capital Costs 7.7% Maintenance Costs	None  1  Basic Data Exchange; Average Analytical Tools  1  Individual Model Files - No File Tracking 1  Difficult to Use - High Need for Training 1  Most Expensive 1  Most Expensive	Hierarchal Structure for Data Only  2 Good Data Exchange; Average Analytical Tools  2 Individual Model Files - Some File Tracking  2 Easy to Use - High Need for Training  2 Moderate Expense  Moderate Expense	Hierarchal Structure for Data and Scenarios  3 Good Data Exchange; Good Analytical Tools  3 Database Structure - Built-in Tracking  3 Easy to Use - Moderate Need for Training  3 Least Expensive  3 Least Expensive			



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#### **Table 3: Hydraulic Model Software Evaluation**

			Software	
Rating Criteria		InfoWorks CS	InfoSWMM	PCSWMM
Hardware Requirements		Moderate Degree	Moderate Degree	Low Degree
Score	5.7%	2	2	3
Graphics Capabilities		Excellent	Average	Average
Score	7.3%	3	2	2
Data Review/Validation		Many Tools and Graphics	Average Tools	Average Tools
Score	7.9%	3	2	2
Model Support		US Supplier; Implements User Feedback	US Supplier; Slow to Implement User Feedback	Local Supplier; Implements User Feedback
Score	8.2%	2	1	3
Simulation Time/Stability		Fast - Robust	Slow - Unstable	Average - More Stable
Score	8.1%	3	1	2
Hydrology/Flow Generation		Average Tools	Advanced Tools as Extra Option	Advanced Tools Included
Score	6.2%	1	2	3
Calibration Capabilities		Good Interface - Manual Tools	Cumbersome Interface - Manual Tools	Good Interface - Automated Tools
Score	8.4%	2	1	3
Scenario Management		Hierarchal Structure for Data Only	Hierarchal Structure for Data and Scenarios	Hierarchal Structure for Data and Scenarios
Score	8.1%	2	3	3
GIS Data Exchange		Good Data Exchange; Average Analytical Tools	Basic Data Exchange; Average Analytical Tools	Good Data Exchange; Good Analytical Tools
Score	7.1%	2	1	3
Database Management		Database Structure - Built- in Tracking	Individual Model Files - No File Tracking	Individual Model Files - Some File Tracking
Score	8.4%	3	1	2
Ease of Use / Training Need		Difficult to Use - High Need for Training	Easy to Use - High Need for Training	Easy to Use - High Need for Training
Score	7.9%	1	2	2
Capital Costs		Most Expensive	Moderate Expense	Least Expensive
Score	7.7%	1	2	3
Maintenance Costs		Most Expensive	Moderate Expense	Least Expensive
Score	6.4%	1	2	3
Training Costs		Most Expensive	Most Expensive	Least Expensive
Score	2.6%	1	1	3
	Total	2.01	1.65	2.60
	RANK	2	3	1
Comments				

How this Works: For each measure and for each rating criteria in Table 2 above, select the relevant rating in each box as defined below. Note that the process is automated using dropdown boxes that provides the list of ratings identified in Table 3. The scores corresponding to the ratings are also described in Table 3 below. The weightings for each criterion are established through the pairwise comparison exercise in Table 1. At the end of each row in Table 2, the total weighted scoring (sum of weight\*score for each criterion) is then used to qualify the level of risk (A, B or C) as defined in Table 4.