# RAW WATER FOR AGRICULTURAL IRRIGATION STUDY

# PHASE 2 PROJECT REPORT

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# 1.0 Introduction

Agriculture is one of the important industries of the Niagara Region, with an estimated $1.8 billion contribution to its economy. A major portion of the agriculture in the Niagara Region is composed of high value crops, such as grapes, tender fruits, and greenhouse products. Extreme weather patterns in recent years have highlighted the importance of securing an irrigation infrastructure at the regional level to reduce the risks associated with weather uncertainty. The prospect of further changes in weather patterns increases concern about the sustainability of this industry unless definite steps, such as the provision of an irrigation infrastructure, are taken.

In an effort to protect and support the important local agricultural industry, the Regional Municipality of Niagara (Region) engaged Stantec Consulting Ltd. (Stantec) to undertake a feasibility study for providing raw water for agricultural irrigation purposes in the Niagara Region. The *Feasibility Study – Raw Water for Agricultural Irrigation* was completed in September 2005. The study identified several alternatives for developing irrigation infrastructure, provided order of magnitude costs, highlighted opportunities and challenges facing the implementation of a regional irrigation project, and provided a range of alternatives for providing raw water for irrigation to the study area. A recommendation from the Phase 1 Report suggested a more detailed study be next step in the implementation of this project. The subsequent Phase 2 Study, which was awarded to Stantec in 2006, represents this next step, and is considered completed by the issuance of this report.

The northern portion of the Niagara Region comprises of five municipalities, namely, Niagara-on-the-Lake (NOTL), St. Catharines, Lincoln, Grimsby, and Pelham. Together, these areas total to about 23,000 hectares. These very fertile areas can benefit by implementing a well designed irrigation scheme. Moreover, with the enhancement of irrigation there is considerable potential for the production of high value crops in the Niagara Region resulting in further increase in revenues.

The Phase 1 Feasibility Study identified the order of magnitude of the costs for the project and recommended that further study into preliminary cost estimations be completed. The Phase 2 Study seeks to further quantify the cost, demands, and benefits of the alternatives, and then evaluate these alternatives for providing water for irrigation. As part of the Phase 2 Study, extensive field studies were carried out to collect information pertaining to unit demands for crops. These unit demands have been utilized in this report for the purpose of determining the preliminary sizing of the infrastructure components for different alternatives proposed. Hydraulic models and conveyance capacity calculations were prepared for the pipe and open channel schemes to ascertain the feasibility of these alternatives and also to obtain an opinion of the probable cost associated with each alternative.

In Phase 2, we examined in detail all technical aspects of the project. Various data gaps that were encountered during the Feasibility Study were addressed by collecting field data. The water demands and the spatial layout of the service areas were better understood. Various alternatives were examined in detail and combinations of alternatives were considered.

The project is set up as a series of deliverables. Each task within the project has an associated report or technical memo that was submitted to the Region upon completion. Subsequently, the Region and the Technical Advisory Committee were provided with an opportunity to comment on the findings of each study for a specified period. The comments were collected and each report or technical memo was revised for inclusion in the final Project Report. All revised reports have new completion dates, and supersede any document previously submitted. Full copies of these revised reports are included as appendices to this report.

This final Project Report is organized into seven (7) sections including this introduction section. Section 2 details the project objectives and outlines the area of study. Sections 3 to 6 summarize the major reports as revised. Section 7 summarizes each of the other supporting deliverables in brief.

This project has been funded in part through contributions by the Government of Canada and the Province of Ontario under the Canada-Ontario Water Supply Expansion Program, an initiative of the federal-provincial-territorial Agricultural Policy Framework designed to position Canada's agri-food sector as a world leader. The Agricultural Adaptation Council administers COWSEP on behalf of the Government of Canada and the Province of Ontario.

Canada Ontario

# 2.0 Project Objectives

1. **Ascertain Servicing Feasibility**

   Much of the general feasibility was identified in the Phase 1 Report. Some of the alternatives listed within that report were explored as a part of the Phase 2 assignment, and are narrowed down in terms of exact areas by way of consultation and field study.

2. **Prepare Servicing Alternatives Along With Opinions of Probable Costs**

   The scope of work below the escarpment is to generate and provide preliminary design of open channel and pipe conveyance alternatives for these areas, and to provide opinions of probable cost associated with each alternative. This section also identifies the opportunities and constraints for each alternative. Areas above the escarpment are included in the hydrogeological report with associated costs and feasibility.

3. **Identify Potential Project Benefits**

   A credible economic study showing that the public benefits of the project exceed its costs should facilitate seeking and securing substantial public investment in the project. Scope of work includes the economic study of the major agricultural sectors, and evaluation of the magnitudes of impact that the irrigation project might have on the different economies.

4. **Identify and Evaluate Environmental Impacts**

   The purpose of the Natural and Social Environment Report is to identify and evaluate the potential impacts of various supply and distribution alternatives on the natural and social environments in the Town of NOTL, Town of Lincoln, and City of St. Catharines. This report is intended to support the Municipal Environmental Assessment (EA) process.

5. **Recommend a Preferred Alternative**

   Utilizing the results from the Natural and Social Environment Report, a preferred alternative could then be selected for each of the study areas.

6. **Follow with Management and Phasing Strategy**

   Subsequent to this Project Report are two separate technical studies related to recommendations for the management structure and the phasing of the construction for the preferred alternatives. They are designated the Management Technical Memorandum and the Project Implementation Report.

## 2.1 AREAS OF STUDY

The terms of the Phase 1 Feasibility Study dictated that the study areas include the five northern municipalities of the Niagara Region. At that time, the areas were divided into districts using a combination of municipal, rural, and physical boundaries. The four districts include:

- West District Zone A (Lincoln and St. Catharines below escarpment)
- West District Zone B (Lincoln and St. Catharines above escarpment)
- South District (Pelham)
- East District (NOTL)

The Study is limited to the rural areas within the above boundaries.

# 3.0 Engineering Study

The *Engineering Report* has been prepared as part of the Niagara Feasibility Phase 2 assignment to evaluate the various alternatives for providing irrigation water to the Niagara Region, and also to determine approximate size and probable cost of the infrastructure required. Opinions of probable cost associated with each alternative have also been presented in this report. These alternatives have been further evaluated from the environmental perspective in the *Natural and Social Environment Report*.

The *Engineering Report* was submitted in June 2007, and comments were collected from the submission date until November 2007. All comments have been incorporated or addressed in the finalized report which is attached in its entirety in Appendix A, along with all relevant figures. The following is a summary of the report and its findings.

The servicing options for irrigation evaluated in the *Engineering Report* are for the areas below the escarpment. Pelham and the West District Zone B were excluded from servicing due to the conclusions reached in the *Hydrogeological Assessment Report*, which is discussed further in Section 4. Grimsby was also excluded from the service area below the escarpment, due to the fact that Grimsby has a limited amount of agricultural area that is below the escarpment.

The service areas are grouped as

- West District Zone A (Lincoln and St. Catharines)
- East District (NOTL)

Various servicing alternatives include a pipe network or an open channel network or a combination of both as means of supplying irrigation water. The water demands for various crops have been developed based on extensive field investigations by Weather Innovations Network, which is a subconsultant for this assignment (see Section 7.3). These crop unit demands have been utilized to generate water demands and size the irrigation infrastructure required for different alternatives. The total water demand for the West District Zone A is approximately 147,000 $m^3$/d (147 ML/d) and for the East District is approximately 142,000 $m^3$/d (142 ML/d).

Four servicing alternatives were examined for the West District Zone A and three servicing alternatives for the East District.

Unit costs have also been assigned to various capital items. These costs have been assigned using a combination of supplier information, NOTL town staff experience, and Stantec's knowledge based on previous projects.

Each alternative comprises of one or more intakes for drawing water from the source and a pipe or an open channel system to convey water. Pipe alternatives also contain one or two booster pumping stations to boost pressures to acceptable levels. A brief description of West District Zone A and East District Alternatives is presented below.

## 3.1 SERVICING ALTERNATIVES WEST DISTRICT ZONE A:

Four alternatives were considered:

- Alternative W1 comprises of an all piped alternative with a single intake.
- Alternative W2 also comprises of an all piped alternative. However, water for irrigation will be drawn from two sources.
- Alternative W3 is also an all piped alternative. In this alternative, water for irrigation will also be drawn from two sources. One of the sources is different from Alternative W2.
- Alternative W4 comprises of servicing part of the area by an open channel network, and the remaining area by the piped network. The service area east of Sixteen Mile Creek will be serviced by the open channel network. The remaining area will be serviced by the piped network. For this alternative, water sources are the same as Alternative W3.

There are six numbered intake alternatives for this District listed below:

1. Lake Ontario at Sann Rd.
2. Jordan Harbour at 1st Ave.
3. Lake Ontario at 5th St. Louth
4. 12 Mile Creek at CN crossing
5. 12 Mile Creek at Ontario Power Generation (OPG) discharge
6. Lake Gibson/Moodie near Decew Rd.

Different combinations of intakes were utilized for each alternative. One or two booster pumping stations were required depending on the alternative. Opinions of probable capital and annual operation and maintenance costs were developed for each. Table 1 summarizes the alternatives presented.

**Table 1: Summary of Alternatives for West District Zone A**

| Item | Alternative | | | |
|---|---|---|---|---|
| | **W1** | **W2** | **W3** | **W4** |
| Capital Cost in Million Dollars | 75 | 82 | 86 | 71 |
| Annual O & M Cost in Million Dollars | 0.3 | 0.3 | 0.3 | 0.4 |
| Total Pipe/Channel Length (km) | 140 | 145 | 152 | 148 |
| No. of New Intakes | 1 | 2 | 2 | 2 |
| Intake Options Number (s) | 1/2/3 | 1/2 + 3/4 | 1/2 + 5/6 | 1/2 + 5/6 |
| No. of Booster Pumping Stations | 2 | 2 | 1 | 1 |
| No. of Major Crossings | 2 | 2 | 2 | 2 |
| No. of Minor Crossings | 24 | 24 | 24 | 16 |

Hydraulic modeling software WaterCAD® was utilized to estimate pipe sizes, and booster station capacities. Open channel sizes estimated by manual calculations based on first principles.

## 3.2 SERVICING ALTERNATIVES EAST DISTRICT:

There are three different alternatives for the East District.

- Alternative E1 comprises of an all piped alternative and utilizing three existing intakes for supplying water. Two of the existing intakes will be upgraded to augment capacity to provide the irrigation water needs for the entire East District.

- Alternative E2 also comprises of an all piped alternative. However, in addition to utilizing the three existing intakes, this alternative proposes a new intake. For this alternative, upgrades have been proposed for one of the three existing intakes.

- Alternative E3 is an open channel alternative and proposes to use the existing open channels within the area with major and minor upgrades, and also proposes some new channels. For this alternative, it is also proposed to utilize three existing major intakes, and propose one new intake.

There are four major intake alternatives for this District listed below:

1. Lock 3 Pumping Station (new)

2. Eastchester Pumping Station (existing capacity 21,800 $m^3$/d (4,000 USGPM))

3. Queenston Pumping Station (existing capacity 27,255 $m^3$/d (5,000 USGPM))

4. Ontario Hydro Canal Pumping Station (existing capacity 22,900 $m^3$/d (4,200 USGPM))

One booster pumping station is required for each of the alternatives E1 and E2.

Different combinations of intakes for were utilized for each alternative. One booster pumping station was required for alternatives E1 and E2. Opinions of probable capital and annual operation and maintenance costs were developed for each. Table 2 summarizes the alternatives presented.

**Table 2: Summary of Alternatives for East District**

| Item | Alternative | | |
|---|---|---|---|
| | E1 | E2 | E3 |
| Capital Cost in Million Dollars | 62 | 66 | 19 |
| Annual O & M Cost in Million Dollars | 0.29 | 0.29 | 0.27 |
| Total Pipe/Channel Length (km) | 167 | 167 | 24 |
| No. of New Intakes | - | 1 | 1 |
| No. of Intake Upgrades | 2 | 1 | 2 |
| No. of Booster Pumping Stations | 1 | 1 | 0 |
| No. of Major Crossings | 2 | 2 | 1 |
| No. of Minor Crossings | 0 | 0 | 0 |

Hydraulic modeling software WaterCAD® was utilized to estimate pipe sizes, and booster station capacities. The open channel option utilizes existing infrastructure with upgrades to expand service area (includes K-Smart proposed upgrades) and pumping station sizes to meet demand requirements. The existing minor intakes (siphons) and transfer pumping stations would also be utilized.

## 3.3 OPPORTUNITIES AND CONSTRAINTS

The level of proposed service would convey water within reach of the individual fields and it is assumed that the individual farmers would employ their own means to transfer water to their fields. A water utilization protocol would need to be developed in order to manage usage of water by individual farmers. The pipe network system alternatives would provide greater levels of service as compared to the open channel system.

Operating and maintenance costs calculated for the systems proposed above are relatively low when compared to municipally supplied drinking water distribution systems. Costs for these systems tend to be estimated by using 2% of the capital cost of the infrastructure proposed. With irrigation, operation and maintenance costs are relatively lower mainly due to the fact that the system is running for a maximum of four months out of the year. Therefore, using this measurement system, it can be expected that operation and maintenance costs will be in the range of 0.5% to 1% of capital costs. These costs do not include the infrastructure replacement costs, which are typically estimated at 2% of the capital cost.

The designated intake alternatives are associated with constraints due to permits and water availability. *Task 4 – Regulatory Requirements and Related Considerations* technical memorandum prepared by Kinkead Consulting addressed the regulatory requirements in general. Subsequently, upon recommendation of preferred alternatives, a detailed memo was also prepared and submitted. This memo detailed the regulatory and policy issues related with the water takings for the preferred alternatives. Both of these memos are attached in Appendix H.

As discussed above, more than one intake location was identified for each intake alternative. Environmental discussion of the intake and distribution alternatives was prepared as a separate report. Based on the findings of the *Natural and Social Environment Report*, a preferred alternative was proposed for each of the two districts. Selection of the exact intake locations is beyond the scope of this study, and will be dealt with during the Class EA stage of individual intake design.

## 3.4 COMMENTS

Comments were submitted to Stantec by the NOTL Irrigation Committee for the *Engineering Report*, and a response was prepared and sent to the NOTL Irrigation Committee. The letter and response are attached to the *Engineering Report* in Appendix A.

# 4.0 Hydrogeological Study

In the *2005 Phase 1 Feasibility Study*, Stantec identified groundwater as the preferred source of irrigation water for the areas above the Niagara Escarpment, namely West Irrigation District Zone B and South Irrigation District.

To further assess the potential for groundwater-based irrigation above the Niagara Escarpment, Stantec undertook a phased hydrogeological study with the following objectives:

- Develop a conceptual understanding of the geology and hydrogeology.
- Determine the theoretical well yields in the study area.
- Determine if surplus groundwater was available for irrigation purposes.
- Evaluate if water quality conditions were suitable for irrigation uses.

The hydrogeological assessment focused on two separate study areas referred to as West District Zone B and the South District. Several staged technical memorandums were submitted to the Region and comments were collected and included in the final report. A final report was issued in June 2007 and a copy of the signed final report is located in Appendix B, complete with all relevant figures.

Zone B is a relatively narrow strip of land located adjacent to the northern face of the escarpment, whereas the South District is situated on the Fonthill Kame-Delta Complex. Conclusions and recommendations for each study area are provided below.

## 4.1 WEST DISTRICT ZONE B STUDY RESULTS AND CONCLUSIONS

It was concluded that establishing a groundwater sourced irrigation supply in Zone B was not feasible, based on the following:

1. The dolostone bedrock (Lockport Formation) was the only aquifer identified in Zone B. The probability of establishing a bedrock well, or multiple wells where space permits, in order to meet the irrigation demand of each parcel is typically less than 10% due to low well yields.

2. Available water quality data indicated that the dolostone can contain elevated concentrations of total dissolved solids and manganese compared with the Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses. Other parameters of potential concern include chloride and iron. As a result, even if a grower were able to establish a high yielding well(s) for irrigation, water quality is likely to be an issue.

## 4.2 SOUTH DISTRICT STUDY RESULTS AND CONCLUSIONS

The following conclusions are presented for the South District:

1. The sand and gravel deposits of the Fonthill Kame-Delta Complex and the upper dolostone bedrock (Guelph and Lockport Formations) were identified as potentially suitable aquifer systems to establish wells for irrigation. The probability of establishing an irrigation supply decreases with increasing demand, from greater than 75% probability for parcels with irrigation demands of less than 100 $m^3$/day (10% of parcels) to less than 35% probability for parcels with irrigation demands of more than 600 $m^3$/day (29% of parcels).

2. The Erigan bedrock channel was not considered to be a significant hydrogeological feature, based on available water well information.

3. The overburden and bedrock water quality data for the South District is variable and may be suitable for irrigation purposes in some areas but not in others. The water quality would need to be evaluated at the parcel level to determine its suitability for irrigation. Specific parameters of concern include total dissolved solids, manganese, iron, and chloride.

4. Based on the water balance calculations for the Fonthill Kame-Delta Complex, water infiltrates to the deeper aquifer systems at a rate ranging from 21 L/s to 225 L/s. Existing groundwater demand was estimated to be 125 L/s, suggesting that further refinement of the water balance would be required to understand if an additional irrigation demand of 33 L/s was sustainable.

5. The cost to construct, permit and equip a 152 mm diameter irrigation well is estimated to be in the range of $67,000 to $80,000. The cost of a larger 203 mm diameter well is estimated to range from $85,000 to $105,000. The costs assume a well depth ranging from 30 m to 50 m and do not include any aboveground irrigation infrastructure costs.

Groundwater-based irrigation is not feasible for all parcels but may be an option for some of the smaller growers pending further study involving:

- A private well survey and sampling program.
- Collection of additional stream flow data from the watercourses in both wet and dry conditions to refine the baseflow and runoff estimates.
- Continuous groundwater level measurements should be collected at a select number of monitoring wells completed in the overburden and bedrock aquifer systems.

- The Fonthill Kame-Delta Complex should be modeled using a finite element model (i.e., FEFLOW) to allow for a more realistic representation of surficial topography, particularly in the vicinity of watercourses where an understanding of groundwater/surface water interaction is critical.

## 4.3 COSTS

An estimated cost to drill and construct a supply well in the South District is based on the following assumptions:

- Well depth ranging from 30 m to 50 m. Drilling costs assume to include mob/de-mob, drilling, well casing/grout, and development. A cost to complete a 152 mm (6") diameter and 203 mm (8") diameter well are provided. A 152 mm diameter well is optimal for well yields of up to 6.3 L/s (545 $m^3$/day) and a 203 mm diameter well is optimal for well yields ranging from 6.3 L/s to 11 L/s (545 to 954 $m^3$/day).
- Installation of a 100 mm (4") or 152 mm (6") diameter submersible pump and pitless adapter.
- Pump testing and permitting.
- Irrigation infrastructure costs were not considered.

Based on these assumptions, the cost per well was estimated at:

**<u>Construction of 152 mm (6") Diameter Well</u>**

| | |
|---|---|
| Well Construction | $22,000 to $25,000 |
| Pump/Pitless Installation and Labor | $20,000 |
| Pump Testing and Permitting | $25,000 to $35,000 |
| **Total Estimated Cost – 152 mm Diameter Well** | **$67,000 to $80,000** |

**<u>Construction of 203 mm (8") Diameter Well</u>**

| | |
|---|---|
| Well Construction | $30,000 to $40,000 |
| Pump/Pitless Installation and Labor | $30,000 |
| Pump Testing and Permitting | $25,000 to $35,000 |
| **Total Estimated Cost – 203 mm Diameter Well** | **$85,000 to $105,000** |

# 5.0 Natural and Social Environment Report

The irrigation study has been developed in accordance with the Municipal EA Master Planning Process. The purpose of the *Natural and Social Environment Report* is to identify and evaluate the potential impacts of various supply and distribution alternatives on the natural and social environments in the Town of NOTL, Town of Lincoln, and City of St. Catharines. This report is intended to support the Municipal EA process. The preferred intake options and distribution alternatives for each district were selected based on a consideration of natural and social features.

The report was submitted in September 2007 and comments were collected from the submission date until November 2007. All comments have been incorporated or addressed in the finalized report which is attached in its entirety in Appendix C. The following is a summary of the report and its findings.

## 5.1 INTAKE OPTIONS SELECTION CRITERIA

- Potential volume impact to water source.
- Presence of notable aquatic habitat.
- Bank stability.
- Potential habitat for aquatic species at risk.
- Potential habitat for terrestrial species at risk.
- Presence of Area of Natural and Scientific Interest (ANSI).
- Presence of evaluated wetlands.
- Presence of woodlots > 2 ha.
- Level of disturbance.
- Number of residences within 100 m.
- Number of communities within 500 m.
- Number of cemeteries within 100 m.
- Number of landfills within 100 m.
- Number of trail features within 100 m.
- Number of public parks.
- Licensed pits and quarries.

## 5.2 DISTRIBUTION ALTERNATIVES SELECTION CRITERIA

- Number and type of watercourse crossings.
- Number of woodlot crossings.
- Number of Provincially Significant Wetland crossings.
- Number of crossings of Areas of Natural and Scientific Interest.

## 5.3 PREFERRED ALTERNATIVES

### 5.3.1 West District

In the West District, four intake options were eliminated for the following reasons:

- Intake 2
  - Presence of notable aquatic habitat
  - Provincially Significant Wetland
  - Area of Natural and Scientific Interest
  - Potential habitat for Species at Risk
- Intake 4
  - Recreational trail
  - Rykert Street Park
  - Impacts to numerous non-user residents
- Intake 5
  - Relatively sensitive terrestrial community that may support plant species at risk
- Intake 6
  - Pipeline crossings of Escarpment Natural Area, the upper reaches of Twelve Mile Creek, and the Twelve Mile Creek Bottomlands
  - Decew Falls, and Decew Gorge Life Science ANSIs

The open channel distribution alternative was eliminated for the West District because:

- It would involve drawing large quantities of water from watercourses containing fish habitat and transporting it across watershed boundaries.

- Water would be added to watercourses with potentially differing chemical, physical, and biological properties.
- Irrigation water would be drawn from watercourses supporting fish habitat.

The resultant preferred alternatives for the West District are Alternative W1 (Piped, Intake 1 or 3) and Alternative W2 (Piped, Intake 1 and 3).

Among Alternatives W1 and W2, Alternative W1 is the less expensive of the two alternatives. Therefore Alternative W1 is recommended as the preferred alternative for the West District.

### 5.3.2 East District

The piped distribution alternative for the East District was eliminated because it would require the replacement of the existing open channel irrigation system, which currently provides aquatic habitat, with a closed pipe system that does not provide aquatic habitat.

The closed pipe Alternatives E1 and E2 are not recommended as their implementation would result in decreased quantity and quality of fish habitat within the current irrigation system. Both closed pipe options would result the cessation of water flow from the three major and two minor intake stations into the drain and channel systems, which currently support Type 1 (critical) and Type 2 (important) fish habitat. Furthermore, a reduction in the water volumes entering the system upstream may lead to impacts to the McNab Marsh, Two Mile-Four Mile Creek Plain and Paradise Grove Plain Life Science ANSIs.

As a result, Alternative E3 is the recommended alternative for the East District.

# 6.0 Economic Benefits Report

The tender fruit and grape growers in the Niagara Region have consistently identified the provision of an irrigation infrastructure as one of the strategies for supporting the agricultural industry in the area. The direct benefit of irrigation to this sector is, therefore, widely recognized. Furthermore, irrigation is indispensable for greenhouses and nurseries. Growth of these high value industries is highly dependent on ease of access to irrigation water.

Although the direct benefits of irrigation to certain sectors of the regional agricultural economy are clear, the direct benefits to the current growers are not sufficient to justify the large capital expenditure required for the development of a regional irrigation infrastructure. *Feasibility Study – Raw Water for Agricultural Irrigation* concluded that the cost of the project is above the capacity of the existing growers to pay and that there is need for substantial public support for this project. This public support can only be justified by demonstrating that the benefits of the project to the regional, provincial and national economies are greater than the public contribution required for the capital investment.

The development of a regional irrigation infrastructure has several types of benefits:

- Increasing the gross revenues of crops that respond well to irrigation.
- Reducing the risk associated with growing crops that respond well to irrigation.
- Inducing a move toward higher value agriculture by opening up areas that currently have no access or restricted access to irrigation water
- Ripple economic effects: a highly productive agricultural sector fuels the local, regional, provincial and national economies, producing economic impacts that are several times greater than direct farm revenues.

A credible economic study showing that the public benefits of the project exceed its costs should facilitate seeking and securing substantial public investment in the project. Stantec's team included Dr. Wayne Pfeiffer, a respected Professor of Agricultural Economics at the University of Guelph. Dr. Pfeiffer led the economic study of the major agricultural sectors and evaluated the magnitudes of the impact of the irrigation project on the different economies.

A peer review of this study was also performed by the project advisor Dr. Kevin W. Ker, B.Sc. Agr., M.Sc., B.Ed., P.Ag., Grape and Tender Fruit Specialist and professor at Brock University. Stantec provided a foreword to the overall report. The full report along with Dr. Ker's review is included in Appendix D.

The following is a brief tabular summary of the results from the *Economic Benefits Study*. For details of the methodology and a full description of results, please see the attached report.

## 6.1 DIRECT ECONOMIC BENEFITS

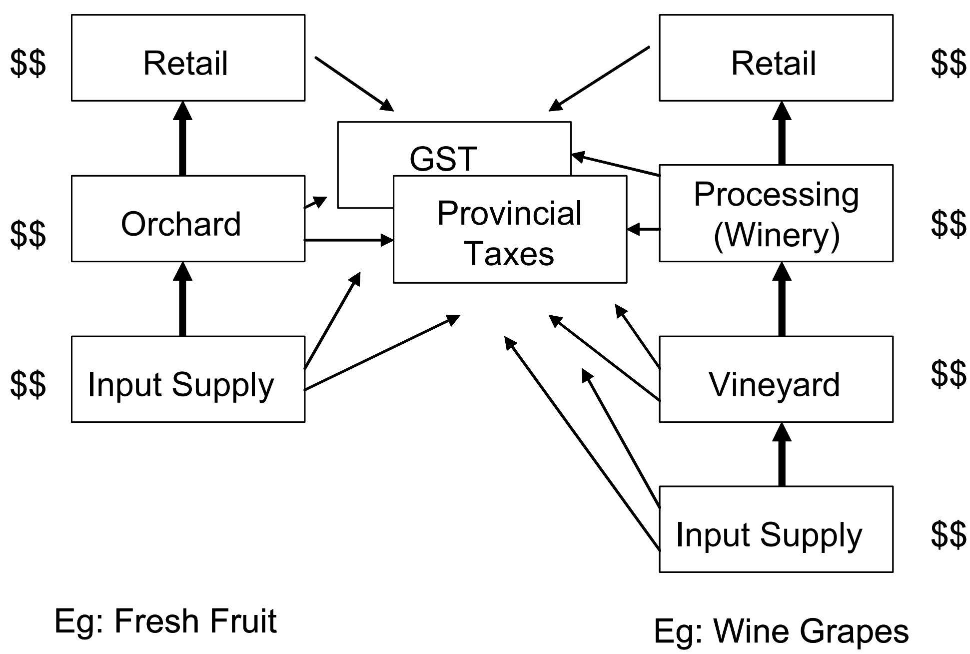
**Table 3: Growers Direct Economic Benefits**

| Sector | Best Case Annual | Worst Case Annual |
|---|---|---|
| **Tender Fruit** | $7.7 Million | $7.3 Million |
| **Wine Grapes** | $7.5 Million | $2.8 Million |
| **Horticulture & Greenhouse** | $0.538 Million | $0.501 Million |
| **Total** | **$15.7 Million** | **$10.6 Million** |

## 6.2 INDIRECT ECONOMIC BENEFITS

Indirect benefits were arrived at by studying the agricultural value chains tracing the agricultural produce from the farm gate to the refined products ready for consumption. Indirect benefits were arrived at using a multiplier to the direct benefits.

**Figure 1: Agricultural Value Chains**



The following indirect benefits were identified:

### 6.2.1 Regional Economic Benefits

**Table 4: Regional Economic Benefits**

| Sector | Growers | Value Chain (multi-level) |
|---|---|---|
| **Tender Fruit** | $7.4 m | $11.5 m |
| **Wine Grapes** | $4.9 m | $22.3 m |
| **Horticulture & Greenhouse** | $500 k | $1.1 m |
| **Total** | **$12.8 m** | **$34.9 m** |

### 6.2.2 Provincial and National Economic Benefits

**Table 5: Provincial and National Economic Benefits**

| Sector | Provincial | National |
|---|---|---|
| **Tender Fruit** | $23.1 m | $1.4 m |
| **Wine Grapes** | $80.6 m | $4.8 m |
| **Horticulture & Greenhouse** | $754 k | $45 k |
| **Total** | **$104.4 m** | **$6.2 m** |

# 7.0 Supporting Reports and Documents

## 7.1 LAND USE STUDY

The objectives of the *Detailed Land Use Study* are to provide an accurate picture of the existing land use in the study areas.

The report was submitted in October 2006 and comments were collected from the submission date until November 2007. All comments have been incorporated or addressed in the finalized report which is attached in its entirety in Appendix E. The following is a summary of the report and its findings.

The technical activities of this task began with obtaining a property boundary map of the rural areas of the five target municipalities. A windshield survey (observation made of each property from roadside) was conducted to identify the crops grown during the 2006 growing season. Subsequently, the property lines were superimposed on the most recent available aerial photograph of the region. A final land use map was prepared using observations from the area photograph in combination with the windshield survey results.

This land use study has produced a valuable picture of existing and potential land use for each district. The entire data is compiled in Table 6, showing total areas of the different crop categories in the five target municipalities during the 2006 growing season. This data together with data from the consumption study will be used to determine the quantity and geographic distribution of demand for irrigation water in the five target municipalities. For a breakdown of the five irrigation districts, and associated maps, see the full report attached in Appendix E.

**Table 6: Land Use – All Irrigation Districts**

| Category | Total (ac.) |
|---|---|
| Grapes - Wine | 15832 |
| Tender Fruit | 9472 |
| Nurseries | 2171 |
| Greenhouses | 1445 |
| Grapes - Juice | 3465 |
| Pome Fruit | 1664 |
| Idle Land | 20788 |
| Cash Crops | 13135 |
| Pasture | 2008 |
| Other Fruit | 283 |
| **Total Categorized** | 70263 |

## 7.2 CONVEYANCE EFFICIENCY STUDY

The conveyance efficiency of an irrigation distribution system is a measure of the fraction of water removed from the source that is conveyed to the end user or, in other words, a measurement of all losses in an irrigation distribution system between the source and the farm field. As introduced within the *Feasibility Study* (August 2005), the relative conveyance efficiency of a given distribution system, be it open-channel or pipeline, represents an important parameter in the comparison of costs and efficiency of utilization of water resources between systems.

The report was submitted in November 2006 and comments were collected from the submission date until November 2007. All comments have been incorporated or addressed in the finalized report which is attached in its entirety in Appendix F. The following is a summary of the report and its findings.

The conveyance efficiency of an open channel distribution system is, in general, substantially lower than a pipeline system due to evaporation and seepage losses, operational wastes, and return flows. The conveyance efficiency is highly dependent on the management of the irrigation system. Environmental factors such as temperatures, humidity, and groundwater levels also have a major impact on the efficiency of the system (losses in drier years are generally higher than losses during a humid year). For the *Phase 1 Final Report*, a preliminary efficiency of 70% was used in all calculations. A more accurate estimate was deemed obtainable by a study of the conveyance efficiency of an existing open channel distribution system.

The objective of this study was to determine an accurate measure of losses that an open irrigation channel would produce during regular operation, as a parameter of comparison with closed systems. Since the concern was not to differentiate between types of losses (i.e. evapotranspiration vs. seepage), a flow measurement system was chosen to facilitate in quantifying losses. This would also facilitate in measuring return flow. Following the recommendations of Agriculture and Agri-Food Canada Prairie Farm Rehabilitation Administration (AAFC-PFRA), v-notch weirs were selected as the preferred flow measurement structures.

The two reaches chosen for the study were the Lavigne Drain and the Harrison 6 Drain in the Town of NOTL's Irrigation System. They were selected because of their relatively long reaches without flow splits or additions, and because they traveled through two relatively different soil types.

A limited data set was collected in 2006, due mainly to large rain events which would disrupt any accurate measure of conveyance efficiency. However, seepage and evapotranspiration losses were deemed to be fairly accurately measured.

Based on the data collected during this study, we have concluded that the major component of conveyance efficiency of open channel systems in the Niagara Region is return flow. Return flow is more pronounced during low demand periods than high demand periods. Also, every system shut-down during the season will entail a significant loss of water for re-filling the channels.

We have estimated the following efficiency for the open channel distribution systems:

A conveyance efficiency of 70%, as recommended by the *Phase 1 Report* is supported for peak demand periods. This efficiency will be used to size the infrastructure, such as intakes, pumps, transmission components and distribution channels.

It should be noted that for average seasonal water takings, the efficiency will decrease, and therefore pumping requirements will not be directly proportional to demand. An average conveyance efficiency could not be drawn from the findings in this report, however, it is expected to be near to 40%, and is dependant on the length of the system, as well as level of automation and management practices.

A related Stantec internal memo (Consumption Memo) was compiled to summarize the use of these findings for the final demand numbers, and can be found as an appendix to the *Engineering Report* (Appendix G of Appendix A).

## 7.3 CONSUMPTION STUDY

A thorough daily evaluation of irrigation demand under a base line season of weather conditions must be completed to quantify water requirements. While studies have postulated the daily plant water requirements, and soil water holding capacities can be tested, little monitoring has been done to prove the calculations, particularly the relationship of water demand to the seasonal weather experience in the Niagara Region. Because of the variations in the soil water holding capacity, the lack of precision in crop factor estimates, and a potential accumulation of error in the reference evapotranspiration calculation, water needs over an entire season may be much different than estimates suggest. Monitoring both weather parameters and soil water depletion rates daily and continuously over an entire season can provide both the peak and seasonal irrigation demand during 2006. This study has both calculated and monitored water requirements for grape and tender fruit under the 2006 season experience and then evaluated the 2006 season's actual and calculated water requirements relative to the average season and 10 year return drought values for the Niagara Region areas in the study.

A detailed consumption study was carried out by our subconsultant, Weather Innovations Network, using leading edge technology for the measurement of soil water content and other weather parameters.

Several staged technical memorandums were submitted to the Region, and comments were collected and included in the final report. A final report was issued in January 2007, and a copy of the final report is located in Appendix G. The following is a summary of the report and its findings.

This study presents measurements of soil and weather variables collected from July to September 2006 in the tender fruit and grape growing regions of Niagara. Six automated weather stations were placed in peach orchards and vineyards within four designated districts of the Niagara Region. At each site a profile of volumetric water content was measured using a capacitance probe while the meteorological variables included rainfall, temperature and solar radiation. All variables were recorded at 15 minute intervals throughout the study period.

Time series of soil volumetric water content at the 10, 30, and 50 cm depths are presented along with corresponding estimated total water content in the 0 to 60 cm soil profile. This information was used to determine the crop coefficient (Kc) value for days following a rainfall event, and to determine the proportion of gross precipitation that infiltrates into the crop-root zone.

Average 10-year return drought was calculated using data from the Environment Canada weather station in Vineland. In addition, potential evapotranspiration (ETo) was available for the growing seasons of 2003 to 2006. This information was used to determine the irrigation needs for tender fruit and vineyard growers in this region.

Based on average precipitation for the Niagara Region (using data from 1970-2002) the water required by irrigation for the peach growing sites, Site 1, 2 and 11, using a drip irrigation system would be 145.4mm, 136.4mm, and 136.4mm, respectively. Using an overhead irrigation system, the water requirement increases to 179.6mm, 168.5mm, and 168.5mm. In a situation of a 1 in 10 year drought, the irrigation water for these sites using drip irrigation is 232.3mm (Site 1), and 223.3mm for Sites 2 and 11. For the grape growing sites, Sites 5, 8, and 17, the irrigation requirement using a drip irrigation system in an average precipitation year is 14.4mm, 14.4, and 25.1mm. For an overhead irrigation system, the water needed is 17.8mm, 17.8mm, and 31.0mm. In a 1 in 10 year drought scenario, the water required for drip irrigation is 101.3mm, 101.3mm, and 112.0mm. For overhead irrigation the water needed increases to 125.2mm for Sites 5 and 8 and 138.4mm for Site 17.

A related Stantec internal memo (Consumption Memo) was compiled to summarize the use of these findings for the final demand numbers, and can be found as an appendix to the *Engineering Report* (Appendix G of Appendix A).

## 7.4 REGULATORY ISSUES

The primary regulatory consideration in obtaining government approval for the proposed raw water irrigation systems is the acquisition of Permits to Take Water (PTTW) under the Ontario Water Resources Act. The Act and the accompanying Water Taking and Transfer Regulation (O. Reg. 387/04) are administered by the Ministry of the Environment (Ministry). The regulation identifies specific considerations the Ministry will and/or must take into account in deciding whether to issue a permit and in establishing conditions upon the withdrawal and use of the water. Those considerations include broader sustainability issues relating to withdrawing water from the Great Lakes Basin and in particular to any proposed transfer of water between major watersheds such as between the Lake Erie and Lake Ontario basins. Such transfers were included in the sourcing and servicing options short-listed in Phase 1.

The Great Lakes – St Lawrence River Basin Sustainable Water Resources Agreement, (SWRA), signed in December 2005, contains an updated framework for implementing the water resources management principles contained in the 1985 Great Lakes Charter and the 2001 Charter Annex.

Until the new mechanisms are in place, Ontario and the other Great Lakes Parties have agreed to operate under existing Charter principles and processes with the caveat that each Party shall "exercise its best efforts to refrain from taking any action that would defeat the objectives of this Agreement". It is imperative, therefore, that the preferred raw water irrigation solution for each district be developed with appropriate consideration of water permitting opportunities and risks reflected in the SWRA policy and regulatory framework.

Stantec employed John Kinkead as the Regulatory Approvals Specialist for the project. Mr. Kinkead was the Regulatory Approvals Specialist for the *Feasibility Study – Raw Water for Agricultural Irrigation*. He built on the general work carried out in the Phase 1 Study. Mr. Kinkead consulted with stakeholders during the current phase, and based on his consultations he provided the specific regulatory requirements of the different alternatives.

Two staged technical memorandums were submitted to the Region. Both are located in Appendix H.

## 7.5 PILOT OFF-STREAM RESERVOIR

The alternative of using off-stream reservoirs to collect water during spring for irrigation use in the summer months is a versatile solution applicable to all irrigation districts. In the areas below the escarpment, it may substantially reduce the cost of the overall irrigation system if pockets of isolated and sparsely irrigated lands could be serviced by off-stream reservoirs, while the more densely irrigated lands closer to large water sources are irrigated using pipeline or open channel communal distribution systems. In the areas above the escarpment, supply from off-stream reservoirs could be the overall solution as the groundwater solution turned out to be unfeasible.

Although ponds have commonly been used in the target areas for storage of irrigation water, the existing ponds are generally designed for being filled throughout the irrigation season (rather than prior to the irrigation season). This limits the applicability of irrigation to the areas with access to water during the dry summer period. The concept of off-stream reservoir allows expansion of irrigation to the entire target area, since virtually all locations within the five targeted municipalities in the northern Niagara Region have access to sufficient water during the spring period. In fact, off-stream reservoirs can be constructed anywhere in the Niagara Region providing a viable solution to pockets of potential irrigators outside the five targeted municipalities of this study.

The objective of this task is to take advantage of the experience with the construction and operation of off-stream reservoirs in other provinces, and to do preliminary feasibility of one pilot off-stream reservoir within the target areas. A review of the off-stream reservoir technology and practice in other provinces was made through PFRA. One location above the escarpment was selected in consultation with willing growers for the feasibility study of the off-stream reservoir. It was hoped that the feasibility study of these reservoirs could allow users in the study areas to accurately assess the applicability and cost of this solution as the preferred solution for districts above the escarpment or a complementary solution for the districts below the escarpment.

A technical memorandum was submitted to the Region located in Appendix I. Unfortunately, it concluded that the study site was not suitable for reservoir construction. Therefore more study is required in order to locate and assess off-stream reservoirs as a viable alternative.

## 7.6 PUBLIC INFORMATION CENTERS

As the initial activity of the Phase 2 Study, we began with Public Information Centres (PIC) in two locations: Niagara-on-the-Lake and Lincoln. These PICs communicated to the communities the conclusions of the Feasibility Study, plans for Phase 2, and the process of the Class EA, which began with the Feasibility Study and will be advanced to the completion of its Phase 2 during the current assignment. This consultation is designated PIC 1.

After the selection of the preferred alternative as determined by the *Natural and Social Environment Report*, it was deemed necessary to present the findings to the public, and at the same time satisfy the requirements of the Municipal EA process. This consultation is designated PIC 2.

Technical memorandums were compiled for both PIC 1 and PIC 2 and are located in Appendix J.

***--- STANTEC CONSULTING LTD. ---***