BURNSIDE

City of Owen Sound
East Side Master Servicing
Volume II
Stormwater Management Study

Prepared by

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Executive Summary

Background

R.J. Burnside & Associates Limited was retained by the City of Owen Sound to undertake a Master Servicing Study (MSS) for the water supply servicing, sanitary sewer servicing and stormwater management for the eastern section of the City. The Master Servicing Study enables the City to identify the projects and initiatives to implement the servicing strategy. The plan will be known as the "East Owen Sound Master Servicing Plan". This report focuses on the Stormwater portion of the Master Servicing Plan. The water and wastewater servicing component of the study is presented under separate cover (Volume 1).

The City's initiative to undertake a Master Servicing Plan was brought about by several issues and recent events including flooding on 15th Street B East, ongoing development along the 16th Street (Hwy 26) corridor and the Sydenham Heights Planning Area, and the need to address servicing requirements for the remaining vacant land in the eastern part of the City. This master plan will serve as a base reference document for the City and property owners wishing to undertake development relative to servicing the remaining vacant land in the eastern part of the City to allow for orderly development.

In consultation with the City, a problem statement was developed for the East Owen Sound Master Servicing Plan. The problem statement was defined as follows:

"Several issues and recent events in the City of Owen Sound have created the need for the City to review its strategies for providing water and sanitary sewer servicing, and stormwater management. As a result, the City needs to consider options to resolve the stormwater management issues on 15th Street B East, 16th Street corridor and the Sydenham Heights Planning Area, and for the servicing of the undeveloped lands on the east side of the study area, that also give due consideration to the constraints and opportunities associated with the existing servicing infrastructure. The intent is to identify an orderly and efficient servicing strategy for the vacant land in the eastern section of the City, while accounting for the technical, environmental, economic, political and social implications of the strategy on the City of Owen Sound's future."

Existing Conditions of the Study Areas

The study has focused on four key areas of East Owen Sound:

- Telfer Creek West Branch – The headwater portion of Tefler Creek that is generally undeveloped but now is beginning to experience pressures of development moving easterly. This provides an opportunity to develop a SWM strategy to avoid flooding and erosion issues as seen in the Kenny Drain.
- Kenny Drain – Extensively developed in the headwater portion of the watershed with erosion occurring along unprotected reaches of the stream banks. With a mix of commercial, industrial, institutional and residential areas, this relatively steep, clayey watercourse has seen

downcutting of the creek invert, failure of creek banks and suspension of clayey material that has affected water quality at its outlet into Owen Sound Bay.

- East Bluff's Area – Primarily an older residential development with some infill areas utilizing both swale and pipe drainage. Development pressures have resulted in a need for review of the downstream pipe capacities to determine the need for upgrades to service new development and avoid flooding of private lands downstream.
- 15th Street B Area – An older residential development with chronic basement and street flooding, and a seasonal high groundwater table.

Stormwater Management Strategy

The objectives of the Stormwater Management Strategy has been to:

- Understand the existing conditions of the distinctly noted drainage areas from a peak runoff flow rate (quantity), water quality, flooding, and erosion potential with regard to policies of the City of Owen Sound, Ministry of the Environment, Grey Sauble Conservation Authority, Ministry of Natural Resources and Department of Fisheries and Oceans.
- Provide an overall framework for the Stormwater Management challenges facing the City of Owen Sound to service the remaining vacant land in the eastern portion of the City that is designated for development under the City's updated Official Plan and reducing flooding and erosion in developed areas.
- Recommend a preferred Stormwater Management servicing strategy by which these challenges can be met, following a systematic evaluation of the alternative solutions.

Telfer Creek

It is recommended to use a "Unit Flow Rate" approach to establish target flow rates for development in the Telfer Creek (West Branch) watershed. This relatively undeveloped 433ha watershed has a low gradient within the City limits but has sensitive thresholds to flooding of road crossings and private lands downstream. The Unit Flow Rate approach takes the peak flow rates determined assuming undeveloped conditions and divides the flow by the total drainage area. This provides a flow rate in cubic metres per second per hectare of land ($m^3/s/ha$) by which all development must adhere to. This approach ensures that peak flow rates will not increase at the outlet because the sum of all the parts (developments) cannot add to more than the original (undeveloped watershed) flow rate.

It is recommended that water quality and erosion control follow the requirements of the Ministry of Environment 2003 Stormwater Management Planning and Design Manual (SMPDM). Enhanced level of protection is recommended with volumes as noted in Table 3.2 of this document (SMPDM).

It is recommended that the landowners work together with the City to establish centralized locations, where possible, of stormwater management facilities at low points in the local topography to service more than one development thereby increasing available development land (the net land area for a single facility is less than multiple facilities servicing the same drainage area due to grading/access requirements) and minimizing the need for the City to maintain multiple smaller SWM facilities. Preliminary SWM block locations have been identified throughout the watershed within the City's limits.

Kenny Drain

Kenny Drain is characterized by intense development in the headwater area with the upstream portion being drained by storm sewer. The storm sewer system discharges to open ditches and then finally into a well incised natural channel that is undergoing extensive erosion. The mid reaches of the Kenny Drain, between 20th Street East and the CP rail trail, have a steep slope and exposed clayey banks. There has been extensive down cutting of the drain invert resulting in failure of the banks and sediment moving downstream. The mid reaches have little to no deep rooted vegetation to hold bank material.

The downstream portion of the drain spreads into a wide floodplain just upstream of the old CP crossing prior to passing through an old culvert under CP rail trail. This culvert has been subject of much debate due to erosion on the downstream face. The drain then passes through the soccer pitch area and an offline water quality pond prior to entering the heavily armoured section of the drain from 9th Avenue East to the outlet into Owen Sound Bay.

Due to the extensive development throughout the watershed there are reduced opportunities on a watershed basis to implement a comprehensive SWM strategy. SWM will need to be completed on a site by site basis or through an update to the Environmental Study Report (ESR) and individual SWM strategies from the proponent. However some significant recommendations have been made.

The following analyses were completed for the Kenny Drain:

- Existing and Post Development Stormwater peak flow modeling for development of water quantity control;
- Floodplain analysis and crossing overtopping frequency analysis; and
- Erosion analysis.

The erosion analysis determined that erosion of the Kenny Drain occurs when the peak flow rate is greater than $0.7m^3/s$. The peak flow analysis determined that the 1 in 2-year storm has a peak flow rate of $6.7m^3/s$ which is approximately 10 times greater than the threshold erosion rate. Given the limited opportunities to reduce the peak flow due to the existing developed condition of the watershed, it is recommended that a reach of Kenny Drain, approximately 750m between 20th Street East to a point upstream of the CP rail trail, have its banks protected from erosion to increase water quality at the outlet at the Owen Sound Bay.

Stormwater management quality and quantity ponds are recommended for all developing areas south of 26th Street East. Stormwater management quality ponds (without quantity control) are recommended for all lands development north of 26th Street East. The timing of peak flows allows the downstream portions of the watershed to discharge without quantity control prior to the peak of the upstream areas with quantity control. The timing avoids the straight addition of the peak flows from the two distinct areas.

A review of cash-in-lieu of SWM ponds without quantity control and cash-in-lieu of SWM ponds for sites less than 5ha should be reviewed through the updated ESR. This cash may initiate the funding for erosion protection along the Kenny Drain. Sites less than 5ha is size will require an oil grit separator (OGS or equivalent) as a minimum water quality standard to meet 80% Total Suspended Solids (TSS) removal.

It is recommended that water quality and erosion control follow the requirements of the Ministry of Environment 2003 Stormwater Management Planning and Design Manual (SMPDM). Enhanced level of protection is recommended with volumes as noted in Table 3.2 of this document (SMPDM).

The floodplain analysis for Kenny Drain concluded that several crossings are susceptible to overtopping. Generally the floodplain is contained within the natural channel with the exception of the open space upstream of the CP rail trail. The floodplain at this location is very broad and a backwater is created upstream of the CP rail trail as a result of the limited culvert capacity under the rail trail. It was identified that a potential spill may occur west along the rail trail. In addition, it was noted that a spill would occur east along the soccer fields and then back through the soccer pitches. Some erosion was noted at the west end of the soccer pitches.

East Bluffs Area

The east bluffs area is characterized by older residential and institutional development with small undeveloped infill areas. Given the name, there is a steep slope (elevation drop of 28m) from the Bluff Area tableland to 3rd Avenue East. The storm sewer system for this area was reviewed to determine available capacity to service the infill areas and identify street segments requiring potential upgrades. Generally the trunk sewer (1350mm) from 21st Street East and 9th Avenue East down the bluff to 3rd Avenue East has sufficient capacity to service all the infill areas. Potential improvements along 8th Avenue East and 23rd Street East are needed to service future infill developments along 9th Avenue East.

15th Street B East

Severe flooding was reported following rainfall events in the vicinity of 15th Street B East over the weekend of May 22-23, 2004 and again on July 26, 2006. The flooding resulted in several basements being flooded along with significant ponding of runoff in the area of 15th Street B East and 12th Avenue East. A detailed dual drainage analysis was completed to determine why this area was flooding.

The analysis concluded that rainfall volumes for both localized events were in excess of the 1:100 year storm. The analysis noted that the runoff from the external drainage areas contributed significantly to the depth of flow on the roads and the amount of runoff being forced into the storm sewer. Basements in the area are connected directly to the storm sewer and therefore were surcharged when the storm sewer reached capacity. The following improvements/developments have/will reduce the area draining to 15th Street B East:

- Rear yard catchbasins on east side of Heritage Heights subdivision now drain to Andpet subdivision storm sewer system to further reduce runoff to 15th Street B East.
- The Andpet subdivision now drains to 16th Avenue East.
- Redirection of runoff from Georgian College with the future construction of 10th Street East and filling at the north end of the Heritage Heights subdivision will ultimately remove 12.3ha from draining into the 15th Street B East sewer.
- The analysis determined the most effective way to reduce flows is to install inlet control devices (ICDs) on the catchbasins within the street. These units were installed by the City in selected catchbasins, as directed by the consultant, through the area draining to 15th Street B East storm sewer in the Fall of 2006. This will reduce runoff into the storm sewer by keeping the runoff in the streets while the sewer maintains capacity and does not surcharge, thereby protecting the basements.

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Appendix F – Figures and Drawings

1 Introduction

1.1 Project Background and Objectives

R.J. Burnside & Associates (Burnside) was retained by the City of Owen Sound to undertake a Master Servicing Plan (MSP) for the eastern section of the City. The study area is bound by the Sydenham River and Georgian Bay on the west, and by the City limits to the north, east and south as outlined in **Figure 1 in Appendix F**. The focus of the East Owen Sound MSP is to recognize the servicing constraints, with respect to water servicing, sanitary sewer servicing and stormwater management, that are facing development of the vacant lands in the study area. The MSP will identify the alternative solutions that are capable of addressing these constraints, evaluate the suitability of each alternative solution and provide a cost effective and orderly servicing plan for the development of the lands in the study area.

The City's initiative to undertake a Master Servicing Plan was brought about by several issues and recent events including flooding on 15th Street B East, ongoing development along the 16th Street East (Hwy 26) corridor and the Sydenham Heights Planning Area, and the need to address servicing requirements for the remaining vacant land in the eastern part of the City. This master plan will serve as a base reference document for the City and property owners wishing to undertake development to service the remaining vacant land in the eastern part of the City to allow for orderly development.

The updated Land Use Plan from the Official Plan for the City of Owen Sound has been altered for simplicity, such that all types of land use are classified as one of the four general land uses; Residential, Commercial, Industrial and Other. This plan is enclosed as **Drawing SWM1** in **Appendix F**.

1.2 Previous Studies

Over the last 30 years, the City of Owen Sound has carried out a number of studies that contribute information and data that is relevant to the City's water servicing, sanitary servicing, and stormwater management. The MSP for the East Side of Owen Sound draws upon work previously completed to obtain an understanding of the existing services, and previously identified servicing strategies. Documents of particular relevance to this study have been reviewed and a list is provided in each servicing section that outlines the studies that have been used in the preparation of the MSP.

1.3 Problem Statement

The problem statement that is used as the basis for the East Owen Sound Master Servicing Plan is defined as follows:

"Several issues and recent events in the City of Owen Sound have created the need for the City to review its strategies for providing water and sanitary sewer servicing, and stormwater management. As a result, the City needs to consider options to resolve the stormwater management issues on 15th Street B East, 16th Street corridor and the Sydenham Heights Planning Area, and for the servicing of

the undeveloped lands on the east side of the study area, that also give due consideration to the constraints and opportunities associated with the existing servicing infrastructure. The intent is to identify an orderly and efficient servicing strategy for the vacant land in the eastern section of the City, while accounting for the technical, environmental, economic, political and social implications of the strategy on the City of Owen Sound's future."

2 Goals and Overview

The objectives of the Stormwater Management Strategy has been to:

- Understand the existing conditions of the distinctly noted drainage areas from a peak runoff flow rate (quantity), water quality, flooding, and erosion potential with regard to policies of the City of Owen Sound, Ministry of the Environment, Grey Sauble Conservation Authority, Ministry of Natural Resources and Department of Fisheries and Oceans.
- Provide an overall framework for the Stormwater Management challenges facing the City of Owen Sound to service the remaining vacant land in the eastern portion of the City that is designated for development under the City's updated Official Plan and reducing flooding and erosion in developed areas.
- Recommend a preferred Stormwater Management servicing strategy by which these challenges can be met, following a systematic evaluation of the alternative solutions.

This report seeks to determine and confirm the drainage area boundaries for Telfer Creek, Kenny Drain and 21st Street East (East Bluff area) catchments. Refer to **Figure 1 in Appendix F** for the study location. Existing land use patterns were identified in order to simulate pre-development peak flow rates. Proposed land use patterns were determined, with the aid of the City of Owen Sound Official Land Use Plan, to determine post-development peak flows.

2.1 Hydrologic and Hydraulic Modeling

Various models were used to assess peak flows, flooding, storm sewer capacities and erosion. The following provides a brief summary of each model utilized in this study.

The hydrologic model SWMHYMO was used to assess peak flows for each drainage area within the Kenny Drain and Telfer Creek watersheds. SWMHYMO is a derivative of the original HYMO program and is similar to the OTTHYMO89 model. SWMHYMO is recognized throughout the industry by the various ministries as being an effective method by which runoff can be determined based on topography, soil conditions and land use.

The hydrologic/hydraulic model OTTSWMM was utilized to assess the 15th Street B East area where a greater level of detail is required to isolate each storm sewer or road segment and understand how catchbasin density affects the peak flow within the storm sewer. This model has been extensively used in the Greater Toronto Area to review existing or proposed storm sewer to assist in determining if the hydraulic grade-line is above the allowable threshold (freeboard, basement, surcharged storm sewers, etc.). The peak flows can be entered in to a spreadsheet along with other hydraulic loss parameters to determine a calculated hydraulic grade-line.

For the calculation of water surface profiles (floodline limits) for the Kenny Drain updates, the HEC-RAS version 3.1.3 computer model developed by the U.S. Army Corps of Engineers has been utilized. This model estimates the change in water surface elevation between selected valley cross-sections and has special routines to account for local increases in water levels due to bridges and/or other flow obstructions. The model is intended for utilization in the analysis of water surface profiles of steady state, gradually varied, one-dimensional flow in natural and man-made channels.

2.2 Rainfall Data

The 6, 12, and 24-hour SCS Type-II as well as the 4-hour Chicago Storm rainfall distributions were used for the 1:2, 1:5, 1:10, 1:25, 1:50 and 1:100 year storm event calculations. The Regional storm event was based on the Timmins storm. The SCS and Chicago storm distributions were developed from recorded rainfall data collected by Environment Canada's Atmospheric Environment Service and summarized in the Owen Sound Intensity-Duration-Frequency (IDF) tables. When comparing flows generated by the 6, 12 and 24-hour SCS Type-II and the 4-hour Chicago Storm Distributions, the 6-hour SCS Type-II storm distribution has been determined to generate the highest peak flows within the Kenny Drain and Telfer Creek watersheds and as a result has been used for design purposes. The 4-hour Chicago Storm rainfall produces the highest peak flows for the 15th Street B East and the 21st Street East (East Bluffs) area due to their relatively small size compared to Kenny Drain and Telfer Creek. The shorter duration higher intensity Chicago Storm has a greater impact on a small catchment and therefore was used in the OTTSWMM model and the Rational Method Analysis. The 4-hour Chicago Storm should be used for design of storm sewers with the greater volume required of the Chicago Storm or 24-hour SCS Type II storm for sizing SWM facilities.

2.3 Time of Concentration

The Uplands Method was used to calculate the time of concentration for the Kenny Drain and Telfer Creek watersheds. The time of concentration is a function of "time to peak" which represents the time from the beginning of rainfall to the peak of the runoff hydrograph. It is indicative of the basin's response to storm events. It depends on the physical characteristics of the watershed such as length, slope, area and surface cover. Estimates of time to peak were determined using the area's time of concentration determined by computing a travel time of an overland flow component and, where applicable, a channel/pipe travel time and then adding the respective travel times together. This established the time of concentration for the area. The required overland flow lengths and slopes were determined from the topographic mapping.

2.4 Soil Conditions and Ground Cover

Soil conditions were determined from Grey County Soils map, prepared for the Department of Agriculture in 1959. Soil conditions and land cover influence the amount of runoff generated by a particular catchment. Soil type A (sand) produces less runoff and Soil type D (clay) produces greater runoff. Land cover was determined from aerial photography (MNR 2006), Google Earth and site reconnaissance.

3 Watershed Areas

3.1 Telfer Creek Overview

The Telfer Creek watershed area is located at the east limit of Owen Sound and provides drainage for approximately 6300ha, discharging to the Owen Sound Bay near of the Hamlet of Leith. Telfer Creek is comprised of a larger east and a smaller west tributary. The west tributary, has a catchment area of 433ha (1070 ac).The total catchment area of Telfer Creek consists of both lands internal and external to the City of Owen Sound Limits The west tributary has a low stream gradient and with minimal erosion sites. This west tributary catchment is relatively un-developed lands consisting of mainly agricultural and rural lands with a small portion of developed lands to the west. With a majority of lands being un-developed, an opportunity to establish SWM criteria early on in the planning process will provide a solid framework to ensure future development does not negatively impact the downstream lands.

3.1.1 Telfer Creek Proposed Analysis Methodology

The first step to assessing stormwater management criteria for Telfer Creek is to establish an existing condition/pre-development SWMHYMO hydrologic model. Next, by examining the City of Owen Sound Official Land Use Plan, a post-development hydrologic model will estimate increased runoff and develop volumes required to attenuate post-development to pre-development peak flow rates.

Allowable unit release rates (m^3/s/ha) will be developed based on pre-development condition peak flow rates divided by the total drainage area. The target allowable release rates will be established for development applications by multiplying the development drainage area by the allowable unit flow rate. Required attenuation volumes for future storm water management ponds for each proponent will then be determined by the proponent's consultant based on the target flow rate. This process eliminates the need for pre-development modeling.

The increased flow rates due to development will cause erosion and reduce the performance of downstream culverts and bridges, resulting in increased flooding on downstream lands. Implementing storm water management (SWM) ponds will mitigate these impacts.

3.2 Kenny Drain Overview

Kenny Drain is the most centralized watershed within the City Limits of East Owen Sound, located to the west of Telfer Creek and to the east of the 21st Street East (East Bluffs) Area. Kenny Drain has a catchment area of approximately 400ha (1000 ac.) discharging to Owen Sound Bay via box culverts under 3rd Avenue East, north of 28th Street East. The catchment area is bound on the south by 8th Street East, to the east by the former CP railway, to the west by 9th Avenue East and finally to the north by 32nd Street East. Under existing conditions the majority of the headwater portion of Kenny Drain is nearing complete build out, with minimal stormwater management, consisting of various commercial, industrial and institutional facilities. The absence of stormwater attenuation in the upstream older developments and presence of a high stream gradient has produced numerous erosion sites in the less developed northern portion of the watershed. The erosion has resulted in a silty/clay sediment plume near the City water intake located in Owen Sound Bay. Grey County has requested a review of alternatives for drainage at the CP railway trail. Due to the overall build out condition, there is a reduced opportunity for implementing a watershed wide SWM plan.

3.2.1 Kenny Drain Proposed Analysis Methodology

Kenny Drain in general is near complete build out from 8th Street East north to 23rd Street East. A pre-development (existing condition) hydrologic model will be developed to account for built out areas and also undeveloped lands located north of 23rd Street East. Several existing stormwater management models for developed sites have been provided by the City of Owen Sound and integrated into the SWMHYMO model to accurately simulate baseline flow rates at key flow nodes within the watershed area.

Using the City of Owen Sound Official Land Use Plan, future build out of individual catchment areas was considered and examined in a post-development (complete build out) hydrologic model.

Since a majority of the proposed future development is located at the downstream portion of the watershed, two post-development models have been considered;

- A post-development hydrologic model without SWM ponds (uncontrolled flows) for developing areas, and;
- A post-development hydrologic model with the implementation of SWM ponds for developing areas.

Due to the location of potential stormwater management facilities within the watershed, timing of release rates will also be considered and comparisons between post development models will be completed to determine optimal SWM facility locations and release rates.

3.3 East Bluffs Area (21st Street East) Overview

The East Bluffs Area is characterized as an older residential and institutional community with small undeveloped infill areas located within the confines of 9th Avenue East, 3rd Avenue East to the west 28th Street East to the north and finally 19th Street East to the south. Given the name, there is a significant elevation differential (28m) from the plateau of the Bluff Area to 3rd Avenue East. Drainage in this 84 ha catchment is provided by a series of open ditches and storm sewers located east of 9th Avenue East. Further from 9th Avenue East, flow is captured into a trunk storm sewer system, conveyed westerly down the escarpment, under 3rd Avenue East and finally discharged into Owen Sound Bay. The storm sewer network for this area will be reviewed and examined to determine existing capacities available to service infill areas and identify key areas and street segments requiring potential upgrades. Refer to **Drawing SWM2** for catchment delineation.

3.3.1 East Bluffs Area Proposed Analysis and Methodology

The East Bluffs area consists of two (2) distinct existing storm sewer networks defined by the above mentioned perimeter boundaries and the halfway point between 23rd Street East and 25th Street East. The two existing storm sewer systems are referred to herein as the North and South Storm Sewer systems.

As-constructed storm sewer data consisting of invert elevations, pipe sizes and slopes have been provided by the City of Owen Sound to aid in the determination of the existing North and South Storm Sewer systems capacities. Based on the existing condition analysis of the North and South Storm Sewer systems, alternative solutions to provide servicing for the future infill developments within the area can be analyzed. Where as-constructed storm sewer information was not available, standard storm sewer design practices were implemented to complete the analysis for the unknown areas.

3.4 15th Street "B" East Storm Sewer

The hydrologic model OTTSWMM was utilized to assess the 15th Street B East area where a greater level of detail is required to isolate each storm sewer or road segment and understand how catchbasin density affects the peak flow within the storm sewer. The best available as-built information for the catchment area and consultant's drawings for adjacent under-construction or proposed developments were used to develop the catchment area parameters. A flow meter was installed to monitor storm sewer flow rates and compare them against measured rainfall volumes. Photos and reports from local residents helped to understand the extent of flooding and validate the model.

4 Telfer Creek Analysis

4.1 Existing Hydrology

4.1.1 General

The drainage limits for the Telfer Creek West Tributary have been determined based on field investigations, Ontario Base Mapping and GIS generated surface flow analysis calculations. In general, existing topographic features indicate that overland sheet flow occurs in a southwest to northeast direction. Three individual drainage areas of 263ha, 124ha and 57ha, Catchment Areas 3, 2 and 1 respectively, have been examined in this report. Flow nodes have been established at the following three key points located along the tributary: the first at the 8th Street East crossing, the second at a confluence point located approximately 200m north of 16th Street East and finally the third at the 28th Ave East crossing. These nodes are located at the northern limits of Catchments 1, 2 and 3, respectively. Refer to **Drawing SWM3** for existing catchment boundaries and aerial photography from 2006.

4.1.2 Soil Conditions

According to the Grey County Soils map, prepared for the Department of Agriculture in 1959, there is a general similarity of soil distribution between Catchment Areas. **Table 1**: Telfer Creek Soils Condition, illustrates soils located within the confines of the individual catchment boundaries along with their corresponding Ministry of Transportation (MTO) Hydrologic Soil Group classification.

Table 1: Telfer Creek Soils Condition

Catchment	Soil Code	Series	Hectares (ha)	Hyd Soil Group
3	Bc	Brookston	20.0	C
	Has	Harkaway	135.5	BC
	Ksc	Kemble	17.0	C
	Vsc	Vincent	90.0	C
2	Bc	Brookston	13.0	C
	Has	Harkaway	96.0	BC
	Ksc	Kemble	0.0	C
	Vsc	Vincent	15.0	C
1	Bc	Brookston	0.0	C
	Has	Harkaway	42.0	BC
	Ksc	Kemble	0.0	C
	Vsc	Vincent	2.0	C
	Wi	Wiarton	*13.0*	*B*

The Runoff Curve Number for the individual drainage areas have been computed by calculating weighted curve numbers based on the corresponding land use and soil type. A summary of these calculations for each drainage area is included in **Appendix A1**.

4.1.3 Land Use Patterns

Land use patterns of individual catchment areas have been determined by field investigations and aerial photography. As illustrated on **Drawing SWM3**, there is a single dominant land use pattern for the west tributary of Telfer Creek. Farmland/crop occupies a significant portion of each catchment area and has been solely used for calculations in this report. It is of note that small developed areas are present at the west limit of the watershed (i.e. hospital) and have been assumed as undeveloped for model simplicity. Farmland, escarpment protected and hazard lands occupy approximately 98% of the total watershed area.

4.1.4 Hydrologic Analysis and Results

By establishing watershed boundaries, soil conditions and land use patterns, pre-development flows have been determined using the SWMHYMO Hydrologic Model. Pre-development flows have been determined for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year and Regional storm events.

These flows are summarized at individual flow nodes illustrated in **Table 2** below. The SWMHYMO runs for the 6-hour SCS Type-II storm distributions are included as **Appendix A1.**

Table 2: Telfer Creek Pre-Development/Existing Condition Peak Flows

*Node	Total Area (ha)	Peak Flows to Flow Nodes (6-hour SCS Type-II Storm Distribution)						
		2 yr. m^3/s SCS	5 yr. m^3/s SCS	10 yr. m^3/s SCS	25 yr. m^3/s SCS	50 yr. m^3/s SCS	100 yr. m^3/s SCS	Regional m^3/s TIMMINS
3	245	2.26	3.85	5.04	6.66	7.92	9.21	15.76
2	267	2.89	4.89	6.38	8.39	7.92	11.58	22.69
1	433	3.18	5.37	7.00	9.21	10.93	12.69	26.07

***Flow node locations are illustrated on Drawing SWM3**

Calculated peak flows to Node 1 represent a total net flow for the 433 ha watershed area of the west tributary of Telfer Creek.

Pre-development flow rates to Flow Node 1, illustrated in Table 2 have been divided by a total drainage area of 432.6 ha to determine unit flow rates as illustrated in **Table 3** below and **Table 1 in Appendix A2.** These unit flow rates will be used in the preceding proposed hydrology calculations.

Table 3: Telfer Creek Unit Flow Rates

*Node	Total Area (ha)	Peak Flows to Flow Nodes (6-hour SCS Type-II Storm Distribution)						
		2 yr. m^3/s SCS	5 yr. m^3/s SCS	10 yr. m^3/s SCS	25 yr. m^3/s SCS	50 yr. m^3/s SCS	100 yr. m^3/s SCS	Regional m^3/s TIMMINS
All	433	0.0074	0.012	0.016	0.021	0.025	0.029	0.060

***Flow node locations are illustrated on Drawing SWM3**

4.2 Proposed Hydrology

4.2.1 General

Proposed land use patterns have been derived from the City of Owen Sound Official Plan, as illustrated on **Drawing SWM1.** Proposed land use patterns within the confines of this watershed are residential, commercial, industrial, and institutional lands. Each of these land use patterns have been examined individually in this report. Hazard lands, escarpment protected lands, rural areas and open space areas have been grouped together for simplicity. As shown on **Drawing SWM1,** the southern portion of Catchment 3 does not fall within the City of Owen Sound Official Plan; as such it has been assumed that these lands will remain undeveloped.

4.2.2 Post-Development Drainage (Application of this Approach)

The basis for examining the post development drainage has been outlined in Section 3.1.1 by developing unit flow rates for Telfer Creek. Analysis of post-development hydrology at this point has been completed to illustrate how this approach will work. This example helps the City and proponent's consultants to understand the methodology and potential Stormwater management volume requirements.

The example continues in the analysis as outlined in **Table 2 Appendix A2**. Table 2: Allowable Release Rates for Each Land Use based on Pre-Development Unit Flow Rates, illustrates the individual land uses patterns derived from the City of Owen Sound's Proposed Land Use Map and associated allowable release rates. The size of each individual land use area (i.e. residential, industrial, commercial, etc.) has been calculated within the individual catchments using GIS and AutoCAD techniques. The land use areas represented in the **Table 2 Appendix A2** represent a summation of like land uses within the total catchment area of approximately 433 ha. This has been done to illustrate the example of required SWM pond volumes. Having the areas of each individual land use, the allowable release rates for each individual land use could then be calculated for each return period by multiplying the Unit flow rates (shown in **Table 1 in Appendix A2**) by the individual land use areas. By multiplying the individual land use areas by the target unit flow rates, post-development flows will not exceed pre-development flows because the summation of the parts (peak flows) cannot be greater than the whole (total peak flow at the outlet).

Finally, the target release rates have been used to calculate storage volume requirements for each land use. Table 3: Required Storage Volumes for Each Land Use based on Pre-Development Unit Flow Rates, illustrates approximate required storage volumes for each land use to attenuate post-development flows to pre-development rates. Target release rates in **Table 2** have been used in conjunction with the SWMHYMO Hydrologic Model to determine post-development storage volumes.

The required storage volumes for each land use illustrated in **Table 3, Appendix A2** are used to calculate the unit rate storage volumes shown in **Table 4**: Required Unit Rate Storage Volumes for Each Land Use Based on Storage Volume/Land Use Drainage Area. By dividing the storage volumes in Table 3, **Appendix A2** by their respective land use area, the required unit storage volumes can then be determined. This table provides an estimate of the storage volume requirements. By multiplying a unit rate by the proponent's development area, allowable release rates and appropriate storage volumes can be determined to assist the proponent's consultant or to review the consultant's submission. It must be noted again, that reference to Tables 1, 2, 3 and 4 in Appendix A2 illustrates the approach of unit flow rates. **Table 3: Telfer Creek Unit Flow Rates** above provides a summary of the recommended target unit flow rates provided to maintain the post-development peak flows at the pre-development target rates.

4.3 Erosion Threshold Analysis

Aqualogic was retained to assist in determining the erosion thresholds of Telfer Creek. Refer to **Appendix C** for complete details of the Erosion Threshold Analysis.

Extended detention provides a means of holding back urban runoff to allow release of the first flush (1 in 1.5 year to 2 year storm) over a longer period of time to reduce the impact of runoff volume increases following development. Erosion thresholds are determined at critical locations along the watercourse where increases in the frequency and duration by which the threshold is exceeded increases the potential erosion following development. This can be mitigated by extending the period of time to release the first flush through SWM facilities being incorporated with a special extended detention control structure, typically a small orifice plate (greater than 75mm diameter). With this method the number of times the erosion threshold is exceeded remains the same as existing conditions even though the runoff volume in total has increased with development. Preliminary locations for SWM ponds are illustrated on **Drawing SWM4**.

The MOE Stormwater Management Planning and Design Manual dated March 2003, recommends the greater of site specific requirements or $40m^3$/ha over 24hrs minimum for extended detention in Stormwater management ponds. Based on the findings of the Erosion Threshold Analysis the minimum of $40m^3$/ha over 24hrs minimum is recommended for extended Stormwater control in future SWM ponds. It is recommended that existing vegetation be maintained along Telfer creek low flow channel to maintain its current stable characteristics. Should the low flow channel be disturbed the vegetation should be reinstated to equal or better.

4.4 Water Quality Control

It is recommended that water quality control follow the requirements of the Ministry of the Environment 2003 Stormwater Management Planning and Design Manual (SMPDM). Enhanced level of protection is recommended with volumes as noted in Table 3.2 of this document (SMPDM) as this watercourse feeds strong fishery communities downstream.

4.5 Conclusions and Recommendations Telfer Creek

With the headwater portion of Telfer Creek being un-developed, there is an opportunity to establish sound stormwater management practices to prevent flooding and erosion issues as witnessed within Kenny Drain. Pre-development target flow rates and attenuation volumes established in this report will allow consultants to use various models or methods for post-development flows/storage volumes while removing the variation of pre-development targets that can be developed with different models. This will ensure that there is no peak flow and flooding increase in Telfer Creek. The general layout of the Tables provided in **Appendix A2** provides an excellent management and implementation tool by reducing review time by the City staff and improving response back to the proponent.

It is recommended that the water quality and erosion control follow the requirements of the Ministry of Environment 2003 Stormwater Management Planning and Design Manual. Enhanced level of protection is recommended with volumes as noted in Table 3.2 (SMPDM).

It is recommended that the landowners work together with the City to finalize centralized locations of stormwater management facilities, where possible, at low points in the local topography to service more than one development thereby increasing available development land (the net land area for a single facility is less than multiple facilities servicing the same drainage area due to grading/access requirements) and minimizing the need for the City to maintain multiple smaller SWM facilities. Preliminary SWM pond locations have been identified throughout the watershed within the City's limits and are illustrated on **Drawing SWM 4.**

5 Kenny Drain Analysis

5.1 Existing Hydrology

5.1.1 General

Kenny Drain is the most centrally located watershed analyzed in this report and provides drainage for approximately 400ha. Kenny Drain is generally bound to the south by 8th Street East, to the east by the former CP Rail line to the west by 9th Avenue East and finally to the north by 32nd Street East. Under existing conditions the majority of the southern portion of Kenny Drain is a developed region consisting of various commercial, industrial and institutional facilities. The northern portion of Kenny Drain contains scattered industrial and commercial facilities with large portions of un-developed lands. Refer to **Drawing SWM5** for an illustration. There is an opportunity for growth and development in this area.

Generally speaking, drainage is provided in a south to north manner. The storm sewer located on 8th Street East, at the most upstream portion of the Kenny Drain watershed, provides conveyance to a trunk storm sewer located on 16th Avenue East. The 16th Avenue East trunk sewer proceeds north of 8th Street East to 17th Street East providing conveyance for the following:

- approximately 1900m of 10th Street East, including drainage from the Grey Bruce Health Services Complex
- approximately 4.4km of existing development fronting 16th Street East
- approximately 2.0km of existing development fronting 16th Avenue East

Stormwater conveyance is provided by two means: north of the 17th Street East; and within the 16th Avenue East right of way. The first is a trunk storm sewer located beneath 16th Avenue East and the second is a channel located on the east limit of the 16th Avenue East right of way. This configuration provides conveyance for approximately 2.0km of existing development fronting 16th Avenue East including the Heritage Place Shopping Centre, Tennaco and P.P.G Industries.

Drainage is maintained through road side ditches and a well defined channel north of 20th Street East to 26th Street East. Further north of 26th Street East stormwater travels in the form of overland sheet and channelized flow to the former CP Rail corridor. North of the CP rail corridor drainage is once again conveyed through a well-defined man-made channel and ultimately discharging to Owen Sound Bay.

5.1.2 Soils Conditions

According to the Grey County soil map, prepared for the Department of Agriculture in 1959, Kenny Drain is mainly comprised of soils in the Hydrologic Soil Group C as illustrated in **Table 4.**

Table 4- Kenny Drain Soils Profile

Soil Code	Series	Hectares (ha)	Hyd Soil Group
Bp	Breypen	1.58	B
Wl	Wiarton	31.74	B
Bc	Brookston	123.33	C
Bc-b	Brookston	38.29	C
Esc	Elderslie	4.24	C
Ksc	Kemble	26.47	C
Mc	Morley	9.03	C
Vsc	Vincent	110.28	C
Dc	Dunedin	57.15	D

As shown in **Table 4**, soils falling in the Hydrologic Soil Group C total approximately 312 ha out of the total 402 ha. Therefore the Hydrologic Soil Group C has been used for further calculations. The Hydrologic Soil Group C consists of Brookston clay loam, Brookston bouldery clay loam, Elderslie clay loam, Kemble silty clay, Morley clay and finally Vincent silty clay loam. The hydrologic soil group was determined in accordance with the Ontario Ministry of Transportation (MTO) soil classification system. Since the majority of the soil composition located within the Kenny Drain watershed is comprised of Hydrologic Soil Group C, weighted runoff curve numbers have been calculated based on this soil grouping and land use. Refer to **Appendix B1** for detailed calculations.

5.1.3 Existing & Proposed Land Use Patterns

Existing condition land use patterns for Kenny Drain have been determined by field investigations and digital aerial photography as illustrated on **Drawing SWM 5**. The existing condition calculations for Kenny Drain have been prepared based on the assumption that all currently developed areas are assumed to be an "existing condition" with areas available for future development (currently undeveloped) based on existing native ground cover. Undeveloped land uses within this region consist of field crop and wooded areas. Refer to **Drawing SWM5** for details.

Post-development conditions are based on the Official Plan designation as illustrated on **Drawing SWM 6**. In general, the northern portion of Kenny Drain is comprised of large areas of undeveloped lands and smaller areas of light industrial, commercial and institutional developments.

Land use patterns show that the southern portion of Kenny Drain is comprised of various commercial, industrial and institutional facilities. Pervious land uses located within these developed areas consist mainly of grassed boulevards. Impervious areas located within each individual catchment area have been determined by viewing aerial photography and using GIS and AutoCAD tools.

5.1.4 Hydrologic Analysis

To accurately model existing and current watershed characteristics for the Kenny Drain several site plan stormwater management reports have been referenced. Reports received have been integrated into the Kenny Drain SWMHYMO hydrologic model by referencing design parameters and site plan methodology. By integrating design parameters and methodology into the existing condition/pre-development hydrologic model, calculated flows will accurately model baseline flows within the watershed.

The first approach in assembling the existing condition hydrologic model for the Kenny Drain was a review of at the headwater portion of the watershed by examining the following report;

- Surface Water Management Report, Andpet Subdivision, 16th Ave. East. Report completed by Gamsby and Mannerow Limited, dated April 2006.

Design parameters have been referenced from the Andpet Subdivision SWM report and imported into SWMHYMO. The Gamsby and Mannerow surface water management report has utilized the 1:100 year MIDUSS hydrologic model and has provided modeling for the upstream corridor of Kenny Drain. Hydrologic modeling provided in the Gamsby and Mannerow report has been completed from 8th Street East to the Andpet Subdivision located adjacent to 16th Avenue East just south of 16th Street East. Flow comparisons at various confluence points and nodes have been determined to be very similar between the MIDUSS and SWMYHYMO models. Other design parameters that have been referenced from external reports and integrated into the SWMHYMO Kenny Drain Hydrologic Model include:

- Site Plan Submission and Storm Water Management Report for Union Gas, 1602 23rd Street East. Report completed by The Walterfedy Partnership, dated March 13, 2006.
- Site Plan Miller Waste Systems- Waste Transfer Station. Report completed by W.G.Mills and Associates, dated September 15, 2004.
- Stormwater Management Design Brief Hwy 26 and 18th Ave. East Commercial Development. Report completed by Cosburn Patterson and Mather Limited, dated April 20, 1999.
- Stormwater Management Report Owen Sound Retirement Residence 1389 16th Ave. East. Report completed by Glos Associates Inc, dated July 2006.
- Preliminary Stormwater Management Plan, Andpet Commercial Development, North-East Corner 16th Street East and 16th Avenue East. Report completed by Gambsy and Mannerow Limited, dated April 2006.
- 16th Avenue East Reconstruction Drawings. Completed by Gambsy and Mannerow Limited, dated May 2006.

Flow nodes have been set up at key locations throughout the model to observe increases in stormwater runoff. These key locations have been pre-determined and set up at confluence points located at or near street intersections along 16th Avenue East and further north of 23rd Street East through undeveloped lands to Owen Sound Bay. Flow Node 1 has been set at the intersection of 16th Avenue East and 16th Street East. Flows to this node include the previously modeled catchments from the Gamsby and Mannerow Limited Surface Water Management report for the Andpet Subdivision located adjacent to 16th Avenue East. Flow nodes north of Node 1 have been identified numerically proceeding to Flow Node 10 at the Kenny Drain outlet at Owen Sound Bay. Lot fabrics, aerial photography and contour data provide a general understanding of catchment boundaries and drainage areas. Field visits were conducted to validate, as best as possible, drainage boundaries.

The existing storm sewer network provided by the City of Owen Sound has also been referenced and included in this report. The GIS generated storm sewer data has been used in the routing operations where possible. Cross-sectional survey data (Aqualogic 2006 and Burnside 2007) has also been completed and used in the channel routing north of Flow Node 5 to Flow Node 8. The existing channel in this section varies in cross sectional width and depth. The SWMHYMO SHIFT HYD command has been utilized in locations where storm sewer and channel data is not available. The SHIFT HYD command allows the routing to be considered for on smaller catchments by calculating the travel time without characteristics of a defined channel/pipe. Conveyance has been assumed to be provided through road side ditches and/or overland sheet flow. **Drawing SWM8** illustrates the SWMHYMO flow schematic for the three scenarios: existing, proposed with no SWM controls and proposed with SWM controls.

5.1.5 Hydrologic Results

By examining the configuration of catchment areas and existing conveyance facilities (i.e. storm sewer, channel, etc.) flows have been calculated to key flow nodes as illustrated on **Drawing SWM5**. The 6, 12, and 24-hour SCS Type-II as well as the 4-hour Chicago Storm rainfall distributions were used for the 1:2, 1:5, 1:10, 1:25, 1:50 and 1:100 year storm event calculations. The Regional storm event was based on the Timmins storm. The 6-hr SCS Type-II storm distribution has been determined to generate the highest peak flows. Using the SWMHYMO hydrologic model, flows have been determined to key flow nodes as illustrated below in **Table 5**. The SWMHYMO runs for the 6-hour SCS Type-II storm distributions can be found in **Appendix B1**.

Table 5- Kenny Drain Pre-Development Peak Flows

Storm Event	Peak Flow (m^3/s) to Designated Flow Nodes								
	TND1	TND2	TND3	TND4	TND5	TND6	TND8	TND9	TND10
2	1.83	2.56	0.55	6.05	6.83	6.93	7.29	7.36	7.31
5	2.39	3.43	1.37	8.22	9.54	9.91	10.62	10.80	10.79
10	2.77	4.02	2.46	9.92	11.49	12.10	13.05	13.32	13.36
25	3.21	4.75	3.79	12.25	14.24	15.12	16.41	16.81	16.88
50	3.93	5.29	4.77	14.14	16.45	17.51	19.05	19.56	19.68
100	5.05	5.87	5.81	16.06	18.76	20.05	21.87	22.51	22.68
TIMMINS	7.84	9.27	8.94	19.01	22.69	24.30	27.30	28.31	28.88

***the notation TND refers to total peak flow to a corresponding flow node. Total peak flow to an individual flow node can be determined by the number designation of the flow node.**

*** Locations of Flow Nodes**

TND1 - Intersection of 16th Avenue East and 16th Street East
TND2 - Intersection of 16th Avenue East and 17th Street East
TND3 - 16th Avenue East and North East corner of Heritage Place Shopping Center
TND4 - Intersection of 16th Avenue East and 20th Street East
TND5 - North limit of 23rd Street East, approx 1.7 km east of 16th Avenue East
TND6 - North limit of 26th Street East, approx 1.8 km east of 9th Avenue East
TND8 - Intersection of channel and CP Trail, north of 26th Street East
TND9- Intersection of drainage channel and 9th Avenue East
TND10 - Outlet at Owen Sound Bay

Pre-development peak flows shown in **Table 5**, illustrate a significant flow increase from Flow Node 3 to Flow Node 4. This increase in flow can be explained by the current drainage configuration to Flow Node 4 located at the intersection of 16th Avenue East and 20th Street East. Flow Node 4 is a significant confluence point within the Kenny Drain watershed. Flow north of flow Node 2 is split between an existing storm sewer and channel. Minor system flow is conveyed through an existing 1200 x 900 mm concrete box culvert while major system flow is conveyed via a channel located on the east side of 16th Avenue East. These facilities accept runoff from the 16th Avenue East right-of-way and adjacent developments and provide conveyance for flows generated upstream. The box culvert and channel further continue through Flow Node 3 accepting additional runoff from the Heritage Place Shopping Centre and Tennaco. Flow is further conveyed north to Flow Node 4. At Flow Node 4 the 1200 x 900 mm concrete box culvert and channel converge at 20th Street East and 16th Avenue East.

5.2 Proposed Hydrology

5.2.1 General

Generally catchments located south of 23rd Street East are in a fully developed condition with the exception of Catchments 1, 2a and 2b (refer to **Drawing SWM6**). Catchments 1, 2a and 2b are located at the east limit of the watershed and adjacent to the CP Rail Trail. Under existing conditions these catchment areas are undeveloped consisting of mainly treed ground cover. Post-development conditions, under the City of Owen Sound Official Plan, assume that Catchment 1 will be comprised of commercial and industrial land uses, Catchment 2a zoned for commercial land use and finally Catchment 2b will be comprised entirely of industrial facilities as illustrated on **Drawing SWM6**.

In addition to the current developed areas, three future proposed land use types are predominant in the Official Land Use Plan and located within the catchment boundaries of the Kenny Drain. As a variety of configurations of buildings and parking facilities can be incorporated into a site plan for the various land use types a conservative approach has been taken to assess total runoff. **Table 6** shown below, outlines the basic approach in assessing developments with high impervious areas. These design parameters have been used in the forecasting of post-development peak flow rates.

Table 6: Kenny Drain Post-Development Condition Design Parameters

City of Owen Sound Official Land Use	TIMP (%)	XIMP (%)	General Notes
Residential	50	30	- Low density developments
Commercial	90	90	- Mostly Impervious Area
Industrial	75	75	- Mostly Impervious Area
Institutional	65	40	- Mostly Impervious areas with drainage to grass fields.

***TIMP- Total Impervious Area Percentage of Catchment Area**
***XIMP- Total Impervious Area Percentage directly connected to storm sewer and SWM Facilities**

5.2.2 Analysis and Commentary

A total of eight catchments consisting of approximately 88 ha have been used in conjunction with the Official Land Use Plan to determine complete future build out conditions north of 23rd Street East. Three catchment areas totaling approximately 25 ha north of 16th Street East and adjacent to the CP Rail Trail have also been considered for future build out. Existing developments located within the watershed north of 16th Street East that have potential to expand within their respective catchment boundaries have also been considered to develop a full build out condition. Using the Official Land Use Plan, two post-development models have been compiled to assess the post-development peak flows.

The first post-development model examines peak flows without additional attenuation or future SWM ponds in build out areas. Results are illustrated in **Table 7**. This model will aid in the understanding of an entire "built-out" condition without attenuation of the Kenny Drain. The SWMHYMO runs for the 6-hour SCS Type-II storm distributions can be found in **Appendix B2.**

Table 7- Kenny Drain Post-Development Peak Flows Without Ponds

Event	Peak Flow (m^3/s) to Designated Flow Node								
	TND1	TND2	TND3	TND4	TND5	TND6	TND8	TND9	TND10
2	1.83	2.92	2.17	6.80	8.56	11.12	11.56	11.55	11.71
5	2.39	3.86	3.00	9.22	11.46	15.11	15.94	16.04	16.31
10	2.77	4.49	4.00	11.13	13.68	17.99	19.05	19.22	19.57
25	3.21	5.27	5.41	13.58	16.70	22.02	23.44	23.65	24.12
50	3.93	5.86	6.54	15.42	18.97	25.19	26.86	27.16	27.71
100	5.05	6.43	8.27	17.60	21.31	28.37	30.30	30.69	31.31
TIMMINS	7.84	9.37	10.82	20.95	24.92	29.96	31.76	32.75	33.47

Peak flows to TND1 and TDN2 remain relatively unchanged in the proposed condition with notable flow increases to the flow nodes located north of Flow node 2 due to increased development.

The second post development model considers implementation of stormwater management ponds for attenuation of peak flows to pre-development rates, flows are illustrated in **Table 8** shown below. The SWMHYMO runs for the 6-hour SCS Type-II storm distributions can be found in **Appendix B2.**

Table 8- Kenny Drain Post-Development Peak Flows With Ponds (All Catchments)

Event	Peak Flow (m^3/s) to Designated Flow Node								
	TND1	TND2	TND3	TND4	TND5	TND6	TND8	TND9	TND10
2	1.83	2.56	0.58	6.07	6.75	6.92	7.33	7.45	7.59
5	2.39	3.42	1.39	8.25	9.39	9.78	10.52	10.77	10.98
10	2.77	4.01	2.48	9.98	11.50	12.07	13.01	13.37	13.63
25	3.21	4.75	3.82	12.36	14.42	15.28	16.54	17.00	17.33
50	3.93	5.28	4.81	14.21	16.59	17.69	19.19	19.77	20.15
100	5.05	5.97	5.86	16.15	19.01	20.39	22.11	22.82	23.27
TIMMINS	7.84	9.29	9.16	19.30	23.03	28.05	29.88	30.90	31.57

Table 8 represents peak flow attenuation with stormwater management ponds. Ponds have been added to each newly proposed catchment area to attenuate post-development flows to pre-development rates. SWM ponds have not been added to existing developed areas. Initial modeling of post-development conditions with stormwater management ponds has yielded attenuated flows to be significantly larger than pre-developed rates. The increase in flow can be explained by the timing of release rates. The implementation of SWM ponds has resulted in the direct addition of peak flows from several catchment areas. The addition of peak flows has resulted in a higher overall runoff.

To achieve optimal release rate conditions and to avoid the direct addition of peak flows, quantity stormwater management ponds were removed from the model on a per catchment basis starting at the downstream limit of Kenny Drain. The flow rates associated with removing a single pond were noted at each flow node and compared to the pre-development flow rates. If the post-development flows were larger than pre-development flows, removal of additional quantity control ponds was completed on a per catchment basis until post-development peak flow rates matched pre-development rates.

Through analysis it has been determined that by not attenuating peak flows north of 26th Street East and by attenuating flows (with quantity and quality control SWM ponds) south of 26th Street East, post development flows will match pre-development flows as illustrated in **Table 9** below. Without the attenuation of peak flows north of 26th Street East, timing of release rates is such that peak flows in the downstream section of the watershed will be discharged to Owen Sound Bay prior to combining with flows from developments south of 26th Street East. The proposed SWM plan is illustrated on Drawings **SWM 6** and **SWM 7.**

Table 9- Kenny Drain Post-Development Peak Flows Without Quantity Control North of 26th Street East

Event	Peak Flow (m^3/s) to Designated Flow Node								
	TND1	TND2	TND3	TND4	TND5	TND6	TND8	TND9	TND10
2	1.83	2.56	0.58	6.07	6.75	6.92	7.35	7.45	7.60
5	2.39	3.42	1.39	8.25	9.39	9.78	10.44	10.68	10.92
10	2.77	4.01	2.48	9.98	11.50	12.07	12.86	13.21	13.50
25	3.21	4.75	3.82	12.36	14.42	15.28	16.30	16.78	17.13
50	3.93	5.28	4.81	14.21	16.59	17.69	18.90	19.47	19.89
100	5.05	5.97	5.86	16.15	19.01	20.39	21.76	22.46	22.94
TIMMINS	7.84	9.29	9.16	19.30	23.03	28.05	29.80	30.82	31.49

Stormwater management ponds were further removed from the model to observe changes in flow patterns through key areas of the catchment. By removing additional ponds located between 23rd Street and 26th Street East a flow increase of 3-5 m^3/s was observed to be produced at Flow Nodes 6-10. The removal of these additional ponds reveals the threshold limit and timing of peak flows produced in the model.

5.3 Erosion Threshold Analysis

Aqualogic was retained to assist in determining the erosion thresholds of Kenny Drain. Refer to **Appendix C** for complete details of the Erosion Threshold Analysis.

The erosion analysis determined that erosion of the Kenny Drain occurs when the peak flow rate is greater than $0.7m^3/s$. The peak flow analysis determined that the 1 in 2-year storm has a peak flow rate of $6.7m^3/s$ at the critical location which is approximately 10 times greater than the threshold rate. Given the limited opportunities to reduce the peak flow to this extent, due to the existing developed condition of the watershed, it is recommended that a reach of the Kenny Drain, approximately 750m between 20th Street East to a point upstream of the CP rail trail, have its banks protected from erosion to increase water quality at the outlet at Owen Sound Bay.

Extended detention provides a means of holding back urban runoff to allow release of the first flush (1 in 1.5 year to 2 year storm) over a longer period of time to reduce the impact of runoff volume increases following development. Erosion thresholds are determined at critical locations along the watercourse where increases in the number of times and period by which the threshold is exceeded increases the erosion following development. This can be mitigated by extending the period of time to release the first flush through SWM facilities being incorporated with a special extended detention control structure, typically a small orifice plate (greater than 75mm diameter). With this method the number of times the erosion threshold is exceeded remains the same as existing conditions even though the runoff volume in total has increased with development.

The MOE SMPDM March 2003 recommends the greater of site specific requirements or $40m^3$/ha over 24hrs minimum for extended detention in Stormwater management ponds. Based on the findings of the Erosion Threshold Analysis the minimum of $40m^3$/ha over 24hrs minimum is recommended for extended Stormwater control in future SWM ponds with the armouring of the noted section of Kenny Drain. It is recommended that additional deep-rooted vegetation be planted or existing vegetation be kept wherever possible in the channel and its banks to maintain its current stable characteristics. Should the low flow channel be disturbed in stable areas, the vegetation should be reinstated to equal or better.

5.4 Water Quality Control

It is recommended that water quality control follow the requirements of the Ministry of Environment 2003 Stormwater Management Planning and Design Manual (SMPDM). Enhanced level of protection is recommended with volumes as noted in Table 3.2 of this document (SMPDM) as this watercourse outlet is located adjacent to the City's water intake and to fisheries within Owen Sound Bay.

5.5 Conclusions and Recommendations for Stormwater Management Kenny Drain

Stormwater management quality and quantity ponds are recommended for all developing areas south of 26^{th} Street East. Stormwater management quality ponds (without quantity control) are recommended for all lands developed north of 26^{th} Street East. The timing of peak flows allows the downstream portions of the watershed to discharge without quantity control prior to the peak of the upstream areas with quantity control. The time lag between the peak flows generated by the two distinct areas mentioned above avoids the straight addition of the peak flows.

A review of cash-in-lieu of SWM ponds without quantity control and cash-in-lieu of SWM ponds for sites less than 5ha should be reviewed through the updated ESR. This cash may initiate the funding for erosion protection along the Kenny Drain. Sites less than 5ha is size will require an oil grit separator (OGS or equivalent) as a minimum water quality standard to meet 80% Total Suspended Solids (TSS) removal.

It is recommended that a reach of Kenny Drain, approximately 750m between 20^{th} Street East to a point upstream of the CP rail trail, have its banks protected from erosion to increase water quality at the outlet at Owen Sound Bay.

It is recommended that water quality and erosion control follow the requirements of the Ministry of Environment 2003 Stormwater Management Planning and Design Manual (SMPDM). Enhanced level of protection is recommended with volumes as noted in Table 3.2 (SMPDM).

5.6 Hec-Ras Modeling Kenny Drain

5.6.1 Hydraulic Analysis

5.6.1.1 Introduction

This section of the report summarizes the analysis carried out to define the backwater flood elevations and develop updated digital floodline mapping for the downstream section of the Kenny Drain watershed. As part of this report, the existing hydraulic and hydrologic models for the Kenny Drain watershed have been updated and/or extended, or new models have been created as required. To coincide with the hydraulic and hydrologic models, floodline mapping has been commissioned, updated or extended accordingly.

5.6.1.2 Purpose

The purpose of this section of the study is to develop an updated hydraulic model (HEC-RAS 3.1.3) for the Kenny Drain, from Owen Sound Bay to approximately 240m north along 16th Avenue East from the intersection of 16th Avenue East and 20th Street East in Owen Sound. Through this hydraulic application the floodplain limits for this watercourse will be evaluated by developing updated mapping.

5.6.1.3 Study Area

1:2000 OBM mapping for the study was provided by the City of Owen Sound. The proposed floodline mapping update for the Kenny Drain required the preparation of one (1) map sheet spanning from Owen Sound Bay to approximately 240m north along 16th Avenue East from the intersection of 16th Avenue East and 20th Street East in Owen Sound.

5.6.1.4 Background Information

The following key information and data was provided by the City of Owen Sound to initiate the project:

- Digital base mapping covering the study area (the mapping is dated and field visits and recent MNR aerial photography was used to fill in erroneous data).
- A hard copy of the existing hydraulic model floodline map sheet for the Kenny Drain.
- Previous hydrologic reports (text, modeling, drawings, etc.) pertaining to the headwaters of the Kenny Drain. This information was provided to aid in the existing hydrologic model update in order to determine peak flows for 2- to 100-year and Regional storm events.

Several field visits were conducted by R.J. Burnside & Associates Limited to review data and to verify information obtained from other sources and to obtain an understanding of the vegetation and general watercourse hydraulics. For the hydraulic analysis, the fieldwork consisted of:

a) Site investigation – to confirm hydraulic structures and low flow channel forms, and take photographs. Burnside also noted the shape and surface characteristics of the drainage course, the degree of maintenance applied to the drainage course and the terrestrial cover of the drainage course floodplain area.
b) Detailed topographic cross sections using a total station in key locations to get current representative cross sections.

5.6.2 Study Approach

5.6.2.1 Purpose

The major components of the project consisted of reviewing structures in the field, preparing a HEC-RAS model (Version 3.1.3), and using flow rate information determined by R.J. Burnside and Associates Limited to generate new digital floodline mapping. An existing hydraulic model report was provided to allow for reference purposes when updating the model.

5.6.2.2 Project Approach

The general components of this project are:

- Creation of a hydraulic model for the watercourse using the HEC-RAS software package (Version 3.1.3) in order to generate flood level estimates for the 2- to 100-year and Regional Storm peak flows.
- Preparation of digital floodplain mapping for the watercourse using the results of the hydraulic analysis.

Burnside developed the model using BOSS RiverCAD to produce floodlines for the subject areas. The BOSS RiverCAD program provides interface modules that links AutoCAD with HEC-RAS 3.1.3. It permitted the integration of the provided 1:2000 Ontario Base Mapping and facilitates the locating and automatic generation of cross-sections. The seamless transfer of the cross-section information into HEC-RAS through BOSS RiverCAD from the OBM avoided errors associated with traditional approaches that rely on manual input.

Tasks

The following tasks were performed:

1. Develop a hydraulic model for the Kenny Drain:

   a) All hydraulic structures were verified based upon survey information.

b) Coded all cross-sections and hydraulic structures. Low flow channel details were derived from field measurements.
c) Flows were input as per the flow tables located in **Section 5.2, Table 8**. All flow change locations were reviewed and additional flow points added as required. Return period and Regional Storm flows were based on the future conditions model. Manning's 'n' values at all cross-sections were coded to represent ultimate re-vegetation potential as per the HEC-RAS model standards for watershed hydraulic modeling.
d) Detailed comments were provided in the HEC-RAS model for all hydraulic structures; including any assumptions with respect to modeling approach.
e) Flood elevations were calculated using the U.S. Army Corps of Engineer's HEC-RAS Version 3.1.3 computer model. Flood levels were generated for the 2-, 5-, 25-, 100-year and Regional storm events for the Kenny Drain. Summary tables are included in **Appendix B3**.
f) The digital floodline was provided for the Regulatory Storm for the Kenny Drain (the greater of the 100-year or Regional storm). The coordinate system of the floodlines matches that of the digital base mapping provided by the City of Owen Sound.

5.6.3 Floodplain Topography

5.6.3.1 General

The aerial photography 1:2000 base mapping was supplied by the City of Owen Sound and used to cut cross-sections generally perpendicular to the contour (or direction of flow). The topography is generally well-defined valley sections within a mix of urban and rural areas. Spill areas were checked and additional information provided in Section 6.2. The use of Boss RiverCAD™ allowed the sections to be cut directly from the base mapping to reduce user error and quicken the pace of coding the geometry of the floodplain.

To define low flow channel cross sections, detailed survey information was collected at key locations along the watercourse. This allowed refinement of the cross sections to current conditions and verify invert and top of road elevations.

5.6.4 The HEC-RAS Computer Model

For the calculation of water surface profiles for the Kenny Drain updates, the HEC-RAS version 3.1.3 computer model developed by the U.S. Army Corps of Engineers has been utilized. This model estimates the change in water surface elevation between selected valley cross-sections and has special routines to account for local increases in water levels due to bridges and/or other flow obstructions. The model is intended for utilization in the analysis of water surface profiles of steady state, gradually varied, one-dimensional flow in natural and man-made channels.

A number of considerations are required in the selection of data and variables to be used in the application of the HEC-RAS model to the floodplains of the study area and these are as follows:

i) Selection of Cross-sections
ii) Selection of Bridge and Culvert Routines

iii) Selection of Hydraulic Parameters
iv) Selection of Starting Water Surface Elevation

5.6.5 Selection of Digitized Cross-Sections

Floodplain boundaries and the lateral extension of flows along a natural stream are controlled by the topographic relief within which the stream flows. This relief is quantified in terms of ground surface elevations and/or contours. For utilization in the HEC-RAS program, it was necessary to convert this topographic relief into its geometric configuration represented by cross-sections of the valley taken perpendicular to the direction of flow. Furthermore, it was necessary to represent the linear topographic relief and variability by drawing repetitive cross-sections at various intervals throughout the length of the valley systems. The distance between the cross-sections required to represent the valley system is referred to as the reach length.

For the selection of digitized cross-sections which are representative of the Kenny Drain, the following criteria were used:

1) Location of Cross-sections

   The digitized cross-sections were initially taken from the topographic maps looking in a downstream direction for the Kenny Drain as per the standard convention associated with HEC-RAS at locations described as follows:

   - Changes in channel and/or valley cross-sectional shape.
   - Rapid changes in channel or valley slope.
   - Significant changes in channel or valley roughness.
   - Upstream and downstream of bridges.
   - At all defined control points.
   - Upstream and downstream of all channel confluences.

2) Orientation of Cross-sections

   Cross-section segments were taken perpendicular to the anticipated direction of flow within the cross-section from left to right looking downstream for the Kenny Drain hydraulic model.

3) Cross-section Spacing and Alignment

   Following the initial evaluation of output using the digitized cross-sections selected as noted above, additional sections were added when calculations indicated any of the following conditions:

   - Where energy slope decreased significantly.
   - Where energy slope increased significantly.
   - When significant changes in the conveyance of adjacent sections were observed.

- Where topographic representation of flow between cross-sections indicated unrealistic transition.

These sections were reviewed and manually edited where needed in the HEC-RAS software. HEC-RAS input geometry files were re-cut from the topographic mapping and iterated through a visual examination of plotted cross-sections and model-generated warnings until the correct number and location of sections provided no warnings.

4) Reach Length

For the determination of reach lengths, the topographic maps were measured between cross-sections parallel to the estimated direction of flow along the low flow channel and along the centroid of water mass moving through the floodplain using the BOSS RiverCAD software. For each reach, a minimum of three lengths was measured defining the channel, right and left overbank flow paths.

For the selection of the direction of the reach length measurement, the topographic relief was analyzed to interpret the direction of flow in the particular reach of the watercourse.

5.6.6 Hydraulic Parameters

Coefficients used in the model evaluate head losses as follows:

- Manning's 'n' values are used to compute flow friction losses and are based on the HEC-RAS standards depending on the terrestrial features.
- Expansion and contraction coefficients for the study area floodplains have been set at 0.1 and 0.3, respectively, for all areas due to the relative uniformity of cross-sectional transitions. For bridge sections, expansion and contraction coefficients have been estimated at 0.3 and 0.5, respectively.
- Bridge loss coefficients relate head losses to weir shape, pier configuration and pressure flow. Conduit shapes have been determined from field survey/visits and appropriate loss coefficients referenced from the HEC-RAS user manual.

5.6.7 Flood Flows

Flood flows for the study area have been determined based on an updated hydrologic model prepared by R.J. Burnside and Associates Limited. Peak flows for the Regional Storm (Timmins Storm) and design return period events are included in **Appendix B3**. The peak flows are based on the future controlled conditions. Flow change locations were reviewed to confirm appropriate changes based on confluences or stormwater management pond input.

5.6.8 Starting Water Surface Elevations

The starting water surface elevation can have an impact on the water surface profiles of the reach of study area. The starting water level for the Kenny Drain hydraulic model was the Lake Huron (Owen Sound Bay) starting level of 176.46m.

5.6.9 Hydraulic Structures

The hydraulic structure information was supplemented with data acquired during the field surveys and investigation. This data included the location, orientation, elevation, width and height, composition, inlet/outlet characteristics, and overflow profile of all hydraulic structures within the study area, including bridges, culverts and weirs.

Each hydraulic structure includes notes in the HEC-RAS comment/description area.

Hydraulic structures such as bridges, culverts and roadways have the greatest potential to change the flood elevation for a given reach assuming a constant flow. Each structure within the study area limits was coded into the hydraulic model based on field survey information. A visual field review by Burnside confirmed the general size, shape, length, type and location of each modeled structure. The following additional checks were performed to ensure these structures were modeled correctly, with additional notes for unique areas:

- Each structure was reviewed and adjusted to use the weir/pressure flow modeling approach or the energy equation. If the structure is highly submerged, such as a pedestrian crossing (i.e., park or golf course), or experiencing a low flow condition (below the obvert), then the energy equation is used; for high flow, the weir/pressure flow modeling approach was used. Expansion and contraction coefficients were checked and inserted as required.

<u>Analysis of HEC-RAS Output and Floodplain Mapping</u>

Output from the HEC-RAS hydraulics model is calculated in an upstream direction with a printout of critical factors determining flow parameters for each cross-section. Summary output is provided in **Appendix B3**.

5.6.10 Flood-Prone Areas

A review of the updated Floodplain Mapping indicates that there are no existing buildings/homes subjected to flooding under the Regional Storm. The map sheet was reviewed to determine if any homes or buildings were located within the floodplain and no instances of potential inundation were discovered.

The following from upstream to downstream are roadways/structures that are overtopped during the Regional storm:

- 23rd Street East
- 26th Street East
- Inline weir structure located within the Kenny Drain between the quality control pond and the soccer complex just downstream of the CP railway trail.

5.6.11 Analysis of Spill Areas

Potential spills were reviewed and identified on the mapping. The following spills are noted for Kenny Drain:

- A spill occurs immediately upstream of the CP railway trail crossing (Crossing 3 in the hydraulic model and on the Floodline Map Sheet). The potential spill in this location drains west along the south side of the CP railway trail to the north side of 3rd Avenue East and ultimately to Owen Sound Bay.
- Another spill occurs immediately downstream of the CP railway trail crossing (Crossing 3 in the hydraulic model and on the Floodline Map Sheet). The potential spill in this location drains north around the east side of the adjacent soccer field and then traverses west back to the Kenny Drain via a swale between the two (2) existing soccer fields.
- The final spill occurs immediately upstream of 9th Avenue East crossing (Crossing 4 in the hydraulic model and on the Floodline Map Sheet). The potential spill in this location drains north along the east ditch of 9th Avenue East and ultimately to Owen Sound Bay via this ditch network.

6 East Bluffs Storm Sewer Analysis

6.1 Introduction

This section of the report summarizes the analysis of the two (2) existing storm sewer systems located in the area known as the East Bluffs of the City of Owen Sound. There are two distinct storm sewer systems within the East Bluffs which have been labeled as the South and North Storm Sewer Systems.

The South Storm Sewer system is bound to the east by 9th Street Avenue East, to the south by 19th Street East and west by Owen Sound Bay. The North Storm Sewer system is bound to the north by 28th Street East and to the east by 9th Avenue East and west by Owen Sound Bay the same as the South Storm Sewer system. The boundary separating the North and South Storm Sewer systems is approximately the halfway point between 23rd Street East and 25th Street East.

The South Storm Sewer system consists of three (3) external drainage areas all located east of 9th Avenue East. The North Storm Sewer System does not consist of any external drainage areas. All external drainage areas have not been considered in the description of the storm sewer system boundaries mentioned above.

6.2 Purpose

The purpose of this section of the study is to analyze the existing North and South Storm Sewer systems located within the East Bluffs of the City of Owen Sound. In addition the study is to analyze and determine the impacts of the potential future infill developments on the existing storm sewer systems and provide solutions to minimize any negative impacts that may be associated with this potential development.

6.3 Background Information

The following key information and data was provided by the City of Owen Sound to initiate the project:

- Digital base mapping covering the study area (included topography of the area, existing storm sewer layout, and official plan information).
- Existing Storm Sewer data (i.e. inverts, lengths, sizes, etc.) where available.
- Additional information regarding the study areas drainage history based on field investigations and past experiences.
- Previous reports (text, modeling, drawings, etc.) pertaining to the developments within or adjacent to the study area.
- Future development application plans and drainage boundaries where available.

6.4 Study Approach

6.4.1 Purpose

The major components of this portion of the project consisted of reviewing background information, preparing a Rational Method analysis on the existing storm sewer systems and providing alternative solutions to improve the existing storm sewer systems in the future condition (i.e. prior to infill development occurring).

6.4.2 Tasks

The following tasks were performed:

1. Develop a Rational Method Analysis for both the North and South Storm Sewer systems located in the East Bluffs of the City of Owen Sound:

   a) Develop a spreadsheet Rational Method Analysis of the existing storm sewer systems and proposed storm sewer system to model their connectivity and catchment areas.
   b) Code in all the storm sewer information provided by the City of Owen Sound and use standard storm sewer design practices to fill in the blank/unknown areas to determine the capacities of the pipes.

c) Delineate the drainage areas to each section of storm sewer and determine an approximate value for the runoff coefficient for the corresponding areas.
d) Finally, based on the Owen Sound Rainfall Intensity-Duration-Frequency (IDF) data provided by Environment Canada's Atmospheric Environment Service, the 5-year storm event rainfall intensities were calculated for each catchment area considered in the analysis. The 5-year storm peak flow rates were then determined by the Rational Method based on the information listed above and these peak flows were compared to the corresponding pipe capacities calculated.

6.5 The Rational Method

6.5.1 Hydrologic Parameters

The Rational Method formula can be expressed in metric units as follows:

$$Q = 0.00278*C*I*A$$

Where Q = required design discharge (m3/s);
C = runoff coefficient (dimensionless);
I = average rainfall intensity for a duration equal to the time of concentration (mm/hr); and
A = effective watershed area (ha).

The formula implies that the rate of runoff (Q) is equal to a fraction (C) of the rate of supply of water (I) to the watershed area (A), and reaches its maximum if steady, uniform rain lasts long enough for the entire watershed to contribute. The time required for the entire watershed to contribute is equal to the time taken by the water to flow from the farthest point of the basin to the proposed crossing, and is called the time of concentration; the rainfall intensity is determined for this particular duration from intensity-duration-frequency data.

6.6 Hydraulic Parameters

The hydraulic parameters used in the calculation of the pipe capacities are as follows:

- Length
- Slope
- Diameter
- Roughness (Manning's Roughness Coefficient)

Using the pipe parameters listed above the capacity of the pipe, velocity within the pipe, time of flow through the pipe from one end to the other, etc. can be determined for each section of the storm sewer system.

6.7 Analysis of the Rational Method

6.7.1 Existing Condition Results

The following are sections of the existing storm sewer systems that have been determined to be of insufficient capacity based on the 5-year storm event rainfall:

South Storm Sewer (Scenario 1)

a) Between MH44 and MH43
b) Between MH63 and MH62
c) Between MH62 and MH61
d) Between MH61 and MH60
e) Between MH60 and MH59
f) Between MH59 and MH58
g) Between MH58 and MH57
h) Between MH42 and MH39
i) Between MH41 and MH40
j) Between MH54 and MH53
k) Between MH53 and MH51
l) Between MH52 and MH51
m) Between MH51 and MH50
n) Between MH50 and MH49
o) Between MH49 and MH48
p) Between MH48 and MH47
q) Between MH47 and MH38

North Storm Sewer (Scenario 1)

a) Between MH34 and MH33
b) Between MH28 and MH27
c) Between MH27 and MH26
d) Between MH26 and MH22
e) Between MH22 and MH7
f) Between MH18 and MH17
g) Between MH17 and MH16
h) Between MH15 and MH14
i) Between MH14 and MH12
j) Between MH13 and MH12
k) Between MH12 and MH11
l) Between MH11 and MH10
m) Between MH10 and MH9
n) Between MH9 and MH8
o) Between MH7 and MH4
p) Between MH4 and MH3
q) Between MH3 and MH2
r) Between MH1 and OUTLET

Please refer to **Appendix D** of this report for the South Storm Sewer Design Sheet (Scenario 1) and the North Storm Sewer Design Sheet and for the corresponding figures, FIG2 and FIG4, respectively. It should be noted that the spreadsheet analysis may determine theoretical insufficient pipe capacity but actual pipe flows may be lower based on actual catchbasin density (i.e. lower catchbasin density may not actually capture the entire 5-year design flow). In addition, these systems may have been designed similar to the 15th Street B East area as a two-year system. However in areas with infill development proposed these section of storm sewer should be considered for additional detailed analysis.

6.8 Future Alternative Solution Results

Based on the potential infill development locations in the area of the East Bluffs, the only storm sewer system likely to face the impacts of future development is the South Storm Sewer system due to the current development pressures in this area.

In general, to improve the efficiency of the existing South Storm Sewer system under the future condition consists of the following changes/modifications:

- Abandon the pipe between MH59 and MH58.
- Direct the runoff from MH59 north to MH62 and enlarge these pipes accordingly.
- Connect MH62 to MH55.
- Abandon the pipe between MH51 and MH50.
- Enlarge the pipes between MH55 to MH51 and then convey the flows from MH51 through the future infill development to the west of 8th Avenue East via a proposed storm sewer system that will connect back into the trunk at MH 35. The infill development should consider the external flows as noted in the report.

The above noted changes/modifications result in several reductions in the existing storm sewer peak flows through in the South Storm Sewer system thereby reducing the number of sewers listed in Section 6.7.1 above. This alternative to improve the future condition drainage of the South Storm Sewer system, achieves a reasonable amount of improvement with minimal alteration to the existing system ultimately making it a cost effective solution. It should be noted that bedrock has been noted by City Staff at a fairly shallow depth. The preferred approach by the City should be further evaluated at detailed design with a few test digs or a geotechnical study to minimize cutting into bedrock.

The following are sections of the existing South Storm Sewer system after modifications (Scenario 2) that have been determined to be of insufficient capacity based on the 5-year storm event rainfall:

South Storm Sewer (Scenario 2)

a) Between MH44 and MH43
b) Between MH42 and MH39
c) Between MH41 and MH40
d) Between MH49 and MH48

e) Between MH63 and MH62
f) Between MH62 and MH55
g) Between MH55 and MH54
h) Between MH54 and MH53
i) Between MH53 and MH51
j) Between MH52 and MH51
k) Between MH51 and MH35a

Please refer to **Appendix D** of this report for the South Storm Sewer Design Sheet (Scenario 2) and for the corresponding figure, **FIG3.**

6.9 Conclusions/Recommendations

Based on the Rational Method analysis outlined above, both the existing South and North Storm Sewer systems of the East Bluffs consist of sections of pipe that are of theoretical insufficient capacity. Many of the areas of the existing storm sewer systems that do not have sufficient capacity, however, have not been noted by municipal staff to be potential problem areas to date should be taken into consideration during the implementation of future infill development to avoid any potential problems. These systems may have been designed using the older standard of 1:2 year design storm, therefore the result of insufficient capacity for some pipes. Finally, based on the current development pressures present in the area of the South Storm Sewer system, the South Storm Sewer Design (Scenario 2) has been provided as a potential alternative to improve the drainage characteristics in this area while remaining as cost effective as possible to achieve a solution.

7 15th Street "B" East Storm Sewer Analysis

7.1 Introduction and Purpose

Severe flooding was reported following rainfall events in the vicinity of 15th Street B East over the weekend of May 22-23, 2004 and again on July 26, 2006. The street flooding resulted in several basements being inundated along with significant ponding of runoff in the area of 15th Street B East and 12th Avenue East. During this time frame the construction of Heritage Heights, located to the east, was on-going. A detailed dual drainage analysis was completed to determine why this area was flooding and what improvements could remedy the situation.

7.2 Background Information

- Miscellaneous drawings from Contract No. 7422C for the 15th Street B East area. Date unknown.
- Heritage Heights, City of Owen Sound, As-Constructed Drawings, Gamsby Mannerow Limited, January 2005.
- Various minutes and reports from the Operations Advisory Committee, City of Owen Sound, July 2005 to September 29, 2005. This included reports and photos from local residents.
- Flow Monitoring, Thompson Flow Investigations Inc. 2006.

7.3 Study Approach

The hydrologic model OTTSWMM was utilized to assess the 15th Street B East area where a greater level of detail is required to isolate each storm sewer or road segment and understand how catchbasin density affects the peak flow within the storm sewer system. The model allows both the available pipe capacity and the depth of flow on the road network to be checked at the same time based on a design storm event.

The best available as-built information for the catchment area and consultant's drawings for adjacent under-construction or proposed developments were used to develop the catchment area parameters. This included the Heritage Heights Development and the Andept Subdivision to the east. A flow meter was installed in the 600mm dia. storm sewer on 12th Avenue East to monitor storm sewer flow rates, levels and compare against measured rainfall volumes. Photos and reports from local residence helped to understand the extent of flooding and validate the model.

7.3.1 Tasks

The following tasks were performed for the dual drainage analysis:

- Review existing studies, drawings and historical reports of flooding.
- Determine drainage areas under May 22/23 2004 conditions.
- Determine future drainage areas with Heritage Heights, Andpet and a 10th Street cut off swale.
- Identify existing sewer locations, sizes, lengths, slopes, number of catchbasins, road types and road slopes.
- Identify drainage areas to each manhole and rear lot catchbasin.
- Develop both the "worst case" May 2004 and future conditions dual drainage models.
- Run the models using the Owen Sound 5-year and 100-year design storms. May 22/23 storm was equivalent in volume to 1:100 year storm.
- Review the street flow depths from the May 2004 simulation and compare to photos as presented in the Operations Advisory Committee Report.
- Review sewer flows as a ratio of Q/Q_{full}. $Q/Q_{full} > 1$ means the sewer is surcharging due to lack of capacity. This does not take into account the downstream sewer backing up which may actually create a worst condition.
- Review results once areas such as Georgian College and Andpet areas are removed in the future model.
- Review opportunities within the Heritage Heights and 15th Street B East areas to reduce flows into the storm sewer (i.e. Redirect flows, add inlet control devices (ICDs)).

7.4 Summary of Dual Drainage Analysis (OTTSWMM)

7.4.1 Existing Condition Results

The following key points were noted from the analysis:

- May 22/23 storm volume was more than a 1:100 year event.
- The runoff from external areas of Georgian College, Heritage Heights and Andpet Subdivision contributed significantly to the flooding problem.
- The model output is validated by illustrating that the major system flow extended more than 3.0m past each curb. This is confirmed with the photos during the peak of the flow on 15th Street B East.
- The 15th Street B East area storm sewer was designed most likely using a 1:2 year storm which was the accepted practice across Southern Ontario at that time.

7.5 Proposed Modification to Existing System

The existing conditions model was refined to remove external areas that were anticipated to change or be re-directed during future development. The following were the modifications to the model:

- Rear yard catchbasins on east side of Heritage Heights were implemented to drain to the Andpet storm sewer system to further reduce runoff to 15th Street B East.
- Andpet to drain to 16th Ave. East in near future.
- Redirection of runoff from Georgian College and filling at the north end of the Heritage Heights subdivision has removed approximately 12.3 ha from draining into the 15th Street B sewer.
- The reduction in area results in 1.0m^3/s less flow to 15th Street B East. This reduction is equivalent to 3 times the sewer capacity on 15th Street B East and results in a significant improvement.
- Even with a reduction in drainage area to 15th Street B East the storm sewer is still over capacity during the 5-year storm (i.e. $Q/Q_{full} > 1$).
- Storm sewers identified as 6, 7, 10, 12, 15, 22, 19 and 20 are over capacity. The primary cause of this problem is the older design criteria for 15th Street B East (1:2 year) and too many catchbasins for the size/slope of the storm sewer along 15th Street B East and 12th Avenue.

Rebuilding the existing storm sewer system within the 15th Street B East areas was considered as an alternative. However, rebuilding the storm sewer requires lowering of the sewer from a point well downstream along 16th Street. It will take years to design/approve/build and is very expensive. The most effective way to reduce flows is to install inlet control devices (ICDs) on the catchbasins within the street.

The existing conditions model was further analyzed using inlet control devices (ICDs). These devices are inserts into the storm lead from the catchbasin to the main storm sewer. The insert has a cut out to allow a reduced peak flow into the main storm sewer and creates ponding (storage) above the catchbasin. Flooding on the roadway must be contained within the Right of Way (ROW).

These devices reduce the effective size of the lead from the CB to the storm sewer. The result is a reduction of approx. 30% to the Q/Qfull ratio.

An alternative is to install backflow preventors at homes that have reported flooding in the past. A detail S-1 is included in **Appendix E** as provided by the City of Owen Sound.

Local improvements and reduction of drainage areas will significantly reduce the surcharging of the storm sewer and flooding on the street.

Please refer to **Appendix E** of this report for the OTTSWMM Analysis and Figures.

7.6 Public Consultation

A public meeting was held at the Bayshore Community Centre on July 4, 2006 to discuss the findings of the 15th Street B East Stormwater Analysis. A copy of the Powerpoint presentation is included in **Appendix E.**

7.7 Flow Monitoring

Thompson Flow Investigations Inc. (TQI) was retained to monitor sanitary and storm sewer flows and correlate them with real-time rainfall data. The analysis included flow monitoring (level) of the 600mm storm sewer on 12th Avenue with rainfall collected at the Works Department. During the period of monitoring a second significant rainfall event was recorded.

The total rainfall on July 26, 2006 was measured at 88.2mm. The rainfall occurred in two pulses. The first at approximately 1:30am and lasting for 110 minutes (1hour and 50min) with a volume of 67.6mm and the second at 3:30pm and lasting 80 minutes with a volume of 21.2mm. Note that term volume is depth.

Referring to the Atmospheric Environment Service Rainfall Intensity-Duration Frequency Values table attached, 67.7mm of rain in less than 2 hours is equal to or slightly greater than a 1:100year rainfall based on statistical analysis of historic data. The second pulse of rain is less than or equal to a 1:2year rainfall.

During this rainfall event and prior to installation of the Inlet Control Devices some basements that were flooded the weekend of May 22 –23 were again flooded on July 26, 2007. Flow monitoring results from this event are included in **Appendix E.**

7.8 Conclusions/Recommendations 15th Street "B" East

The analysis concluded that rainfall volumes for both localized events were in excess of the 1:100 year storm. The analysis noted that the runoff from the external drainage areas contributed significantly to the depth of flow on the roads and the amount of runoff being forced into the storm sewer. Basements in the area are connected directly to the storm sewer and therefore were surcharged when the storm sewer reached capacity. The following improvements/developments have/will reduce the area draining to 15th Street B East:

- Rear yard catchbasins on east side of Heritage Heights subdivision will drain to Andpet subdivision storm sewer system to further reduce runoff to 15th Street B East.
- All of the Andpet subdivision will drain to 16th Avenue East.
- Redirection of runoff from Georgian College with the future construction of 10th Street East "Link" and filling at the north end of the Heritage Heights subdivision will ultimately remove 12.3ha from draining into the 15th Street B East sewer.
- The analysis determined the most effective way to reduce flows is to install inlet control devices (ICDs) on the catchbasins within the street. These units were installed by the City in selected catchbasins, as directed by the consultant, through the area draining to 15th Street B East storm sewer in the Fall of 2006. This will reduce runoff into the storm sewer by keeping the runoff in the streets while the sewer maintains capacity and does not surcharge, thereby protecting the basements.

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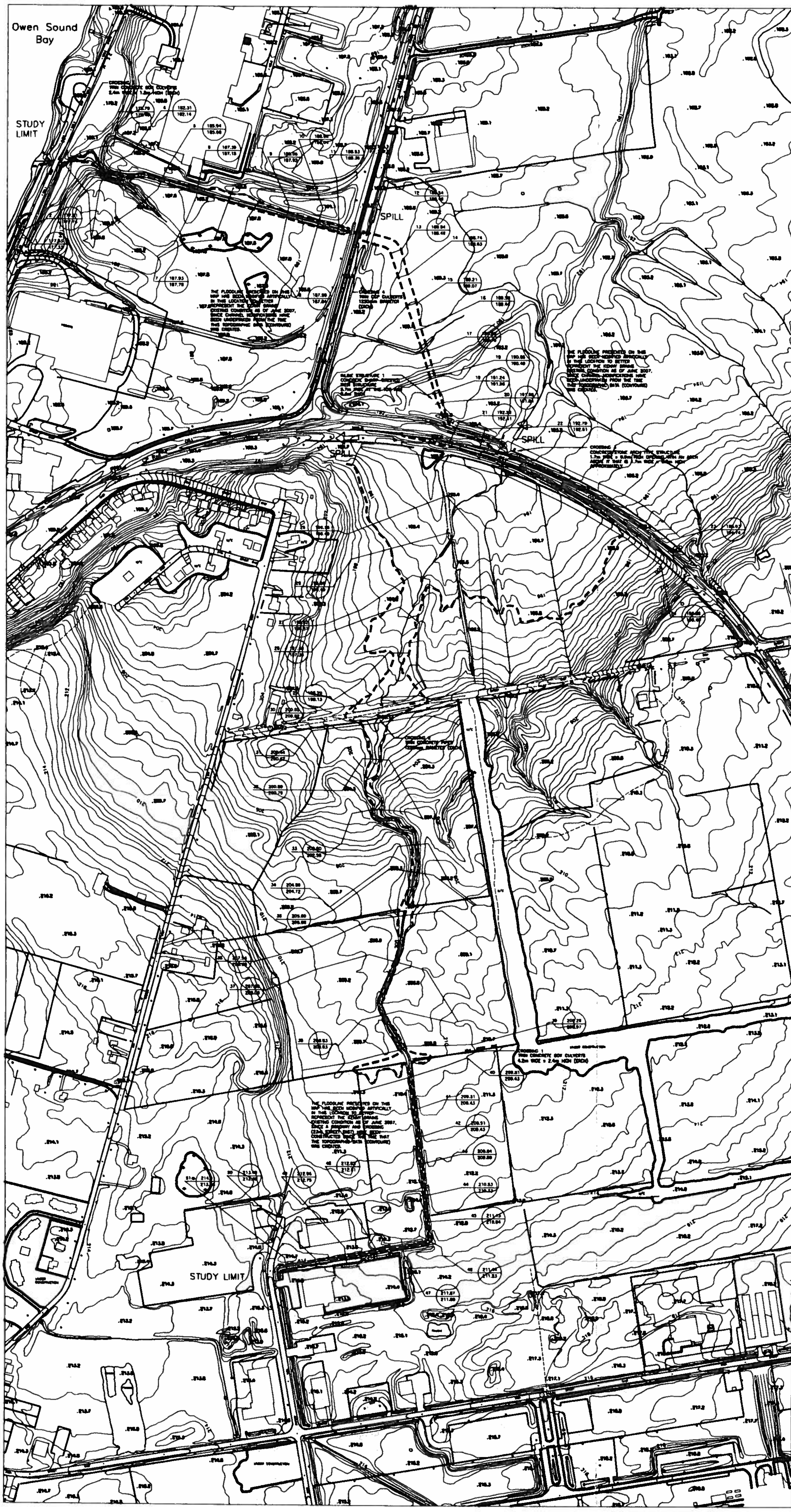
Appendix F
Figures and Drawings



1. This drawing is the exclusive property of R. J. Burnside & Associates Limited and the reproduction of any part without prior written consent of this office is strictly prohibited.

2. The contractor shall verify all dimensions, levels, and datums on site and report any discrepancies or omissions to this office prior to construction.

3. This drawing is to be read and understood in conjunction with all other plans and documents applicable to this project.

4. Do not scale the drawings.

No.	Issue / Revision	Date
1	DRAFT SUBMISSION	OCTOBER 15 2007

BURNSIDE

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CITY OF OWEN SOUND
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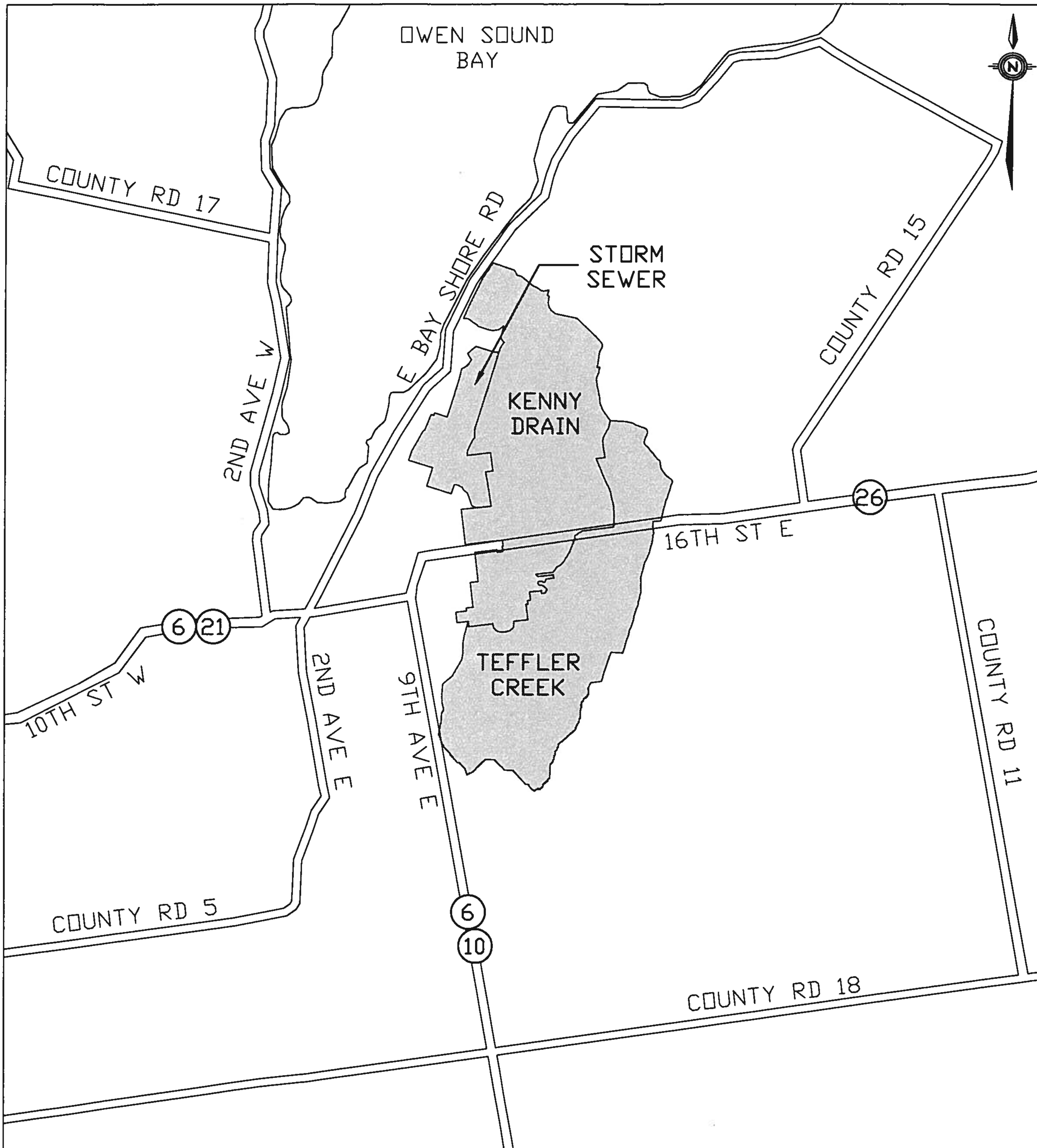
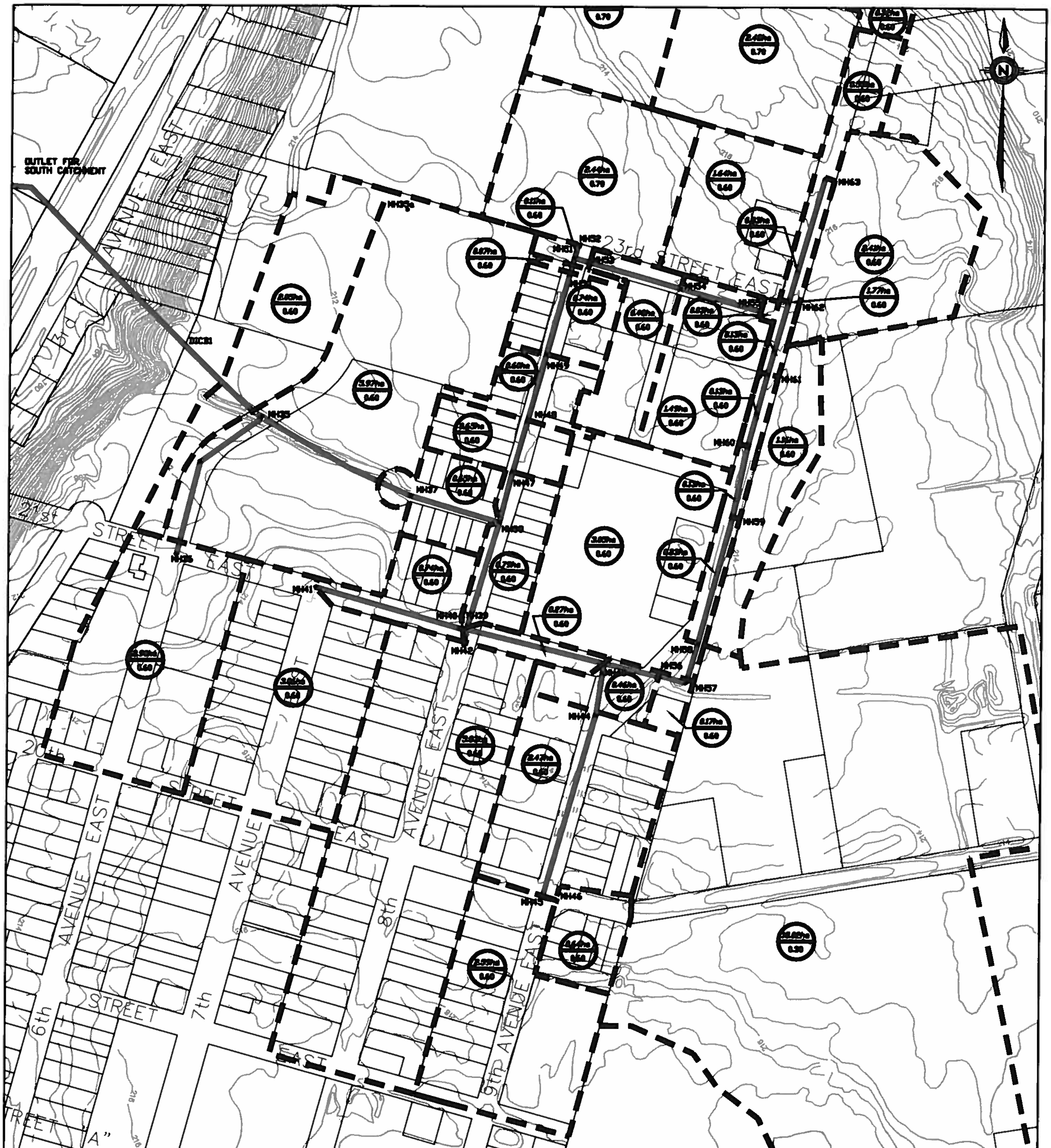
OWEN SOUND, ONTARIO
N4K 2H4

KENNY DRAIN FLOOD PLAIN MAPPING

Drawn By	Checked By	Drawing No.
J.D.R.	D.M.	HEC1
Scale: 1:1500	Project No.: MCC 10665	



Project Title CITY OF OWEN SOUND 808 SECOND AVENUE E. OWEN SOUND, ONTARIO N4K 2H4	BURNSIDE R. J. Burnside & Associates Limited 3 Ronell Crescent, Collingwood, Ontario telephone (705) 446-0515 fax (705) 446-2399			
Drawing Title SITE LOCATION PLAN	Drawn By C.M.P.		Checked By DRM	Drawing No. FIG1
	Scale N.T.S.	Date 07/08/15	Project No. MCG 10665	



LEGEND

- STORM SEWER HAS SUFFICIENT CAPACITY
- STORM SEWER CAPACITY EXCEEDED
- EAST BLUFFS DRAINAGE AREA
- 3.06ha DRAINAGE AREA
- 0.60 RUNOFF COEFFICIENT
- MH47 MANHOLE

Project Title

CITY OF OWEN SOUND

808 SECOND AVENUE E.
OWEN SOUND, ONTARIO
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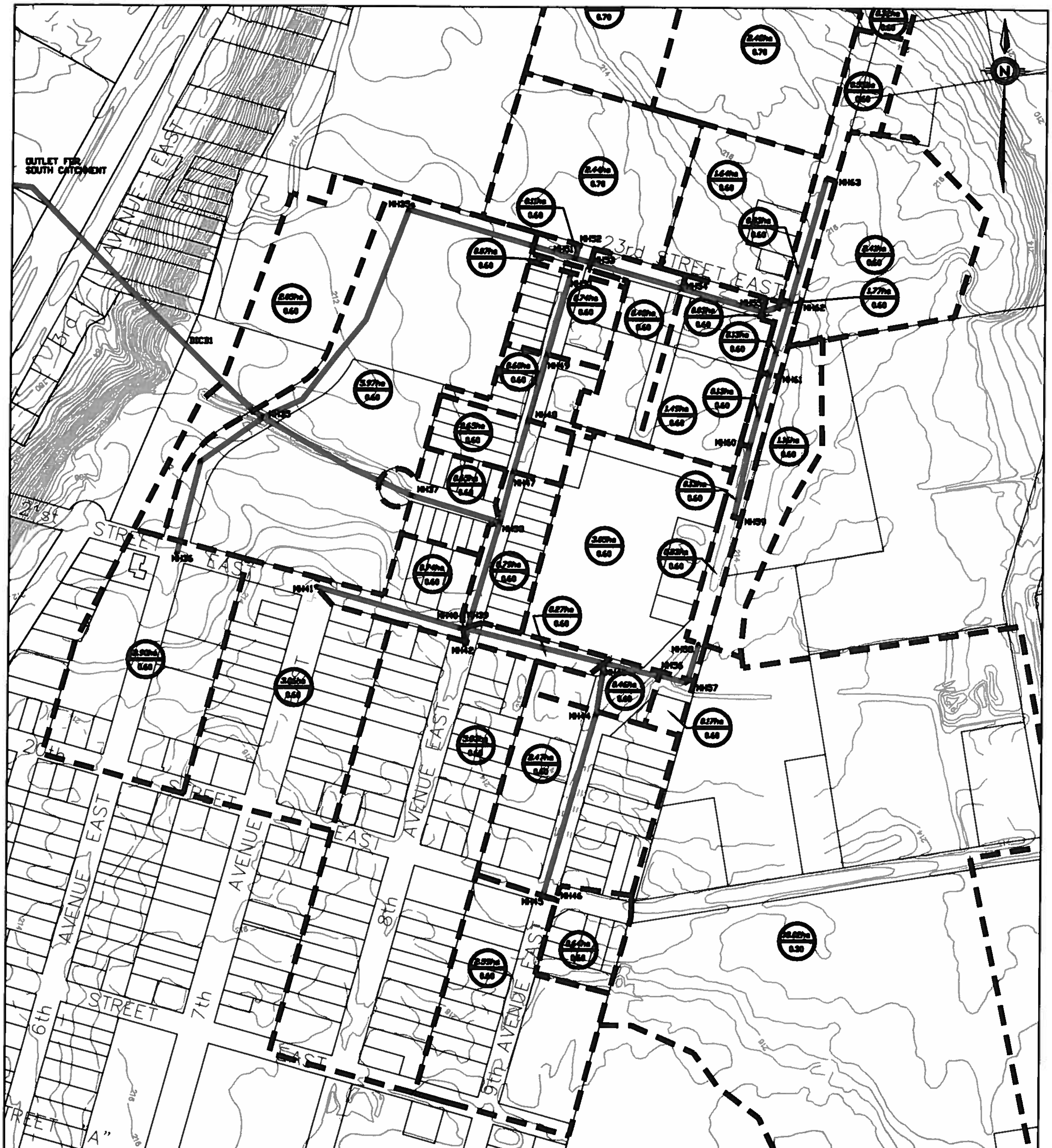
Figure Title

EAST BLUFFS AREA SOUTH STORM SEWER ANALYSIS SCENARIO #1

Drawn By	Checked By	Figure No.
CMP	DRM	FIG2
Scale 1:5000 / Date 07/08/15	Project No. MCG 10665	



LEGEND

STORM SEWER HAS SUFFICIENT CAPACITY

STORM SEWER CAPACITY EXCEEDED

EAST BLUFFS DRAINAGE AREA

DRAINAGE AREA (3.06ha) / RUNOFF COEFFICIENT (0.60)

MANHOLE (MH47)

Project Title

CITY OF OWEN SOUND

808 SECOND AVENUE E.
OWEN SOUND, ONTARIO
N4K 2H4

BURNSIDE

R. J. Burnside & Associates Limited
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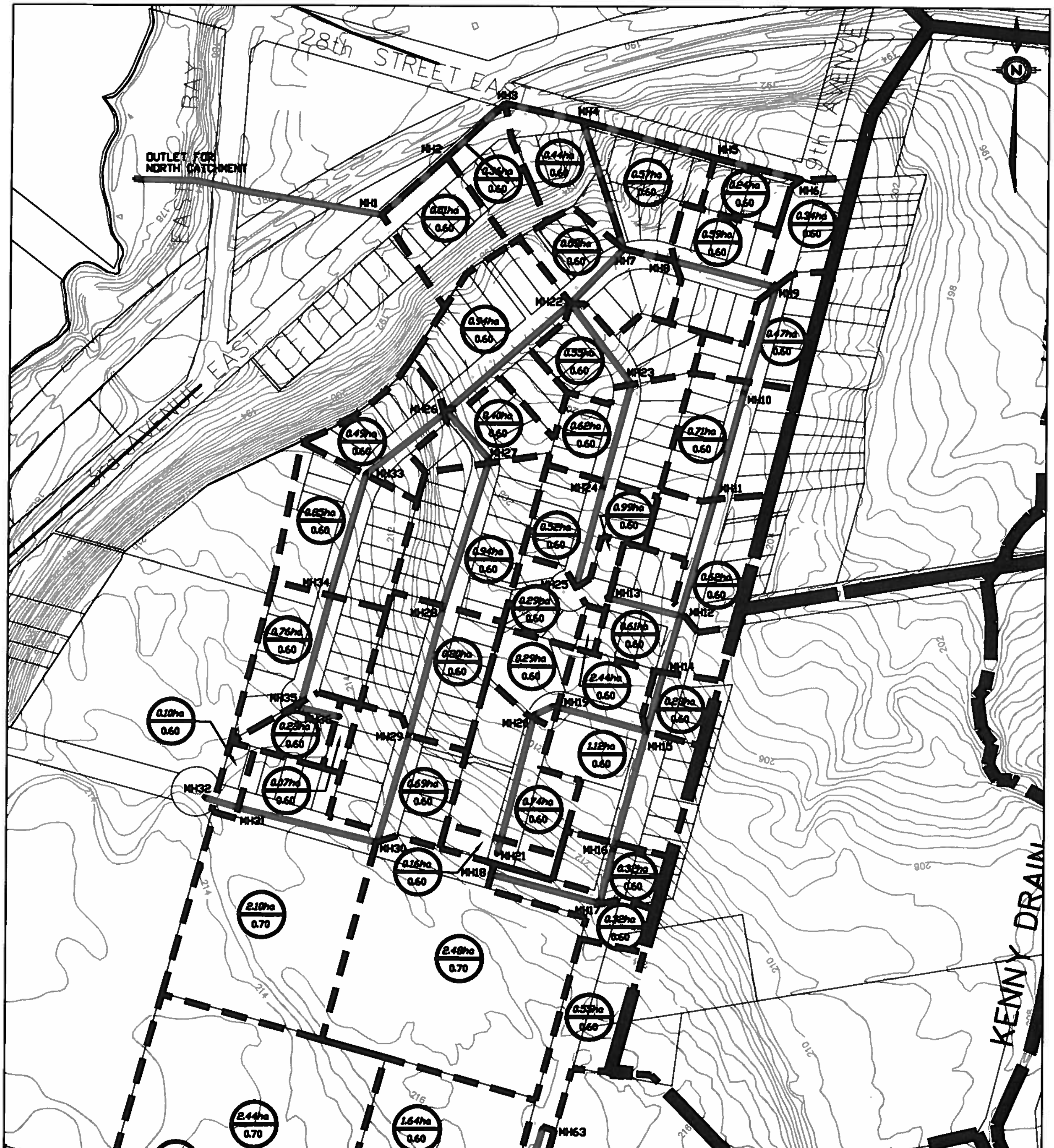
Figure Title

EAST BLUFFS AREA SOUTH STORM SEWER ANALYSIS SCENARIO #2

Drawn By	Checked By	Figure No.
CMP	DRM	FIG3

Scale	Date	Project No.
1:5000	07/08/15	MCG 10665



LEGEND

STORM SEWER HAS SUFFICIENT CAPACITY

STORM SEWER CAPACITY EXCEEDED

EAST BLUFFS DRAINAGE AREA

DRAINAGE AREA (3.06ha)

RUNOFF COEFFICIENT (0.60)

MANHOLE (MH47)

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Figure Title

EAST BLUFFS AREA NORTH STORM SEWER ANALYSIS

Drawn By		Checked By	Figure No.
CMP		DRM	FIG4
Scale	Date	Project No.	
1: 4000	07/08/15	MCG 10665	