Executive Summary

Introduction

The Big Creek Watershed has a drainage area of over 7,300 hectares (18,000 acres) and includes parts of the urban core of Amherstburg as well as rural and agricultural lands. Big Creek Marsh is the watershed's largest natural heritage feature, and consists of approximately 900 hectares (2,500 acres) of Provincially Significant Wetland (PSW) that has a controlled outlet to Lake Erie. Alterations to drainage, re-routing of watercourses and clearing of natural features in the Big Creek Watershed since European settlement have resulted in changes to watershed hydrology, reductions in water quality and diminished ecological function. However, recent terrestrial fieldwork provides that the marsh areas at the southern end of the watershed contains one of the best examples of a shoreline lacustrine wetland in the Province of Ontario.

The historical major diversions of headwater areas out of the Big Creek watershed has resulted in the loss of about half of the original watershed area. One major and historical diversion is associated with the Long Marsh Drain, as well as the disconnection of one of the Big Creek tributaries on the southwestern portion of the watershed from the Detroit River. The number of historical diversions that have occurred within one watershed is an unusual situation in the region, which has very substantially affected the natural hydrology and flow conditions of this watershed.

Various local stakeholders of the Big Creek Watershed have embarked on the development of a watershed plan as a proactive approach to planning and stewardship activities. This report provides the existing water quantity conditions of the Big Creek Watershed, including watershed hydrology and wetland water balance. An erosion characterization was also undertaken to provide estimates of non-point source pollutant loadings.

The purpose of the water quantity study is to understand the hydrologic impacts associated with the watershed to a level of detail that the need and recommendations for protecting and enhancing water quantity levels throughout the watershed can be understood. This information, along with other reports on natural heritage and water quality, will be used for the development of the Big Creek Watershed Plan.

Methodology

The quantification of water resources in the watershed is of paramount importance in developing the watershed plan. In order to undertake a comprehensive water quantity analysis of this watershed, many tools and methods have been utilized. Discussions with municipal and Conservation Authority administration, as well as residents has provided a great deal of insight regarding observations in changes to the drainage and hydrology throughout the watershed. A water budget was prepared as one of the major components of the water quantity study. This is a mathematical model assessing and balancing water entering, leaving and being stored in a system. In order to develop hydrologic modeling tools, physical data requirements include: topography, soils, land use and drainage information. As well, climate data including daily precipitation, maximum and minimum temperature, wind speed, relative humidity and solar radiation were necessary models inputs.

A Geographical Information System (GIS) based continuous simulation model called the Soil and Water Assessment Tool (SWAT) was used to develop an understanding of the water budget components of the Big Creek Watershed. A spreadsheet-based model was developed to provide water budget component estimates of the Big Creek watershed, including the significant inflows and outflows.

There is no historical streamflow data available for Big Creek Watershed to calibrate and validate the model, however short term streamflow monitoring was performed for model testing. Results from a recent modeling exercise of the Canard River Watershed were also used as a model check based on a similar spatial and temporal characteristics. The SWAT model was used to describe the hydrologic components of the watershed, most of which contributes to the Big Creek Marsh. A total of 40 subwatersheds were delineated within the study area with information utilized for a period of 20 years (1990 to 2009).

In order to characterize the watershed's contributing sediment and nutrient loadings, a continuous agricultural non-point source pollution simulation model, AnnAGNPS, was used. Tile drainage throughout the watershed is extensive due to the high level of agricultural land use activities and poor natural soil drainage to improve soil productivity. Topographical data in the form of a Digital Elevation Model (DEM) is a fundamental input of spatially distribution models including SWAT and AnnAGNPS.

SWAT Model Results

The SWAT model simulated hydrologic water budget results from 1990 to 2009 which have been presented annually, seasonally and in monthly time scales.

The annual model results show that evaportanspiration (ET) is the largest hydrologic component at a depth of 601 mm, which is 65% of the average annual precipitation of 907 mm. The other hydrologic components include surface runoff (water yield), tile drainage flow and groundwater flow at 224 mm, 69 mm and 14 mm, respectively (25%, 8% and 2%, respectively). The simulated groundwater flow is relatively low compared to the other hydrologic components, which could be due to a variety of reasons such as major historical watercourse diversions and the existence of tile drainage networks within the Big Creek Watershed. The model results identified that the highest levels of ET are occurring in the northern and southwestern portion of the watershed.

Average seasonal analysis indicates that precipitation is higher than ET and water yield combined in the winter, spring and fall. During the summer period, precipitation is less than ET and water yield combined, which indicates soil moisture generally depletes during the summer season. This depletion is normally replenished during the following fall season with the higher relative precipitation.

Average monthly precipitation for the watershed study varied from 59 mm to 91 mm, with higher precipitations of above 80 mm during the months of April, May, August and September. The lowest average precipitation of 59 mm occurs in February. Higher ET rates are found in June, July and August, with the July average the maximum value at 121 mm. Lower average ET values of below 20 mm are found in December, January and February. Higher surface runoff volumes above 35 mm are found in February and March, while lower surface runoff volumes ranging between 6 mm and 11 mm are found during the months of July to November.

Monthly average streamflow analysis shows that streamflow varied between 2.5 m^3/s and 3.1 m^3/s as high values during some years. A number of streamflow values were also found to be less than 0.01 m^3/s over the study period, which indicates that this watershed frequently experiences very low flow conditions in certain years. The lowest monthly flow occurred in the year 2005. These results, along with anecdotal observations, indicate that flow conditions in Big Creek are among the most stressed of Essex Region watersheds. This is likely due, at least in part, to the historical major diversions of headwater areas out of the Big Creek Watershed.

Big Creek Marsh Model Results

Big Creek Marsh is a riparian wetland in Essex County and is primarily fed by streamflow from the greater Big Creek Watershed. The marsh is approximately 682 hectares in area and is located east of the Detroit River and north of Lake Erie. The marsh was investigated in detail using a spreadsheet for water budget analysis with a daily time step. The historical information related to the marsh was selected for a 40 year period from 1969 to 2008. The Big Creek Marsh is large and shallow, and experiences significant water losses through ET as a result. The water levels of the wetland have been managed to some degree since 1909, using a system of pumps, dykes and a control dam.

Water levels in the marsh have the ability to be managed, which could include targets as approved in a recent management plan associated with an Ministry of the Environment (MOE) Permit to Take Water (PTTW). The goal of this component of the study was to develop a model that would adequately simulate the marsh operations and reactions to streamflow and climatic changes in order to provide suggestions and recommendations to property owners toward a future management plan.

For Big Creek Marsh water budget, inflow and outflow components may include many different components during specific periods of time. The inflow components considered include precipitation, streamflow from the upstream watershed, seepage from Lake Erie into the marsh through the beach ridge along the shore, inflow water pumping from Lake Erie to achieve the desired water level, and flow overtopping the control dam structure from Lake Erie. Outflow components considered for the water budget includes ET, seepage flow to Lake Erie, outflow pumping of the marsh to Lake Erie, outflow to Lake Erie from the control gate, and flow overtopping the control dam structure to Lake Erie. Groundwater inflow and outflow sources excluding Lake Erie are assumed to be zero.

The water budget was developed using 40 years of data, some of which is recorded and some of which is from anecdotal information and observations. The operation of this wetland over this period of time has been split into three operation periods, including the historic management period (1969 to 1984), the carp fishery period (1985 to 1999) and the current management period (2000 to 2008). Though there generally is a lack of information about the specific operations over all three management periods, there is some recorded information available from 2006 to 2008 and anecdotal information available for other years.

During the historic management period, anecdotal information suggests that the operators attempted to manage the wetland in a similar fashion to the current management period, but were limited to the resources available at that time to maintain the infrastructure. For the carp fishery period, the water levels were maintained as high as possible according to anecdotal information, to maximize the carp fishery productivity. For this time period, water levels were held through various means including soil reinforcement of the structure and there was limited to no outflow pumping. The current management period has an assumed marsh operation managed according to a specific management plan as provided to the MOE as part of a 2007 PTTW application. From this application, three potential annual water level operation plans were submitted: Overgrown, hemi and open water. These three operation plans have varied target water levels at different times of the year, and generally consist of a high, medium and low water level operation. The main tools available for wetland operators include the outflow gate and in and outflow pumping.

Since very little recorded data pertaining to the wetland is available, model calibration and validation is not possible. However, to ensure the marsh components are being estimated in a reasonably accurate way, the model was tested against a series of years with some partial information. The drought conditions experienced in the entire watershed in 2005 is a recent extreme event that ERCA staff has a great deal of anecdotal information about, while the MOE PTTW database contains inflow pumping data for the years 2006 to 2008. Comparisons with the model to these test years show that the model development is acceptable. Another model check was performed using sensitivity analysis, which also indicated an acceptable model.

The results for the historic management period shows that the majority of the marsh water level varied between 174.30 m and 175.20 m, with drier periods (water level below 174.30 m) occurring in 7 years (1969, 1970, 1971, 1977, 1978, 1979 and 1982). The overall period water level average is 174.66 m, with an overall minimum and maximum value of 173.90 m and 175.30 m, respectively. In terms of annual average water budget component values, the main inflow components are streamflow (74%), precipitation (23%), and the main outflow components are gate outflow (49%), overflow over the gate (26%) and ET (24%).

The model results for the carp fishery period indicates that the water levels remained higher, primarily varying between 174.80 m and 175.20 m. There were brief dry periods with water levels below 174.80 m during the 5 years of 1988, 1991, 1996, 1998 and 1999, and wetter periods with water levels above 175.20 m during the 6 years of 1985, 1986, 1989, 1990, 1993, 1995, 1998 and 1999. It has also been noted that there is some overlap of years with dry and wet periods. The overall period average water level is 174.85 m, with an overall minimum and maximum value of 174.20 m and 175.50 m, respectively. In terms of annual average water budget component values, the main inflow components are streamflow (72%), precipitation (21%), and the main outflow components are overflow over the gate (76%) and ET (23%).

The model for the current management period assumed that the hemi (medium) operation plan was generally implemented for most years as an overall average operation. The water level tends to vary between 174.10 m and 174.80 m, with an overall period average water level of 174.40 m. In terms of annual average water budget component values, the main inflow components are streamflow (73%), precipitation (22%), and the main outflow components are gate outflow (73%) and ET (24%).

When considering the entire study period, the two largest inputs into the marsh are streamflow (between 72% and 74%) and precipitation (between 21% and 23%), which indicates that the largest inputs affecting this wetland are linked to the natural hydrologic cycle. The higher outputs largely depend on the management period, as gate outflow is the largest parameter for the historic and current management period (49% and 74%, respectively), however this tool is not available for the carp fishery period. The most common output parameter among all operation periods is ET, which varies between 23% and 24%.

The connection between Lake Erie and the Big Creek Marsh was also investigated. Over the 40 year period studied as defined previously, the marsh water levels were higher than the lake water level the majority of the time (93%). This is further confirmed through aerial photograph research during high and low lake water periods as a comparison of marsh health with lake levels for that specific period. It was also determined that there is a correlation between higher marsh water levels and lake water levels. There are also indications that during lower lake water levels, the wetland would experience a natural drawdown period if not artificially maintained with the outlet control gate and dyke system.

Although the optimal operation of the private dam and portable pumping system may be able to sufficiently augment the water levels in the marsh (to be confirmed, depending on water level 'targets' yet to be finalized), it may not be realistic to expect that this will always be feasible during prolonged and/or extreme dry periods in the future when there is little or no inflow from the upstream watershed, combined with substantial loss of water due to ET. Another potential complicating factor is climate change, which may result in more extreme weather events and climate variability in the future. It is also important to note that artificially maintained water levels in the marsh do not extend upstream to the middle and upper reaches of the watershed due to historical diversions at the headwaters. These upstream reaches will continue to be highly stressed during drought conditions. Due to major historical diversions of flow out of the headwaters, the natural flow conditions have been highly impacted to a much greater degree than other watercourses in the region. For all of these reasons, serious consideration will likely be given to the feasibility of introducing flows to the upper or middle reaches of Big Creek.

AnnAGNPS Model Results

The Annualized Agricultural Non-point Source (AnnAGNPS) is a computer model which was utilized to simulate the Big Creek Watershed's sediment, nitrogen and phosphorus non-point source loading results at a daily time step. The model is able to assess impacts of land use alternatives because it can estimate both point and non-point source pollutant loadings on a watershed scale. The watershed was divided into a total of 660 cells over a study period of 20 years (1990 to 2009). Since there is a lack of data available for validation and calibration of this model, hydrologic parameters were compared with the SWAT model to ensure the model development was acceptable. The model can be used to examine current conditions in a watershed, to compare effects of different conservation alternatives, to evaluate results for implementation of best management practices (BMPs) and to analyze risks and cost/benefits within a watershed.

Sediment loading results shows that material eroded three soil types, including clay (49%), silt (42%) and sand (9%). Clay, as the largest contributor to sediment loading, is to be expected as the watershed is composed primarily of clayey soils and the deposition rate of clay is the slowest. The total average watershed sediment yield is 0.974 Mg/ha/yr, with higher sediment erosion contributions from the north-west and south-east regions of the Big Creek Watershed. The maximum and minimum modelled daily flows are 2,153 Mg/day and 0 Mg/day, respectively, with an average of 8.3 Mg/day. The months of April, May and June have the highest average monthly sediment yield rates, which is likely caused by spring runoff events.

For nitrogen, the average annual yield for the watershed is approximately 17.1 kg/ha/yr, with a minimum cell value of 0 kg/ha/yr and maximum cell value of 60 kg/ha/yr, most of which comes from the south-east. The months of March, April and May have the highest monthly average total nitrogen yield.

Phosphorus is not as mobile as nitrogen, but is strongly absorbed by the soil. Phosphorus that is absorbed by sediment particles may be conveyed in overland flow. The average annual phosphorus yield for the entire watershed is 11.4 kg/ha/yr, with a minimum cell value of 0 kg/ha/yr and maximum cell value of 81 kg/ha/yr, most of which comes from the south-east. The months of April, May and June have the highest monthly average total phosphorus yield.

The future Big Creek Watershed Plan will provide recommendations where appropriate to reduce the impacts of sediments and nutrients on specific reaches of the watershed and the lower Big Creek basin. These recommendations will likely include well known and tested farming activities addressing crop residue management, conservation tillage practices, tile drainage and other specific treatments including buffer strips and rock chutes.

The next step for the Big Creek Watershed Plan is to integrate the various existing condition findings. The development of the overall watershed plan will strive towards maximizing watershed benefits with respect to water quantity, water quality and natural heritage.