Water Balance in the Holland Marsh
Progress Report

(Geovisuals , 2014)

Globomatics Inc.

Project ID: 201415-07

3/25/2015

March 25, 2015
Project ID: 201415-07

Mr. Brett Ruck
Executive Director
Drainage Investment Group
4321 Queen Street
Niagara Falls, Ontario
L2E 2K9

Dear Mr. Ruck

RE: Project Proposal Report – Water Balance in the Holland Marsh

Please accept this letter as the formal submission for Project 201415-07: Water Balance in the Holland Marsh for the Drainage Investment Group completed by Globomatics Incorporated.

The goal of this project is to calculate the water balance of the Holland Marsh and identify areas of high susceptibility to nutrient intake. The project will provide an understanding of climatic trends within the Holland Marsh, allowing for greater land management practices. These goals will be reached by completing the following objectives:

- Obtain and manage meteorological data,
- Undertake an analysis of meteorological data over the previous decade, and
- Identify potential areas of increased nutrient loading.

This document outlines the proposed schedule for the water balance project, including major tasks, methodology, and the budget, along with the benefits and potential risks.

This project has begun as of October 2014 and will run until June 2015, concluding with a formal report and presentation. The total cost of this project has been updated $42,600.00, to be covered by Globomatics Inc. in collaboration with Niagara College.

If you have any questions or concerns about the details contained in this document, please feel free to contact us at josh8valenti@gmail.com or by phone at (905) 515-2666.

Regards,

Josh Valenti
BSc (Hons.) Physical Geography
GIS-GM Graduate Certificate Candidate
JV/

Enclosures: Project 201415-07 Water Balance in the Holland Marsh
Cc: Ryan Roque – GIS Analyst, Ian Smith – Project Advisor

Executive Summary

Globomatics Inc. is a newly founded consulting organization created in association with Niagara College, in September of 2014. The company strives to provide the best quality geospatial solutions for Southern Ontario for both private and public organizations. Their technical and management skills in conjunction with GIS and professional expertise of advisor, Ian Smith, will provide the client (Drainage Investment Group) with a unique business opportunity.

This document represents the second deliverable for the Water Balance in the Holland Marsh project. The following document is the progress report, underlining what tasks have been completed, and any updates to the proposed budget and schedule.

Phase 1 has been completed on time and on budget; with this document marking the end of Phase 2 some noticeable updates are as followed:

- Currently under budget by $1,600.00 due to under budget creation of the Geodatabase,
- Currently on schedule to complete project by June, 2015, and
- Updated budget calculated at $42,600.00.

The next stage in completing this project is to process the climatic data over the 10-year study period [2004-2014], followed by the project's finalization that will occur in June, 2015.

By investigating the water balance of the Holland Marsh, this study will be contributing to a much bigger project. Globomatics in collaboration with the Drainage Investment Group and Niagara College, will be providing this analysis for the benefit of any future river restoration and management initiatives. Globomatics Inc. is on track for the successful completion of this project, on time and on budget.

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1 Introduction

1.1 Project Background

The Holland Marsh is a remarkably unique area in terms of farmland and agricultural activity. The Marsh is referred to as the "Salad Bowl of Ontario" because of its fertile soil and ability to grow a wide variety of fresh produce. Located in Bradford, Ontario, Canada, the Holland Marsh is one of only two designated Specialty Crop Areas in Ontario, along with the Niagara Peninsula's Tender Grape and Fruit Area (The Friends of the Greenbelt Foundation, 2015). Covering an area of 2900 hectares, the Holland Marsh is home to approximately 250 farms with 100 farmers, and producing over 90% of Toronto's Asian Greens (Walton and Hunter Planning Associates, 1999). The main crops produced include carrots and onions, with each contributing to approximately 40% of total crop yield. Annually, the Marsh produces over one billion dollars in revenue with some of the most productive soil in Canada (Ontario Ministry of Agriculture, Food and Rural Affairs, 2013).

1.2 Project Understanding

The Marsh was drained in the early 1920's strictly for agricultural use. This process consisted of the building of the canal that travels along the north and the south borders of the marsh, allowing for the Holland River to flow through the heart, draining north into Cook's Bay of Lake Simcoe. Over the last decade, the Holland Marsh has experienced drainage issues, causing valuable land to flood and as a result, destroying crops. Along with flooding, soil erosion has become a primary concern, as the water flow has become a key factor in depleting the land available for agricultural production (Planscape Inc. , 2009).

To mitigate against events destructive to the land, a water balance will be calculated for the previous decade (2004 to 2014). A water balance is an analysis over an area calculating the amount of incoming water and outgoing water flow for a system. A surplus of water has been occurring recently within the marsh, causing fields to be completely submerged under water. A surplus occurs when the amount of incoming water (precipitation, inflows from surface and groundwater) exceeds that of the storage capacity and the output of a system.

1.3 Literature Review

The thesis written by Wypych provides a significant framework for the methods to undertake a water balance investigation (Wypych, 2012). The main purpose of the study by Wypych was to find the best method to describe spatial differentiation of climatic water balance (CWB) in Poland. This study focused on GIS techniques for use in climatology and meteorology to develop new CWB methods. The climatic

water budget was reviewed, providing advantages and defects of each method utilized. Data collected for this study included monthly mean values of air temperature and precipitation totals for 60 synoptic stations, as well as monthly totals of solar radiation for 21 points. The CWB was conducted with three methods: simple and multiple linear regression and map algebra. Validation of the study showed that map algebra was the best calculation method using Equation 1 below derived from Wypych (2012).

Equation 1: $CWB = P - 0.4 \frac{t}{t+15} I + 50$

Where:

P – Monthly precipitation totals [mm]

t – Monthly Average temperature [°C]

I - Sum of monthly total solar radiation [cal cm^{-2} day^{-1}]

For future recommendations, Wypych stated that to optimize the accuracy it is necessary to reduce the research scale with the utilization of more in-situ data.

In addition to understanding the CWB methods, ex-situ flow analyses were introduced by project advisor Ian Smith (Smith, 2015). The literature provided served as an introduction to Flood Recurrence (Flow Duration Analysis) and allowed the preliminary analysis of precipitation events within the Holland Marsh calculated in Section 8.2.

1.4 Study Area

The location of the study area is the very fertile Holland Marsh. Located in Bradford, Ontario, the Holland Marsh is located 50 kilometers north of Toronto. The ability to grow and harvest one billion dollars in product each year, is a result of the incredibly fertile muck soil. Figure 1-1, on the following page shows the location of the Holland Marsh.

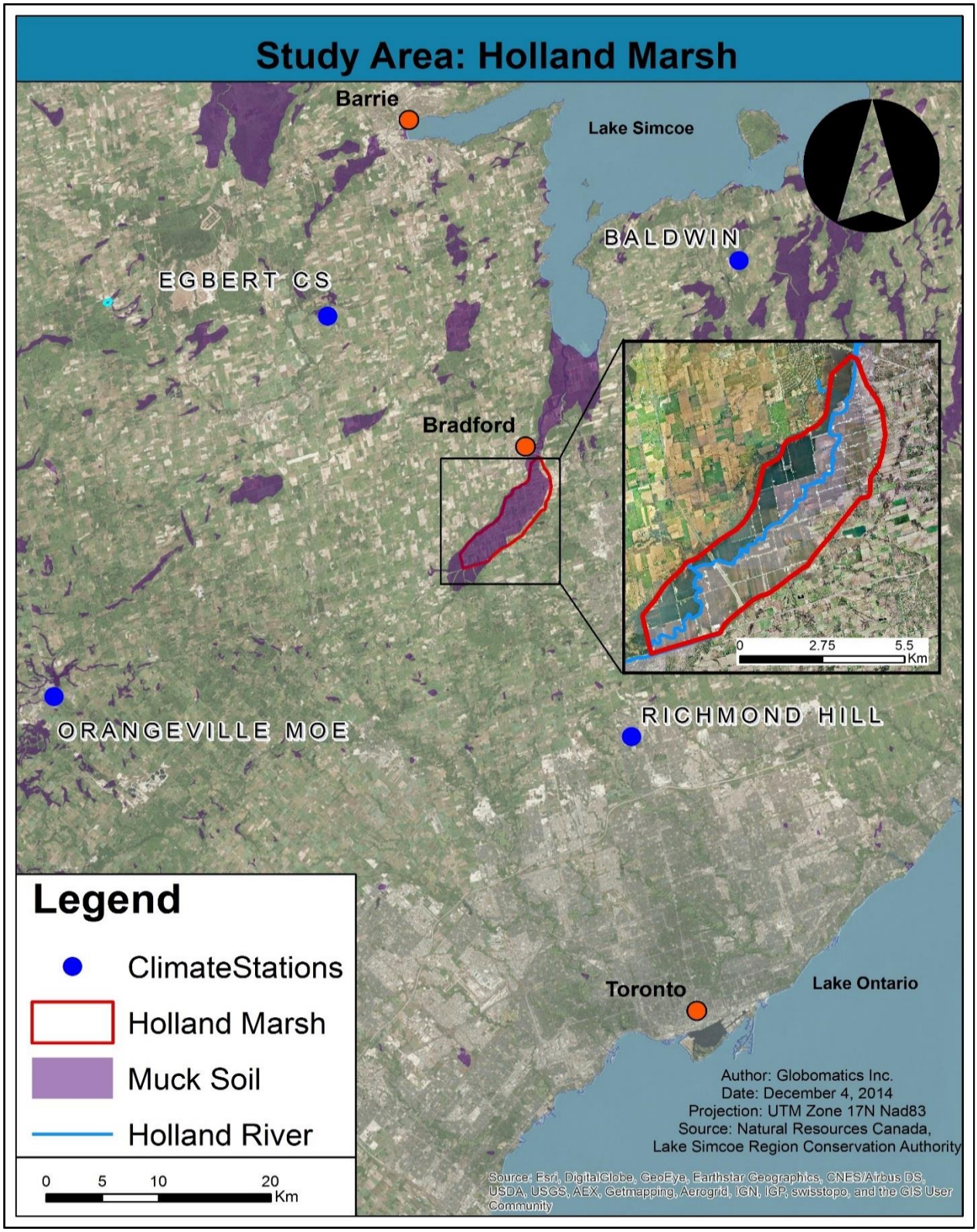


Figure 1-1: Study Area Map - Holland Marsh

2 Project Goal and Objectives

2.1 Project Goal

The project goal is to derive and calculate the water balance of the Holland Marsh to allow for the identification of areas that are potentially susceptible to high nutrient intake. This will be done by initiating an analysis of meteorological data in the Holland Marsh area. By investigating past climatic trends such as temperature, precipitation, solar radiation and major storm events, the water balance will be calculated on a seasonal basis to highlight areas vulnerable to nutrient loading.

2.2 Project Objectives

As noted in the project proposal document, to calculate the water balance of the Holland Marsh, an analysis of climate data from the previous ten years (2004 – 2014) will be undertaken to identify trends in climatic variables (Temperature, Precipitation, Storm Events, etc.). In return locations will be identified that have excess or deficit of water within the lower South-West region of the Marsh.

The objectives of this project are outlined as the follows:

- Obtain and manage meteorological data (completed);
- Undertake an analysis of meteorological data from the previous decade, identifying trends in climatic variables (completed);
- Produce climatic variable maps and graphics for seasonal periods;
- Calculate solar radiation maps for seasonal periods; and
- Calculate water balance of the Holland Marsh for seasonal periods over the last 10 years.

For a detailed list of steps on how the project will be completed, please refer to the Project Overview Statement, located in Appendix B.

2.3 Project Deliverables

The goal and objects stated above were initiated, in October 2014, with completion anticipated in June 2015. The project deliverables are outlined below in Table 1, including expected submission dates for each stage.

Table 1 - Project Deliverables

Deliverable	Submission Date	Status
Project Overview Statement	November 11, 2014	Complete
Project Proposal	December 5, 2014	Complete
Project Progress Report	March 25, 2015	Complete
Final Project Report	June 12, 2015	In Progress
***Submission dates are not subject to compromise or change.**		

3 Major Tasks

The proposed major project tasks can be divided into three phases. Each of these phases are within the timespan of one term, concluding in June of 2015. The final deliverable will consist of a formal report and presentation. For a complete and updated list of the project tasks, scheduling and cost estimates, refer to Appendix C: Gantt Chart.

3.1 Project Management

For the purpose of accountability, in reference to work performed for the completion of this project, a series of meetings and status reports will continue to take place, bi-weekly with Project Advisor Ian Smith. During these meetings, bi-weekly status reports will be constructed and presented to all parties, ensuring that any concerns or questions from both the client (DIG) and the consultant are addressed on a timely manner. The project management expectations are summarized in the Gantt chart in Appendix C: Gantt Chart, including estimated working hours, duration, and status of each task.

3.2 Project Initiation

The first phase consists of initiation and planning of the project. Familiarization with the project goal, supporting objectives and deliverables are critical in this stage. As the beginning phase of the project, most of the duration will include initial research of the Holland Marsh area in order to gain a complete understanding of the study site. This information will form the basis for a project literature review. This phase began on September 16, 2014 and concluded with the Formal Project Proposal Report on December 5, 2014. Table 2 outlines the main tasks completed during the completion of Phase 1.

Table 2 – Phase 1

Phase 1: Project Initiation		Completion Date
Deliverable 1.1:	**Project Acceptance Confirmation**	September 16, 2014
Deliverable 1.2:	**Project Kick-off Meeting**	October 3, 2014
Deliverable 1.3:	**Project Overview Statement (POS)**	November 11, 2014
Deliverable 1.4:	**DIG Holland Marsh Site Visit**	November 28, 2014
Deliverable 1.5:	**Project Proposal Presentation**	December 2, 2014
Deliverable 1.6:	**Project Proposal Report**	December 5, 2014

Highlights of project initiation include a Site Visit with DIG, in which Globomatics travelled to the Holland Marsh to gain background and hands-on knowledge of the area.

3.3 Progress Report

In the second phase, the main focus was to collect and evaluate the climatic data obtained from four different Environment Canada climate stations plus the solar data obtained from the University of Toronto. The proposed tasks completed during the duration of this phase are indicated below in Table 3.

Table 3 - Phase 2

Phase 2: Data Evaluation and Progress Report		Completion Date
Deliverable 2.1:	**Data collection**	February13, 2015
Deliverable 2.2:	**Geodatabase Creation**	January 26, 2015
Deliverable 2.3:	**Bi-weekly status reports**	May 2015
Deliverable 2.4:	**Project Progress Presentation**	March 2015
Deliverable 2.5:	**Project Progress Report**	March 2015

3.4 Project Finalization

The final phase will be completed in June, 2015, concluding with a detailed report and presentation that will highlight the findings of the Water Balance study in the Holland Marsh project, proposed completion dates shown in Table 4.

Table 4 - Phase 3

Phase 3: Preparation of Final Report and Presentation		Deadline
Deliverable 3.1:	**Final Project Presentation**	June 9/10, 2014
Deliverable 3.2:	**Final Project Report (Hardcopy and digital)**	June 12, 2014

4 Project Revisions

4.1 Project Research Revisions

The first revision for this project occurred within the project research. The background literature got pushed back due to time constraints from other ongoing projects. However each step has been completed by the date stated below in Table 5, and on budget.

Table 5 - Project research revisions

WBS	Task Name	Start	Finish	Revised Finish
1.3	**Project Research**	**11/28/14**	**1/27/15**	**3/10/15***
1.3.1	Site Field Trip	11/28/14	11/28/14	11/28/14
1.3.2	Background Literature Review	11/28/14	1/21/15	3/5/15*
1.3.3	Define Methodology	1/20/15	1/27/15	3/10/15*
***Revised Dates.**				

4.2 Data Collection Revisions

The second, and the greatest revision to this project was during the data collection stage, shown in Table 6 below.

Table 6 - Data collection revisions

WBS	Task Name	Start	Finish	Revised Finish
1.5	**Data Collection**	**10/30/14**	**2/13/15**	**3/2/15***
1.5.1	Obtain Data from Client (DIG)	10/30/14	1/7/15	1/7/15
1.5.2	Collect Meteorological Data	12/12/14	1/12/15	3/2/15*
1.5.3	Organize/Quality Check Data	12/15/14	2/13/15	3/2/15*
***Revised Dates.**				

The collection of the meteorological data took much longer than proposed, going over budget by $2,316.25. This extract cost however has been matched by the under budget creation of the geodatabase.

4.3 Assemble Geodatabase Revisions

As stated above, the geodatabase design was scheduled for completion by March 3, 2015, however the completion date has been revised to March 31, 2015 as shown below in Table 7. This revision was caused by the extra time allocated to the data collection process.

Table 7 - Assemble geodatabase revisions

WBS	Task Name	Start	Finish	Revised Finish
1.6	**Assemble Geodatabase**	**1/16/15**	**3/20/15**	**3/31/15***
1.6.1	Create Basemaps	1/23/15	1/28/15	1/28/15
1.6.2	Design Geodatabase	1/22/15	1/26/15	3/31/15*
1.6.3	Progress Report Presentation	3/18/15	3/20/15	3/25/15*
1.6.4	Progress Report	3/16/15	3/20/15	3/25/15*
***Revised Dates.**				

With the revised date pushed back, the geodatabase design has also been substantially under budget, with a savings of $4,220.00 to date. These savings have been allocated to the over budget data collection process, keeping the overall budget on track. A complete list of the projects up-to-date revisions is located in Section 6.2, Table 10

4.4 Budget Revisions

Revisions to the proposed budget are highlighted below in Table 8. The major changes to date occurred with completion of Tasks 1.3 and 1.5 over budget by $2,803.25 while tasks 1.4 and 1.6 are under budget by $8,769.00, totaling the project being under budget by $5,965.75 to date.

Table 8 - Budget revisions

WBS	Task Name	Planned Value	Percent Complete	Actual Cost	Change	Current Status
1.1	Initial Cost	$2,200.00	100%	$2,200.00	$0.00	Complete
1.2	Project Initiation	$4,350.00	100%	$4,350.00	$0.00	Complete
1.3	Project Research	$3,300.00	100%	$3,787.00	-$487.00	Complete
1.4	Project Management	$5,400.00	7%	$851.00	$4,549.00	In Process
1.5	Data Collection	$3,975.00	100%	$6,291.25	-$2,316.25	Complete
1.6	Assemble Geodatabase	$4,500.00	75%	$280.00	$4,220.00	In Process
1.7	Data Processing	$4,875.00	0%	$0.00	$4,875.00	Not Started
1.8	Project Finalization	$7,113.00	0%	$0.00	$7,113.00	Not Started
Total		$35,713.00		$17,759.25		

5 Collected Resources

Data provided by the Drainage Investment Group covers the South-West portion of the marsh. This data set consists of orthoimagery with a spatial-resolution of 4 cm, a Digital Elevation Model (DEM) of the southwest portion of the study area, and a digitized drainage polygon.

Daily meteorological data have been obtained by Globomatics Inc, and have been compiled into a database. This database includes meteorological data obtained from Environment Canada (Environment Canada, 2015) from four different collection stations providing Globomatics Inc. with the means to interpolate the climatic variables needed in calculation of the water balance.

Globomatics Inc. has collected solar radiation from the University of Toronto (University of Toronto, 2010) daily over the years spanning 2008 to 2012. The source for this data set lies approximately 50km south of the study area; however, using the ArcGIS Solar Radiation tool, this data set will provide the correct parameters for Globomatics Inc. to calculate the incoming solar radiation typical for the Holland Marsh.

A Digital Elevation Model (DEM) has also been acquired from the Ontario Ministry of Natural Resources and Forest (Ontario Ministry of Natural Resources, 2006). The dataset covers the entire Holland Marsh at a spatial resolution of 10m, providing a detailed elevation of the study area. A summary of the datasets obtained for this project can be seen below in Table 9.

Table 9 - Acquired Datasets

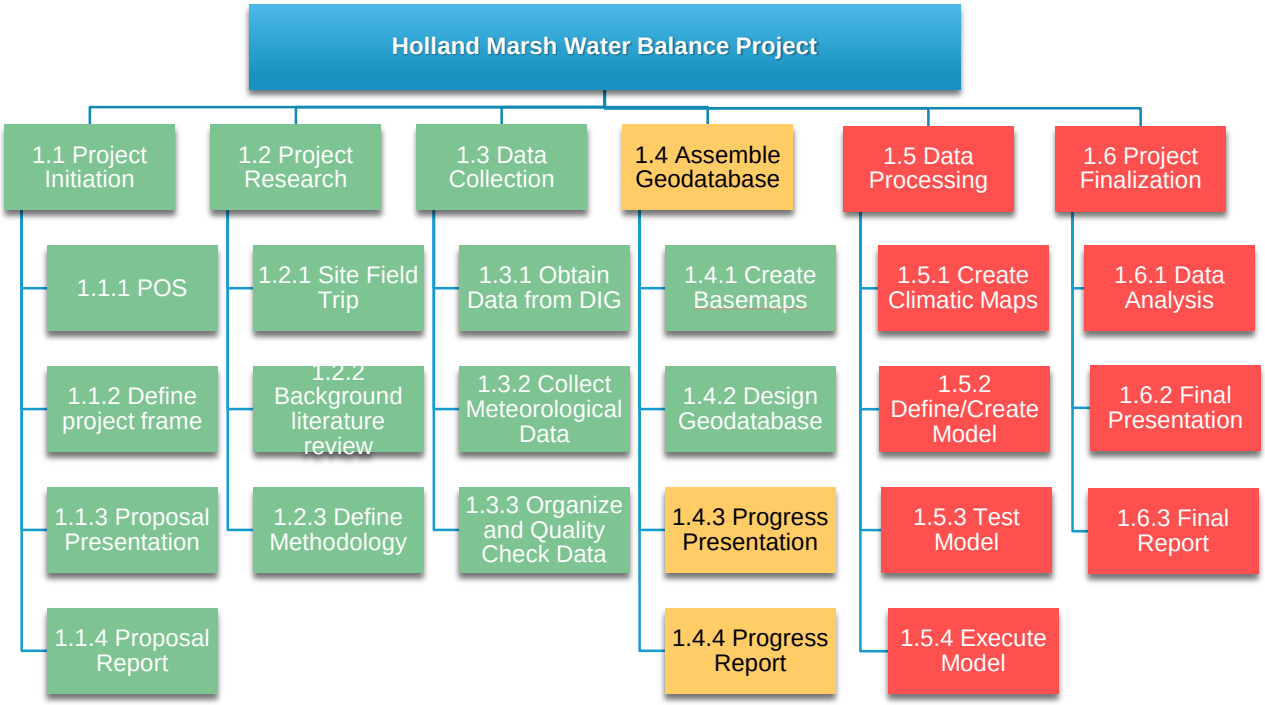
Data Set	Collection	Source
Baldwin Station	2004-2014 (Daily)	Environment Canada (2015a)
Egbert CS Station	2004-2014 (Daily)	Environment Canada (2015b)
Orangeville MOE Station	2004-2014 (Daily)	Environment Canada (2015c)
Richmond Hill Station*	1964-2013 (Daily)	Environment Canada (2015d)
Toronto Buttonville Station	2014 (Daily)	Environment Canada (2015e)
Solar Radiation	2008-2012	University of Toronto (2012)
DEM (10m)	Tile #091d_w_m	Ontario Ministry of Natural Resources (2006)
DEM (4cm)	Southwest location	Lake Simcoe Region (2014)
Orthoimagery (4cm)	Southwest location	Lake Simcoe Region (2014)
Orthoimagery (20cm)	2007	Ontario Ministry of Natural Resources (2007)
***Station used to calculate precipitation events.**		

6 Project Management

6.1 Work Breakdown Structure

An updated work breakdown structure (WBS) (see Figure 6-1 below) displaying the overall structure of the project, while highlighting the steps completed in green, steps that are in progress in yellow, and the steps that are to be completed in red.

Figure 6-1- Work Breakdown Structure



6.2 Schedule

This project began in October 2014, and will be completed by June 14, 2015. Within this time, a number of deadlines will be met. The Project Proposal has already been completed as of December 5, 2014, followed by this Project Progress Report for March 25, 2015. This project will conclude with the Project Final Report to be completed by June 12, 2015. A complete schedule that compares the proposed task schedule versus actual task occurrences can be seen below in Table 10

Table 10 - Schedule

WBS	Task Name	Start	Finish	Revised Finish
1	**Holland Marsh Water Balance Project**	**10/15/14**	**6/19/15**	**6/12/15**
1.1	**Initial Costs**	**10/15/14**	**6/19/15**	**6/12/15**
1.1.1	Computers and Hardware	6/19/15	Fri 6/19/15	Fri 6/19/15
1.1.2	Stationary, Printing, Binding	6/19/15	Fri 6/19/15	Fri 6/19/15
1.1.3	Field Trip Expenses	6/19/15	Fri 6/19/15	Fri 6/19/15
1.2	**Project Initiation**	**10/15/14**	**12/5/14**	**12/5/14**
1.2.1	Project Kick-off Meeting	10/3/14	10/3/14	10/3/14
1.2.2	Project Overview Statement	11/10/14	11/11/14	11/11/14
1.2.3	Define Project Outline	11/26/14	11/27/14	11/27/14
1.2.4	Proposal Presentation	11/27/14	12/2/14	12/2/14
1.2.5	Proposal Report	11/28/14	12/5/14	12/5/14
1.3	**Project Research**	**11/28/14**	**1/27/15**	**3/10/15***
1.3.1	Site Field Trip	11/28/14	11/28/14	11/28/14
1.3.2	Background Literature Review	11/28/14	1/21/15	3/5/15*
1.3.3	Define Methodology	1/20/15	1/27/15	3/10/15*
1.4	**Project Management**	**1/8/15**	**6/19/15**	**6/19/15**
1.4.1	Advisor Meeting with Ian Smith (Bi-weekly)	1/8/15	6/19/15	6/19/15
1.4.2	Client Meeting with DIG (Bi-weekly)	1/9/15	6/12/15	6/12/15
1.5	**Data Collection**	**10/30/14**	**2/13/15**	**3/2/15***
1.5.1	Obtain Data from Client (DIG)	10/30/14	1/7/15	1/7/15
1.5.2	Collect Meteorological Data	12/12/14	1/12/15	3/2/15*
1.5.3	Organize/Quality Check Data	12/15/14	2/13/15	3/2/15*
1.6	**Assemble Geodatabase**	**1/16/15**	**3/20/15**	**3/31/15***
1.6.1	Create Basemaps	1/23/15	1/28/15	1/28/15
1.6.2	Design Geodatabase	1/22/15	1/26/15	3/31/15*
1.6.3	Progress Report Presentation	3/18/15	3/20/15	3/25/15*
1.6.4	Progress Report	3/16/15	3/20/15	3/25/15*
1.7	**Data Processing**	**3/26/15**	**5/29/15**	**5/29/15**
1.7.1	Create comparative maps and graphs of climate change	3/26/15	4/10/15	4/10/15
1.7.2	Define/Create Water Balance Model	5/11/15	5/20/15	5/20/15
1.7.3	Test Model	5/20/15	5/22/15	5/22/15
1.7.4	Execute Model	5/22/15	5/27/15	5/27/15
1.8	**Project Finalization**	**5/27/15**	**6/12/15**	**6/12/15**
1.8.1	Climate change analysis	5/26/15	5/29/15	5/29/15
1.8.2	Identify areas of increased nutrient loading	5/26/15	5/29/15	5/29/15
1.8.3	Report of analysis and methods used	6/1/15	6/10/15	6/10/15
1.8.4	Create maps and graphics	6/5/15	6/10/15	6/10/15
1.8.5	Final Presentation	Wed 6/10/15	6/12/15	6/12/15
1.8.6	Final Report	6/5/15	6/12/15	6/12/15
***Revised Dates.**				

6.3 Project Budget

The total budget for project is an estimated $37,750 with a 10% contingency built in to account for any unforeseen circumstances that may arise. This budget was then further broken down by cost per task as seen in Table 11 and Figure 6-2 below.

Table 11 - Total Budget

	Original	Updated
Total Budget	**$35,700.00**	**$34,300.00**
Total + Contingency	$39, 270.00	$37,730.00
HST (13%)	$5,100.00	$4,904.90
Total + HST	**$44,400.00**	**$42,634.90**

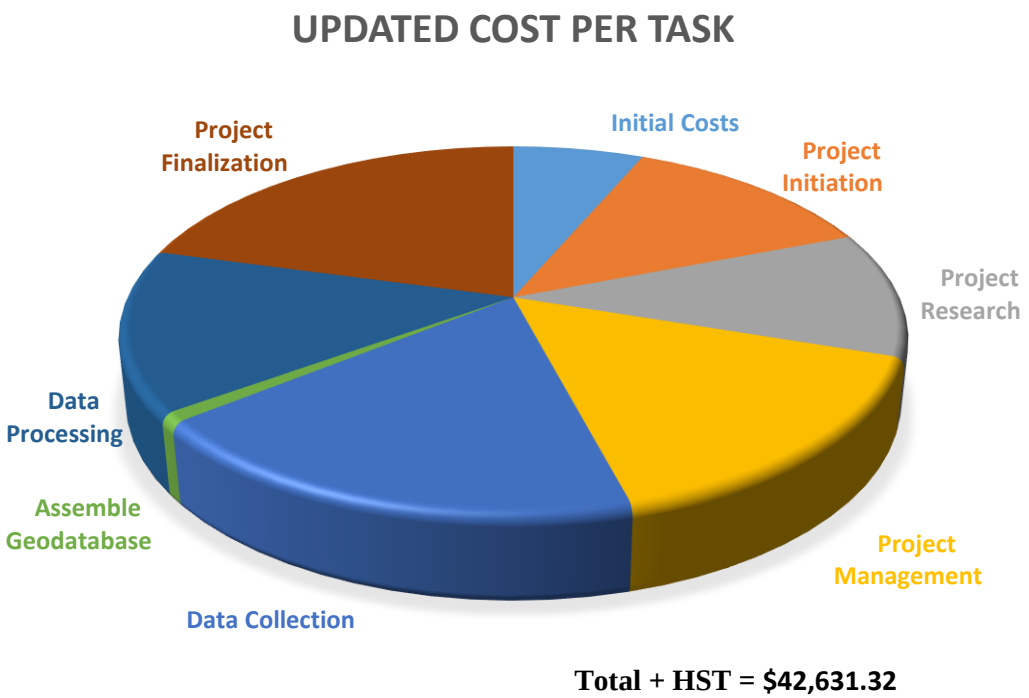


Figure 6-2 - Cost Per Task

Note: This Project Budget has been prepared for the learning purposes and in no way is the client expected to incur these prepared costs. The value of this project will be donated to the client organization by the student consultants, Niagara College and the advisory staff.

6.4 Earned Value Analysis

The earned value chart shown below in Figure 6-3, shows that the project is up-to-date and under budget. The earned value charts represents the predicted project cost (Planned Value) on an ongoing basis, referenced against the Actual cost of the project as the stags are completed while displaying the overall earned value to date. The spike in actual cost during the January period is due to the over budget data collection stage. The spike in earned value in February is due to the under budget cost of the geodatabase assembly.

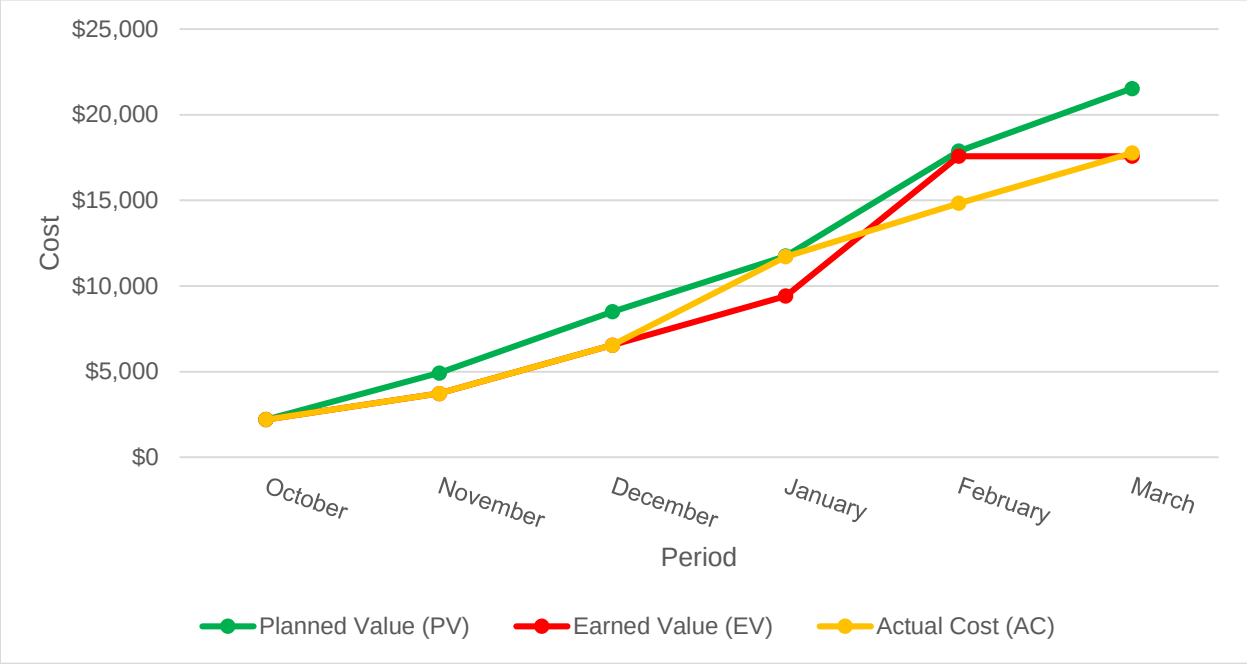


Figure 6-3 - Earned Value Analysis

6.5 Project Resource Cost

To account for the resources used to complete this project, a flat rate of $2,000.00 was allocated to cover the computer hardware and software provided from Niagara College. In addition the project advisor (Ian Smith) has been allocated $150.00 per hour for his expertise while the project manager and project GIS analyst have been allocated $80.00 and $70.00 respectively per hour respectively. Table 12 displays a more detailed breakdown of the project cost by major task, to date.

Table 12 - Updated Budget Breakdown

Task Name	Cost Per Task	Updated Cost Per Task
1.1. **Initial Costs**	$2,200.00	$2,200.00
1.2. Project Initiation	$4,350.00	$4,350.00
1.3. Project Research	$3,300.00	$3,787.00
1.4. Project Management	$5,400.00	$5,400.00
1.5. Data Collection	$3,975.00	$6,291.25
1.6. Assemble Geodatabase	$4,500.00	$280.00
1.7. Data Processing	$4,875.00	$4,875.00
1.8. Project Finalization	$7,113.87	$7,113.87
Contingency	$3,571.39	$3,429.71
Subtotal	$39,285.26	$37,726.83
HST	$5,107.08	$4,904.49
Total	**$44,392.34**	**$42,631.32**

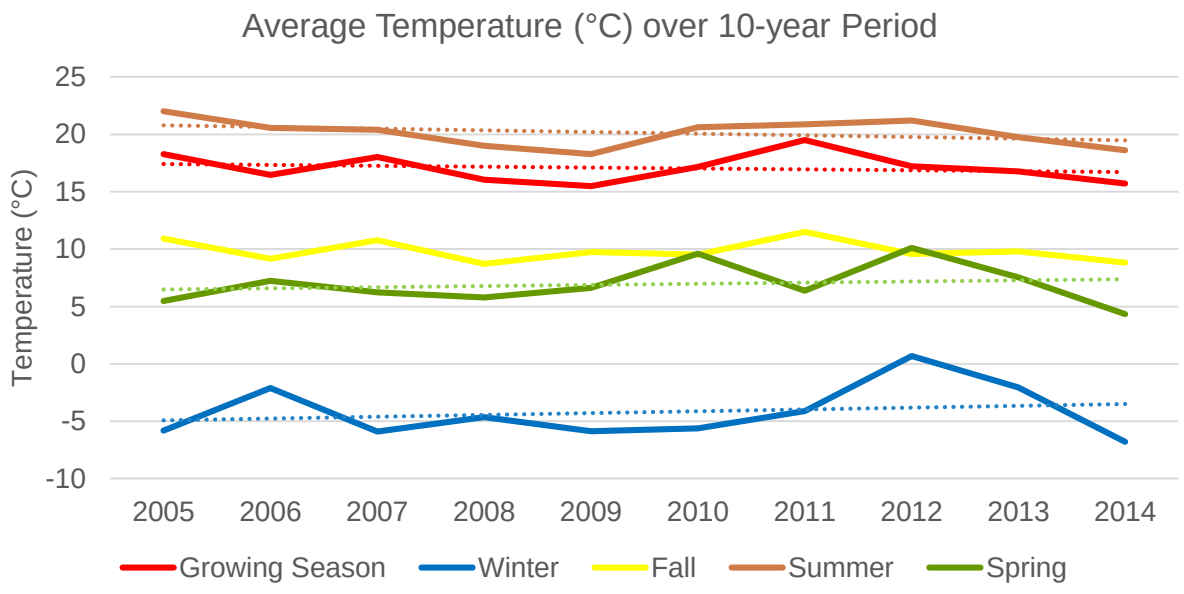
7 Preliminary Analysis

This section displays a sample of preliminary analysis done for the collected data. Included in this sample are graphs to visualize a sample of temperature and precipitation data.

7.1 Temperature

The average temperature for the past 10 years are depicted below in Figure 7-1.

Figure 7-1 - Average Temperature in the Last Decade

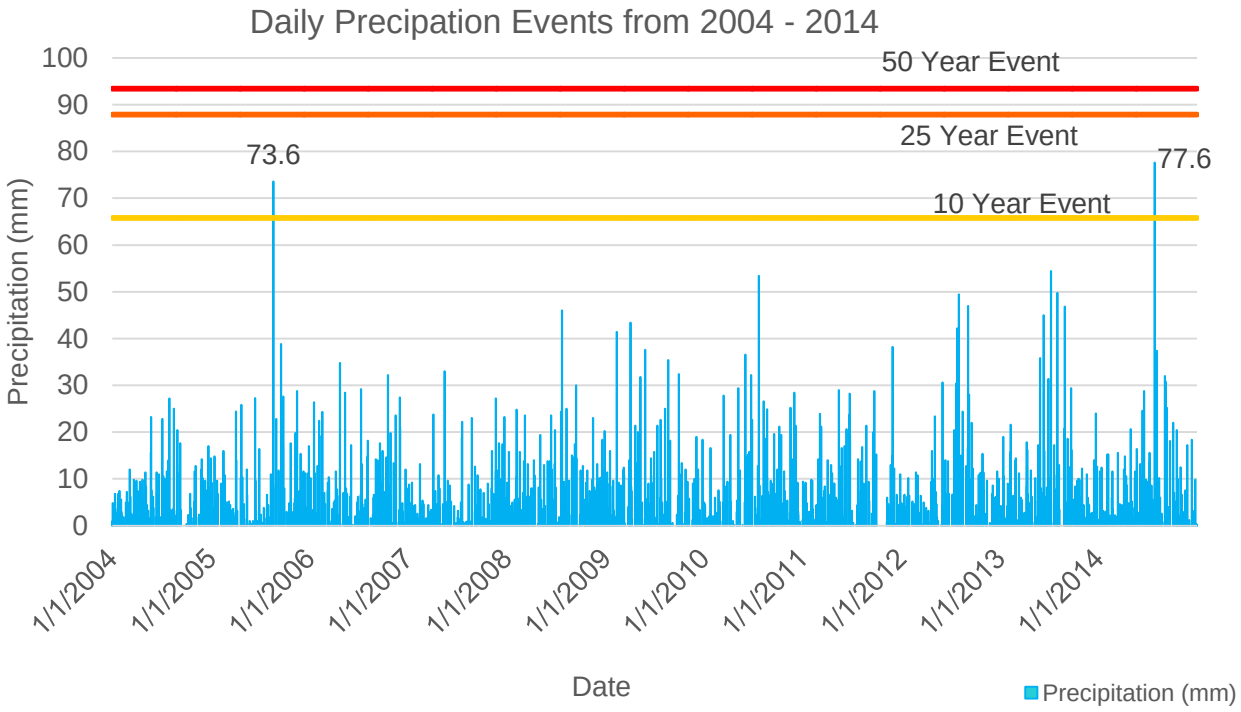


These temperatures are separated by seasons which include Growing Season (July-October), Winter (December-February), Fall (September-November), Summer (June-August), and Spring (March-May). The trend lines indicate a general increase in winter and spring temperatures, and a general decrease in summer temperatures. These changes in temperature trend can be indicative of longer growing seasons in the Marsh.

7.2 Precipitation

The precipitation events in Richmond Hill for 2004 -2014 have been illustrated in Figure 7-2.

Figure 7-2 - Precipitation for Richmond Hill Station in the Last Decade



In addition to the events, the 10, 25, and 50 year events have been determined. Significant extremes can be shown for August 19, 2005 and July 27, 2014. In particular, the flood of August 2005, was the second largest recorded precipitation event; the largest being 1954's Hurricane Hazel (Toronto Sun, 2009).

8 Risk Assessment and Challenge Management

8.1 Assumptions

Assumptions are specific circumstances or events which are critical for this project to be successful. These events are most likely to happen according to the DIG. Some of the main assumptions are:

- Data will be provided by Drainage Investment Group (DIG) and Niagara College,
- Aerial Photography, Digital Elevation Models, etc.,
- Additional data, such as climatic data, will be obtained by Globomatics,
- All the objectives and deliverables can be completed successfully within the given time period,
- Access to the GIS lab, necessary hardware and software will be provided by Niagara College, and
- Additional fieldwork will not be required for an effective analysis of the water balance.

8.2 Risks

With every project, there is some sort of risk. Since this project will not involve any intensive fieldwork, most of our risks pertain to errors in software, data or methodologies.

- All software packages and storage devices may crash, resulting in loss of work and/or data.
    - In order to avoid this, proper use of software and constant back-up practices must be done to keep data safe.
- The data provided and collected may not be entirely correct, accurate or precise.
    - To avoid using incorrect data, a data quality check must be done.
    - Not all obtained data are required to be used.
- Water balance calculation method may not yield an accurate and precise result.
    - Suitable calculation methods must be researched through academic articles.
    - Calculations must be tested multiple times to improve the quality of the results.

8.3 Issues and Constraints

- All deliverables must be fully completed by each set deadline.
    - Major tasks like presentations and reports have a hard deadline.
    - The project must be completed by June, 2015.
- Management of costs and time to keep project under budget and on time.
    - This is essential to ensure that the project runs as scheduled, and also to make sure that the project is finished before the due date.
- Any travel to the Marsh will be difficult due to travel and time restrictions.
    - This means that a limited amount of *in-situ* observations and data collection can be done.
    - Information from site field trips must be valued and taken in account for this study.

9 Conclusion

The Holland Marsh is known to be of significant importance in terms of agricultural practices and growing fresh produce in Ontario. Analysis of climate data is important for the understanding of how historic trends has impacted the area. A water balance model will be created to calculate the total water balance over a ten year period within the Holland Marsh. This model will calculate areas that have excess or deficit water trends by a 10m×10m grid.

The main deliverables for this project will include three presentations followed by three reports. The first phase will conclude with a proposal presentation and a proposal report which will be completed around December 2014. The second phase consists of a presentation and report, outlining the progress done in terms of data collection and data development. The final phase will finalize the water balance project with another presentation and report, summarizing the analyses done in the Marsh.

The proposed schedule outlined in Deliverable 1 has been updated, with the total work hours necessary to complete this project to 300 hours. The updated schedule has decreased the overall budget by $1,800.00 with a total budget updated to $42,600.00. By following the schedule outlined in Appendix C: Gantt Chart the project will be completed successfully on time and on budget.

By investigating the water balance of the Holland Marsh, this study will be contributing to a much bigger project. Globomatics in collaboration with DIG and Niagara College, will be providing this analysis for the benefit of any future river restoration and management initiatives. Globomatics Inc. is on track of completing this project successfully and on time.

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Appendix A: Terms of Reference

GIS Postgraduate Student/Consultant Project for

2014-15

Project ID: **201415-07** (for our office use only)

Contact Person & Organization Details

Contact Person	Name:	Brett Ruck
	Title:	Executive Director
	Telephone:	289-296-0701
	Fax:	
	Email:	bruck@digcorp.ca
Organization	Name:	Drainage Investment Group (DIG)
	Address:	4321 Queen Street, Niagara Falls, ON, L2E 2K9
	Website:	www.digcorp.ca
Date:		

Water Balance in the Holland Marsh

Project Details

Project Background

Project Problem/Opportunity: The Holland Marsh area is known as the "Salad Bowl of Ontario" producing over $1billion in revenue annually from what is possibly the most fertile soil in Canada. This area is made up of 125 farms covering 2900 hectares just 50km north of Toronto in Bradford, Ontario. The Holland River flows through the marsh and drains into Cook's Bay of Lake Simcoe. Of particular concern is the continued infiltration of nutrient contaminates.

Business Goal: To calculate the water balance of the Holland Marsh and identify areas of high susceptibility to nutrient intake.

Primary Project Objectives [Provide a list of the project objectives.]

- Undertake an analysis of climate data from the last decade to identify trends in climatic variables (Temperature, Precipitation, Storm Events, etc.).
- Identify potential areas of increased nutrient loading to the Holland Marsh River, mainly nitrogen and phosphorus.
- Identify the areas that have excess or deficit of water into the lower part (South-West) of the Holland Marsh River watershed.

Primary Project Deliverables [Provide a list of the project objectives.]

- Create comparative maps and graphs of climate change over the last decade.
- Undertake an analysis of climate change in the last decade and their impact on the Holland Marsh River.
- Performed detailed report of the analysis and methods used to calculate the water balance, including maps and graphics

For the Attention of the Students: This project will be used as part of the GIS postgraduate course GISC9302, GISC9309, and GISC9310. Forward letter of interest (including GIS project posting Number) and resume to Janet Finlay (jfinlay@niagaracollege.ca) via WORD attachment by **5 pm, Thursday, September 11, 2014**.

Requirements

Number of students required to complete the project:	2
Equipment required (if any):	None
Data required (if any):	DIG will provide data
Software required (if any):	ArcGIS, Office Suite
Confidentiality	TBD

Appendix B: Project Overview Statement

Project Overview Statement (POS)

Executive Summary

Project Name:	Water Balance in the Holland Marsh
Last Updated Date:	Tuesday, November 11, 2014
Author(s):	Josh Valenti, Ryan Roque
Project Manager(s):	Josh Valenti
Project Members:	Ryan Roque
Client Name:	Brett Ruck (Executive Director), bruck@digcorp.ca, 289-296-0701
Client Organization:	Drainage Investment Group (DIG)

Project Business Case

Business Problem/Issue/Opportunity

The Holland Marsh produces over one billion dollars in revenue annually, from what is possibly the most fertile soil in Canada. The wide variety of fresh produce grown in the area is the reason why it is referred to as the 'Salad Bowl of Ontario'. Located in Bradford, Ontario, the marsh covers 2900 hectares and contains about 250 farms. The Holland River is of particular significance because of its watershed, which flows through the marsh and drains into Cook's Bay of Lake Simcoe.

Project Business Goal

The overall goal is to calculate the water balance of the Holland Marsh and identify areas of high susceptibility to nutrient intake. This will be done by initiating an analysis of climate data in the Holland Marsh area. By investigating past climatic trends such as temperature, precipitation, and major storm events, the water balance can be calculated highlighting areas vulnerable to nutrient loading.

Primary Project Objectives

Primary Project Objectives

- Undertake an analysis of climate data from the last decade to identify trends in climatic variables (Temperature, Precipitation, Storm Events, etc.).
- Identify potential areas of increased nutrient loading to the Holland Marsh River, mainly nitrogen and phosphorus.
- Identify the areas that have excess or deficit of water into the lower part (South-West) of the Holland Marsh River watershed.

Project Benefits

Project Benefits

- Gain knowledge of climatic variables and water balance trends, for future analysis of areas with high susceptibility nutrient intake in the Holland Marsh River.
- Results may be used to develop future monitoring methods for water sustainability and prevention of high nutrient intake.
- Understand where and why the incoming and outgoing water flows in the Holland Marsh area, in order to sustain fertile soil for agricultural activities.

Primary Project Deliverables

Phase 1: Project Initiation

- Deliverable 1.1: Project Acceptance Confirmation (September 16, 2014)
- Deliverable 1.2: Project Kick-off Meeting (October 3, 2014)
- Deliverable 1.3: Project Overview Statement (POS) (November 11, 2014)
- Deliverable 1.4: Project Proposal Presentation (December 2, 2014)
- Deliverable 1.5: Formal Project Proposal (December 5, 2014)

Phase 2: Data Evaluation and Progress Report

- Deliverable 2.1: Data collection (November 2014 - April 2015)
- Deliverable 2.2: DIG Holland Marsh Site Visit (November 28, 2014)
- Deliverable 2.3: Bi-weekly status reports
- Deliverable 2.4: Project Presentation and Progress Report (March 2015)

Phase 3: Preparation of Final Report and Presentation

- Deliverable 3.1: Final Project Presentation (June 2014)
- Deliverable 3.2: Final Project Report (Hardcopy and digital) (June 12, 2014)
- Deliverable 3.2.1: Comparative maps and graphs of climate change over the last decade
- Deliverable 3.2.2: Analysis of climate change in the last decade and their impact on the Holland Marsh
- Deliverable 3.2.3: Details of analysis and methods used to calculate the water balance, including maps and graphics

Project Conditions

Project Assumptions and Risks

Assumptions:

- Data will be provided by Drainage Investment Group (DIG) and Niagara College.
- The objectives can be completed successfully within the course of each time period.
- Access to the GIS lab, hardware and software will be provided by Niagara College.
- Additional fieldwork is not necessarily needed for a successful analysis of the water balance.

Risks:

- All software packages and storage devices may crash, resulting in loss of work and/or data.

- The data provided and collected may not be entirely correct or accurate.
- Suitable calculation method of the water balance must be determined by researching academic articles.

Project Issues and Constraints

- All deliverables must be fully completed by the set deadline.
- Management of costs and time to keep project under budget and on time.
- Any additional fieldwork will be difficult because of time and travel restrictions.

Project Critical Success Factors (Key Performance Indicators)

Project Critical Success Factors

- Completion of reports, presentations and all other deliverables by each deadline.
- Excellent teamwork and communication between team members, project advisor and client.
- Understanding of the tasks required to efficiently and effectively meet each set objective.
- Full utilization of given resources (Personnel, software, data).

Project Duration Estimates

Project Phases	Date Estimate
Project Start Date	2014-09-16
Phase 1: **Project Initiation**	2014-09-16 – 2014-12-05
Phase 2: **Progress Report and Data Evaluation**	2014-11-01 – 2015-03-20
Phase 3: **Preparation of Final Report and Presentation**	2015-03-20 – 2015-06-12
Project End Date	2015-06-12

APPROVALS (sign on the dotted lines)

PREPARED BY ..... **DATE** .....
(PROJECT MANAGER)

APPROVED BY ..... **DATE** .....
(PROJECT / EXECUTIVE / CLIENT SPONSOR)

By signing this document, the above objectives, statements and dates have been agreed upon. However, due dates are only an estimate and are qualified to change based on certain situations and issues.

Refer to http://www.tenstep.com/open/miscpages/94.3Glossary.html for terms used in this document.

Appendix C: Gantt Chart