

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. B. R. Davis,
Bridge Engineer,
Bridge Division,
Admin. Bldg.

ATTENTION: Mr. F. I. Hewson,
Sr. Bridge Liaison Engr.

OUR FILE REF:

FROM: Foundation Section,
Materials & Testing Division,
Room 107, Lab. Bldg.

DATE: October 15, 1968

IN REPLY TO

OCT 18 1968

SUBJECT:

REPORT ON RESULTS OF WELL SURVEY
AND COMPLEMENTARY DATA

PROPOSED CROSSING OF THE RE-ALIGNED
WELLAND CANAL

MAIN STREET EAST TUNNEL

WELLAND -- ONTARIO

W.J. 68-P-71-1 W.P. 240-66

Attached, please find two copies of the above mentioned report for your use. Should you require additional copies, please let us know and we will supply same.

At this state we have no comments to make. The matter dealt with in the report has been discussed on a number of occasions and a general agreement has been reached.

Copies of the report have also been sent to the tunnel designer who is presently studying the information. All questions arising will be dealt with at appropriate meetings of persons concerned, and conclusions communicated to all parties involved.

Should you have any queries, please feel free to contact this Office.

AGS/MdeF
Attach.

cc: Messrs. B. R. Davis (2)
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G. Tustin (S.L.S.A.) - (4)
H. Q. Golder & Assoc. Ltd.
Gibb, Albery, Pullerits & Dickson
R. G. Tanner, Executive Engr. -
(H. G. Acres Ltd.)

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REPORT ON RESULTS OF WELL SURVEY
AND COMPLEMENTARY DATA

PROPOSED CROSSING OF THE RE-ALIGNED WELLAND CANAL		
--	MAIN STREET EAST TUNNEL	--
WELLAND		ONTARIO
W.J. 68-F-71	--	W.P. 240-66

1. INTRODUCTION:

The Federal Government initiated a major construction project to improve the alignment of the Welland Canal in order to facilitate a projected increase in the shipping volume. This will necessitate the construction of roadway and railway crossings. The first phase of this project, on which construction has already started, consists of re-aligning the canal between Port Robinson and Port Colborne. This re-alignment is located to the east of the existing canal. In the vicinity of the City of Welland two tunnel crossings are in the design stages, namely:

- a) Main Street East roadway tunnel crossing.
St. Lawrence Seaway Authority (S.L.S.A.) and
Department of Highways, Ontario, joint project.
- b) Townline Rd. railway - roadway tunnel crossing.
St. Lawrence Seaway Authority project (S.L.S.A.).

This report will be involved primarily with the East Main Street Tunnel Crossing of the Re-aligned Welland Canal.

This tunnel is to be installed in open-cut prior to the final flooding of the canal. The open-cut excavations required will, however, be carried out below the piezometric groundwater level recorded in the overburden and bedrock deposits existing

cont'd. /2 ...

1. INTRODUCTION: (cont'd.) ...

at this site. In order to ensure the stability of the cut slopes and the base of the excavations so formed, it will be necessary to lower the piezometric groundwater pressure head, in the lower glacial till and bedrock, which constitute a confined aquifer, by installing gravity relief and deep pumped wells. This was discussed in detail in the Foundation Investigation Reports No. 67106, Vol.'s I, II and III, prepared by H. Q. Golder and Associates Ltd.

As indicated in the reports, a dewatering scheme, installed within the plan limits of the tunnel site, will lower the groundwater level in the aquifer; the effects of this lowering may be realized for distances of up to 3-1/2 miles. There are numerous privately owned producing wells in the Welland area which would be influenced by such a dewatering scheme. Because of this fact, the Foundation Section decided to carry out a detailed survey on the majority of the wells likely to be affected by the construction of the tunnel. This report presents the factual data obtained from this study as well as complementary information provided by the S.L.S.A. and the Ontario Water Resources Commission. This data is also assessed with respect to the probable groundwater lowering expected due to future excavations, to be carried out as part of the overall project.

2. DESCRIPTION OF THE AREA AND GEOLOGY:

The site of the proposed Main Street East Tunnel Crossing of the Re-aligned Welland Canal is located in the Township of Crowland at the eastern limit of the City of Welland, Ontario. The topography of this site is generally flat to gently undulating in relief, with the ground surface elevation ranging between 595 and 605. The surrounding area, although of the same topographical pattern, does gradually rise to as high as elevation 620 east of the site. The majority of the land is being farmed.

cont'd. /3 ...

2. DESCRIPTION OF THE AREA AND GEOLOGY: (cont'd.) ...

The Pleistocene geology of the Welland area is characterized by thick, discontinuous deposits of glacio-lacustrine silts and clays, which were laid down in the several glacial lakes occupying the Lake Erie Basin during the latter stages of the Wisconsin Period of Glaciation. Due to the complex depositional stages during this geologic period the resulting deposits can, within a few hundred feet, vary from stratified clay to massive silty materials containing gravel and cobbles.

The area is underlain by dolomitic limestone bedrock of the Salina Formation, Devonian Period. The surface of the bedrock, within the area under consideration, ranges from approximately elevation 480 to 500 - i.e., some 100 to 140 ft. below ground surface. There are some locations where local bedrock hummocks rise to as high as elevation 530 (for instance at S.L.S.A. Sta. 70+00). The bedrock contains numerous inter-bedded siltstone and calcareous shale layers and gypsum inclusions; the thickness of these layers and inclusions can vary anywhere from a few inches to a few feet. The bedding planes of the bedrock dip slightly southward and pass under the present Lake Erie basin. The upper 10 to 15 feet of the bedrock is generally in a fractured and fissured condition.

3. HIDROGEOLOGY:

Foundation investigations carried out at the various crossing sites indicate that the principal aquifer underlying the area is contained within the upper fractured and weathered portion of the dolomitic limestone bedrock and the overlying more permeable granular zone of the basal glacial till deposit. Pumping tests carried out indicate that the equivalent permeability of this aquifer zone ranges from 5×10^{-4} to 1×10^{-3} cm./sec. The relatively sound portion of the bedrock has a permeability of the

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3. HYDROGEOLOGY: (cont'd.) ...

order of 1×10^{-6} to 1×10^{-4} cm./sec. In the area under investigation the piezometric groundwater level within this aquifer, with only a few notable exceptions, ranges from about elev. 570 to 590. At the tunnel site it was originally at about elev. 576. The piezometric groundwater level within the overlying clays and silts is generally within 4 to 8 feet of ground surface.

It was originally believed that the piezometric groundwater level within the aquifer was independent of the level within the overlying deposits. If this were the case, the aquifer would have to be hydraulically charged with groundwater from an external source, which is in direct communication with the aquifer over long distances. The piezometric pressure within the aquifer would, therefore, be completely independent of the groundwater level in the overlying strata and thus the overburden pressure. It is now considered that this is only partially true and that, in fact, significant groundwater filtration is occurring through the overlying deposits down into the aquifer. The aquifer could thus be described as being "leaky". The piezometric groundwater pressure would to some extent, therefore, be dependent on the overburden pressure. The significance of this is that a reduction in overburden pressure would also be followed by at least a partial reduction in the piezometric groundwater pressure within the aquifer.

4. DETAILS OF FIELD SURVEY OF WELLS:

Data from two sources, namely: a) S.L.S.A., and b) O.W.R.C., was available. Following assimilation of this data a field survey was undertaken. This survey consisted of contacting all property owners, within a 3-1/2 mile radius of the tunnel site, who presently are utilizing a well for domestic or commercial use. The following was ascertained:

cont'd. /5 ...

4. DETAILS OF FIELD SURVEY OF WELLS: (cont'd.) ...

- i) location of well.
- ii) type of well - drilled or dug.
- iii) lining - casing or stone, etc., and condition of same.
- iv) elevation of the top and bottom of the well and surface of the water in the well.
- v) description of water.
- vi) use of water and yield.
- vii) type and location of pump in well.
- viii) whether any water level changes have been noticed recently, particularly at those wells located in close proximity to the portion of the re-aligned Welland Canal presently being excavated.

In all, 75 wells have been studied within the expected radius of influence of the dewatering scheme required for the proposed tunnel excavations. To date, pertinent information has been obtained at the well locations at two different periods, the first being between August 15 and 23, 1968, and the second between September 25 and October 3, 1968.

During the first period, representative samples of the groundwater were obtained in 32-ounce, hermetically sealed containers at 48 of the well locations. Following this phase of the investigation, 20 of these samples were selected and detailed analyses were carried out on each to determine the most important chemical properties. During the second phase, water samples were again taken at all the wells in which the water had been tested. Chemical analyses are presently being carried out on all these specimens.

The locations of the individual wells surveyed are shown on Drawing 68-F-71B. A detailed log for each of the wells was prepared; these logs are presented in Appendix I. The results of the chemical analyses, carried out on the water samples obtained

4. DETAILS OF FIELD SURVEY OF WELLS: (cont'd.) ...

are presented in Table 4. The most important of the chemical properties are also summarized on the well logs.

It is this Section's intention to check the water levels in the wells periodically, particularly once the tunnel excavation commences, so as to monitor the fluctuations in the levels. In this way the groundwater lowering, due to the dewatering schemes at the tunnel and associated sites, can be assessed. Additional water samples will be obtained and tested as well, in order to identify any chemical changes that may be occurring in the environment.

5. RESULTS OF SURVEY:

5.1) Private Wells:

A brief resumé of the pertinent information from the well survey is presented in Table I (Appendix I). In all, 27 dug wells and 48 drilled wells were studied. The dug wells generally vary from 15 to 35 feet in depth and are 5 to 10 feet in diameter. These wells, which are founded in the upper cohesive strata of the overburden, are most often lined with cut stone blocks which may or may not be bonded with mortar. The mode of construction would tend to indicate that the majority of these wells have been in place for a considerable period of time - i.e., more than 100 years old. In most cases this assumption was confirmed verbally by the property owners. The water level in these dug wells, at the time of the investigations, was approximately 8 to 12 feet below existing ground surface, corresponding to an elevation between 596 and 631. The wells are generally pumped from a level about 4 to 5 feet above the bottom. There is no doubt that these relatively shallow wells are supplied with groundwater originating from within the upper strata rather than the aquifer. As such, the water level in the dug wells would be more dependent on the

cont'd. /7 ...

5. RESULTS OF SURVEY: (cont'd.) ...

5.1) Private Wells: (cont'd.) ...

localized conditions such as: a) precipitation and infiltration factors, and b) the seepage - i.e., re-charge characteristics of the upper strata. There were no significant changes in the water levels in the dug wells from the first survey period to the second. Further, verbal conversations with the owners indicate that the supply of water from such wells has not fluctuated markedly over the last few years.

The drilled wells are composed of from 5 to 8 inch diameter steel casing, some of which are fitted with well screens within the last few feet. The wells range anywhere from 65 to 170 feet in depth, being on the average, about 110 feet deep. The most reliable sources indicate that these wells extend down into the lower portion of the basal glacial till or, alternatively, into bedrock - i.e., they extend into the confined aquifer. Based on available information, some of the wells have been in place for only a year, while others have been there for 80 years. In most instances the casing appears in reasonably good condition and performing satisfactorily, with only slight visible signs of rusting. It should be noted, however, that only the upper portion of the casing could be observed; the soundness of the casing at depth can only be inferred from its performance record. The type of pump being employed, and its location, is given on the well log sheets.

At the time of the investigation the groundwater level in the deep drilled wells varied from elevation 550 to 590. It is pertinent to note that the lower groundwater levels are predominant in an area immediately north of the tunnel site and adjacent to the re-aligned canal, approximately between Stations 50+00 and 150+00. This portion corresponds closely with S.L.S.A. Sections 2 and 3, Canal Prism Excavations (Contracts 743 and 783), which are both well underway. The water levels, in the wells in this area, were lower during the second phase of the survey carried out in September and October, 1968. This would indicate that the water levels have not reached a stabilized condition

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5. RESULTS OF SURVEY: (cont'd.) ...

5.1) Private Wells: (cont'd.) ...

and, in fact, are still dropping. This will be substantiated by future monitoring.

A typical cross-section in this area is shown on Figure #1; it includes the approximate stratigraphy in an east-west direction, well locations, and the water level changes noted at the various wells. Referring to this figure, it can be seen that the water level has been lowered by as much as 30 feet (Well No. 4) close to the Section 2 excavation, and up to 3 to 10 feet at a distance of 3-1/2 miles from the excavation. The relative magnitude of the lowering that has taken place to date at the wells, located in close proximity to the excavations, was further substantiated by the fact that some of the pumps had to be lowered, while at others deep well pressure systems had to be adopted.

The wells located south of the tunnel crossing are outside of the influence of the excavations presently being carried out in Sections 2 and 3. During the period of the first survey (August, 1968), no noticeable fluctuations were noticed in the water levels at the wells located in this area. However, fluctuations were observed at the time of the second survey (September - October, 1968). For example, the following was observed:

- a) Well No. 43 - difficulty pumping water on October 3, 1968.
- b) Well No. 45 - water level lowered by approximately 4 feet.

It is pertinent to note that these wells are in close proximity to the Townline Rd. excavation (S.L.S.A. Section 6), which was commenced in September, 1968. At this site 4 deep wells extending into bedrock, were pumped continuously at the rate of

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5. RESULTS OF SURVEY: (cont'd.) ...

5.1) Private Wells: (cont'd.) ...

100 l.g.p.m./well from September 29, 1968. Readings taken in monitor piezometers installed at this site indicate that the groundwater level in the confined aquifer has been drawn down about 24 feet over a one-week period by this continuous pumping.

5.2) Groundwater Level Fluctuations at Main Street East Tunnel Site:

Some piezometers, installed at the tunnel site, have been monitored since their date of installation in December, 1967 and January, 1968. Water level readings taken in four such piezometers, are summarized on Table 2 in Appendix I. These observations indicate that the groundwater level in the aquifer has been lowered from an elevation of 576 (January, 1968) to approximately 560 (September, 1968). The fluctuations of the water level at this site will be determined by monitoring these piezometers periodically.

6. WELL WATER AND GROUNDWATER CONSIDERATIONS:

6.1) Results of Laboratory Chemical Analyses of Water Samples:

The results of the chemical analyses are given on Table 4, in Appendix II of this report; in addition, a summary of the most important properties are presented on the well log sheets. Chemical analyses have also been performed on groundwater samples obtained from boreholes put down at the proposed Main Street East Tunnel site. A comparison of the groundwater from these sources is presented in Table 5, located in Appendix II. Four basic chemical properties were used for comparison purposes, namely: calcium, sulphate and dissolved solids contents, and the conductivity. Study of these properties showed that the water samples could easily be classified and identified as belonging to one of the three following groups:

6. WELL WATER AND GROUNDWATER CONSIDERATIONS: (cont'd.) ...

6.1) Results of Laboratory Chemical Analyses of Water Samples:
(cont'd.) ...

- a) Tunnel Boreholes
- b) Private Wells (drilled)
- c) Private Wells (dug)

The following observations could then be made:

Each of the four chemical properties for the private dug wells showed markedly lower values than those of the drilled wells.

The water samples from the tunnel boreholes and those from the private drilled wells could be identified relatively easily by their differences in the sulphate and dissolved solids contents. For example, the sulphate content at the drilled wells and tunnel boreholes, is about 1,800 and 2,100 p.p.m., respectively. Generally speaking, the lower average sulphate and dissolved solids contents of the private drilled wells should also be followed by a lower conductivity. The average conductivity of the water from the drilled wells, however, showed no decrease compared to that at the boreholes; this is probably due to the relatively high chloride content of the water from these two sources. These chloride radicals, being excellent electrolytes, boosted the conductivity to such a level that it completely masked the effects of the slight difference in the sulphate and dissolved solids content. The overall analyses indicated that the high chloride content at the well locations may have been the result of the use of rock salt as a chemical de-icer.

The reason for the higher sulphate and dissolved solids contents of the groundwater from the boreholes, when compared to the water from the drilled wells, could possibly be due to one of the two following reasons:

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6. WELL WATER AND GROUNDWATER CONSIDERATIONS: (cont'd.) ...

6.1) Results of Laboratory Chemical Analyses of Water Samples
(cont'd.) ...

a) the elevation of the bedrock at the locality of the tunnel borings is generally lower than that in the vicinity of many of the outlying wells. If such is the case, there would tend to be a natural hydraulic gradient in existence which would direct seepage through the confined aquifer towards the tunnel site. The migrating groundwater would tend to leach out minerals from the bedrock, particularly gypsum, during its flow; thus the groundwater arriving at the tunnel site would have a relatively higher concentration of minerals. This is further corroborated by another hydrological study, carried out by H. G. Acres Ltd., for the Town Line Rd. Tunnel crossing, which is in this same general area. This study indicated that the aquifer underlying the City of Welland and surrounding district is within a cone of depression - i.e., groundwater seepage is directed towards this area.

b) the water samples from both sources originally had a similar mineral concentration. Frequent use and subsequent leaching of the adjacent soil by water, replacing the water that was taken out of the wells, caused a local decrease in mineral content. This, in turn, ultimately reduced the mineral content of the water in the wells in question.

As indicated above, the groundwater emanating from the aquifer has a high sulphate concentration. This concentration could cause some deterioration of the outer zone of a buried concrete structure, such as the tunnel. For this reason, sulphate resistant cement has been recommended in the construction of the tunnel.

6.2) Use of Water at Well Locations:

Water obtained from the shallow dug wells is fresh and is being used for domestic purposes as well as for livestock.

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6. WELL WATER AND GROUNDWATER CONSIDERATIONS: (cont'd.) ...

6.2) Use of Water at Well Locations: (cont'd.) ...

As discussed previously, the water obtained from the deep drilled wells has a high mineral content and can be classified as very hard. Water from this source is being used for livestock and domestic purposes. The domestic use of the water, however, is quite variable, being primarily dependent on the individual property owner's discrimination. For instance, some of the owners use this water solely for washing, bathing, and sewage disposal. Others use it for human consumption as well; often, water used for this purpose is chemically treated (filters, etc.).

7. DISCUSSION:

7.1) Piezometric Groundwater Level Variation at the Drilled Well Locations:

As discussed in Sub-section 5.1) the lowering, noted at the well locations north of the tunnel site, seems to be associated with the S.L.S.A. excavations presently underway. The sequence of construction along the re-aligned canal is summarized on Table #3, located in Appendix I. It is pertinent to note that the excavation for the canal prism at Section 2 has nearly been completed, while the excavation at Section 3 is well underway. In the vicinity of Section 2 the bedrock surface rises to as high as elevation 535; the bedrock is overlain by about 15 feet of granular glacial till. In this area the canal prism extends down to approximately elevation 538 - i.e., the excavation will penetrate into the glacial till and within a few feet of the bedrock. The confined aquifer has, therefore, been penetrated. This being the case, a hydraulic gradient was established and seepage has taken place through the confined aquifer towards the excavation; the excavation thus acts as a sink. The groundwater level within the aquifer

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7. DISCUSSION: (cont'd.) ...

7.1) Piezometric Groundwater Level Variation at the Drilled Well Locations: (cont'd.) ...

would, therefore, be lowered for a considerable distance from the excavation. Based on the results of the full-scale pumping tests carried out at the Main Street East site, it is expected that drawdown would occur as far as 3-1/2 miles from the source - i.e., radius of influence would be approximately 3-1/2 miles. As an example, refer to Drawing No. 68-F-71A, on which the drawdown, expected in the aquifer following installation and continuous pumping of the relief well system at the Main Street site, is shown. The magnitude of the drawdown should increase as the excavation is approached. Referring to Figure #1, it can be seen that this trend is corroborated. In addition, the dewatering scheme required for the Townline Rd. tunnel construction would contribute to further drawdown in this area.

Information obtained from S.L.S.A. personnel at the Townline Rd. tunnel crossing indicates that water levels in the domestic wells have been affected by the dewatering presently being carried out at the site. The explanation for this lowering is similar to that given previously - i.e., the pumping of the deep wells is drawing down the water level in the aquifer for a considerable distance.

7.2) Hydrological Considerations at the Main Street East Tunnel Site:

As discussed previously, the piezometric groundwater level in the aquifer will have to be lowered in order to construct the tunnel in open-cut. The hydraulic characteristics of the aquifer were determined by full-scale pumping tests, the results of which were presented in the foundation report. Based on these studies, it was concluded that the piezometric level across the site can be lowered and sufficiently controlled by providing:

- a) gravity relief, and
- b) deep pumped wells; the majority of

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7. DISCUSSION: (cont'd.) ...

7.2) Hydrological Considerations at the Main Street East Tunnel Site: (cont'd.) ...

these wells are to extend down into bedrock. The approximate locations of all temporary, permanent and suggested wells required, as well as the associated monitoring schemes, are shown in plan on Drawing 68-F-71C.

As discussed in Sub-section 5.2), considerable lowering of the groundwater has been observed. It is believed that this lowering is primarily due to the canal prism excavations carried out to the north of the site (Sections 2 and 3), particularly since the tunnel location is within 1-1/2 miles of these excavations. Excavation of the canal prism (Section 4) has commenced at the tunnel site; however, at this time only 10-foot deep excavations have been completed. It is inconceivable that such a minor excavation could have had any appreciable effect on the groundwater level in the confined aquifer.

It is considered that additional lowering of the groundwater level within the aquifer can be expected at the site, due to the dewatering measures presently underway at the Townline Rd. site, which is located approximately 2-1/4 miles to the south. Taking this into account, the consultants re-assessed the dewatering scheme. It is their opinion that the temporary pumped and gravity relief well system originally proposed for the canal prism excavation phase (S.L.S.A. project) may not be required.

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8. CONCLUSIONS:

The surveys have indicated that the water level in some of the deep drilled wells is being lowered by the canal prism excavations (Sections 2 and 3) and the Townline Rd. excavation (Section 6), all of which are partially completed. Based on this knowledge, it is most probable that the dewatering measures proposed at the Main Street East site will lower the water level in some of the deep drilled wells, particularly those located within 3-1/2 miles of the crossing.

Taking into consideration the conclusions drawn in the previous paragraph, it should be stated that the water level in a well, located equi-distant from the Main Street and Townline Rd. sites, would be lowered to a much greater extent by the latter since:

a) the excavation at Townline Rd. extends well into bedrock - i.e., well into the confined aquifer, while at Main Street East the excavation does not penetrate the aquifer to the same extent, and

b) the expected discharge quantities at the Townline Rd. site are greater and thus the relative magnitude of the piezometric groundwater level drawdown in the aquifer, within the zone of influence of the dewatering system, should be greater.

The surveys indicate that the water levels in the shallow dug wells have not been markedly affected by any of the excavations carried out to date. In view of this, it is concluded that no major lowering of the water level in these wells can be anticipated due to the proposed excavation and associated dewatering for the Main Street East tunnel site.

As discussed previously, monitoring of the water levels in the wells will be carried out periodically to assess the drawdown effects of the various excavations and their associated dewatering schemes. It is suggested that the fluctuations be substantiated by installing a number of piezometers within the

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8. CONCLUSIONS: (cont'd.) ...

radius of influence of the dewatering scheme proposed at the Main Street site - i.e., within 3-1/2 miles. These piezometers, which should extend into the aquifer, could be monitored along with the wells. Tentatively, 12 piezometers are proposed, the location of which are shown on Drawing No. 68-F-71B. No attempt has been made to outline the following:

- a) piezometer installation details,
- b) the organization who will be responsible for installing and monitoring the piezometers,
- or
- c) the frequency of readings and the interval over which information is required.

The above should be agreed upon by all organizations actively involved in the Main Street East Tunnel Project.

9. MISCELLANEOUS:

Two surveys have been carried out to date, the first between August 15 and 23, 1968, and the second between September 25 and October 3, 1968, by Messrs. B. Longson and S. Wilson, under the supervision of Mr. B. T. Darch, Senior Foundation Engineer. This report was prepared by Mr. Darch and reviewed by Mr. M. Devata, Supervising Foundation Engineer.

The Foundation Section would like to acknowledge the assistance provided by The St. Lawrence Seaway Authority and the Ontario Water Resources Commission.

APPENDIX I

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
0 - 1 MILE		(DISTANCE FROM TUNNEL LOCATION)										
1	-	Drilled	D. Moteak	Oxford Rd., Welland	Dry							Taken from OWRC records.
2	-	Drilled Casing not visible because of pump. Well is in poor condition.	J. Carl R.R.#1, Welland	Lot 16, Con. 4 Crowland Twp.	Not used for 15 years.				Hand pump not working			Owner buys water for house.
1 - 1 1/2 MILE												
3	1	Drilled (1947) 5" casing extending into bedrock. Casing appears in good condition.	C. Schmanz R.R.#1, Welland	River Rd. Crowland Twp.	Domestic Stock	595'	560' ^a 553' ^b	510'	Pumping Level 40'. Shallow well double action piston pump	Hard Sulphur	*(1) 2853 (2) 2440 (3) 1927 (4) 50 (5) 742	Pumping problems due to a recent lowering of the water level. Owner is now trucking water for his stock.
4 (SLSA) 4 9	2	Drilled (before 1926) 6" Casing to 70', 2" diameter hole down to 125'. Casing appears in good condition.	P. Gerbhart R.R.#1, Welland	Cambridge Rd. Crowland Twp.	Industry Domestic 500 Gal/day	595'	552' ^a 545' ^b	528'	Pumping Level 60'. Jet pump.	Hard Sulphur	*(1) 2846 (2) 2370 (3) 1848 (4) 95 (5) 763	Has installed a new pump because of lowering of the water level from 20' to 44'. Odour has developed recently, owner now has to chlorinate his water.
5	3	Drilled (1953) 6" casing extending to the bedrock. Casing appears in good condition.	W. Horton R.R.#1, Welland	Cambridge Rd. Crowland Twp.	Domestic	595'	550' ^a (Est.)	503'	Original Pumping level 50'. New jet pump installed at 70' depth.	Fresh Hard Sulphur		Owner out of water at the time of survey because of a recent lowering of the water level. Owner feels this has burnt out his original pump and has bought a new pump.
			a) First survey, August 15 to August 23, 1968. b) Second survey, September 25 to October 3, 1968					<u>LEGEND</u> *(1) Dissolved Solids (ppm) (2) Conductivity at 18 °C (micro Mho/cm) (3) Sulphate (SO ₄) (ppm) (4) Chloride (Cl) (ppm) (5) Calcium (CaO) (ppm)				

[illegible]

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
12 (SLSA) 44	7	Drilled (1915+) 6" Casing extending to bedrock. Casing appears in good condition.	F. Roberts R.R.#1 Port Robinson	Darby Rd. Lot 15, Conc. 4 Crowland Twp.	Stock	608'	563' ^a 555' ^b	488'	Pumping Level 60' Jet pump 1 year old	Hard Drinkable		Water has developed an odour recently. Pump has lost its prime twice in the last two weeks.
13		Cistern Spring Fed	"	"	Domestic	608'	598' ^a 598' ^b	595'	Shallow well pressure system.	Fresh Hard		No change from last survey.
14	2	Dug Well 5' Diameter Well is in good condition	"	"	Domestic	608'	598' ^a 598' ^b	586'	Hand Pump	Fresh Hard	*(1) 684 (2) 794 (3) 202 (4) 54 (5) 151	Used for drinking. No change from last survey.
<u>1 1/2 - 2 MILES</u>												
15 (SLSA) 51	21	Drilled 5" casing Well might end in sand or rock. Casing appears in good condition	Mrs. Schomberger	Derby Rd. Lot 14, Conc. 3 Crowland Twp.	Stock	598'	- Cannot measure the well without pulling the pump.	488'	Pumping Level 60' Jack Pump	Drinkable Sulphur Hard		Cistern provides the house. Originally 25' to water level. Water takes longer to pump lately.
16	37	Drilled (1962) 6" Casing extending into sand (100') Casing appears in good condition.	Mr. Cheshire	Pearson Rd. Lot 12, Conc. 5 Crowland Twp.	Domestic	600'	- 578' ^b	490'	Pumping Level 50'. Jet Pump	Sulphur Hard	*(1) 4331 (2) 3850 (3) 2160 (4) 590 (5) 833	Do not use water for drinking. No noticeable change in quality of water.
17	32	Drilled (1968) Casing extends 75' to sand. Casing appears in good condition	P. Protz	Ontario Rd. between Strawn - Co. Rd. 16	Domestic Industry 1000 Gal/day	610'	585' EST. Well covered cannot measure.	535'	Pumping level 40' Jet pump	Fresh Sulphur Hard		Bottom of well terminated in gravel deposit. No noticeable change.

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
18	-	Dug 4" Concrete Tile Well is in good condition.	P. Protz	Ontario Rd. Lot 14, Conc. 6 Crowland Twp.	Domestic	610'	600' ^a 600' ^b	586'	Shallow Pump	Fresh Hard		Bottom of well terminated in sand deposit. Water is murky at times since first survey.
19 (SLSA) 58	30	Dug 4" Diameter. Stone lined. Well is in good condition	Gerald Haynes	Ontario Road Lot 13, Conc. 6 Crowland Twp.	Domestic	605'	595' ^a 596' ^b	590'	Shallow well pump and hand pump.	Fresh	*(1) 671 (2) 800 (3) 170 (4) 16 (5) 132	Water has developed odour and dark color since the first survey.
20	43	Drilled (1965) 5" casing extends 102' to gravel. Casing is in good condition.	O. Haeberle R.R. #4, Welland	Strawn Rd Lot 15, Conc. 7 Crowland Twp.	Stock	597'	583' (est.) Type of pump prevents measurement	497'	Pumping Level 28' Hand Pump	Fresh Sulphur Hard		Water level obtained from OWRC data. No recent changes.
21 (SLS4) 56	31	Drilled (1965) 6" casing extend- ing 82' to gravel. Casing is in good condition.	E. Alward	Ontario Rd. Lot 14, Conc. 7 Crowland Twp.	Stock Domestic	610'	587' (est.)	528'	Pumping level 70' Jet pump	Fresh Hard Sulphur	*(1) 2500 (2) 2030 (3) 1650 (4) 1650 (5) 782	Bottom of well terminated in gravel deposit. No noticeable change in quality of water.
22	-	Dug 4" Diameter Stone lined. Well is in good condition	E. Alward	Ontario Rd. Lot 14, Conc. 7 Crowland Twp.	Stock	610'	602' ^a 596' ^b	590'	Two hand pumps.	Fresh Hard		Owner has started watering stock from this well since first survey.
2 - 2 1/2 MILE												
23	20	Drilled (1960) 5" casing extend- ing 90' to bedrock	Mr. Hern R.R. #1, Port Robinson	Carl Rd. Lot 16, Con. 2 Crowland Twp.	Domestic	593'	561' (est.) Casing covered with earth.	497'	Pumping level 27'	Iron Hard	*(1) 2863 (2) 2490 (3) 1840 (4) 89 (5) 743	Water level obtained from OWRC data. Well founded 6' into bed- rock. Water noted to become muddy after heavy rain due to infiltration. No recent changes.

[illegible]

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
22	-	Drilled (Abandoned gas well) No casing visible.	C. Matthews R.R.#1, Welland	Cooks Mills Rd. at Matthew Lot 10, Conc. 6 Crowland Twp.	Stock	-	-	-	Flowing	Fresh Sulphur Hard		Well flowed continuously up until about July 1968.
30	-	Drilled (1925±) 5" casing extends 106' to rock. Casing is in poor condition.	M. Johnson	Townline Twp. Lot 13 Conc. 6 Humberstone Rd.	Domestic Stock	600'	-	488'	Hand Pump	Fresh Sulphur Hard		No noticeable change in water recently.
31	-	Dug Spring Fed 4" Diameter. Stone lined. Good condition.	E. Warner	Lincoln Rd. Lot 10, Conc. 5 Crowland Twp.	Stock Domestic	640'	-	-	Shallow Well pump	Fresh Hard		No noticeable change in the water
32	38	Dug Spring Fed 6" Diameter. Stone lined. Good condition.	J. Myers	Lincoln Rd. Lot 10, Conc. 6 Crowland Twp.	Domestic	640'	631' ^a 631' ^b	623'	Hand Pump	Fresh Hard		No noticeable change in the water.
33		Dug Spring Fed 4" diameter. Stone lined. Good Condition.	"	"	Domestic	640'	633' ^a 633' ^b	623'	No pump			No noticeable change in the water. This well is used as a reserve well.
34	27	Dug Well Spring Fed. 5' diameter. Stone lined. Sandy bottom.	G. Pearson	Pearson Rd. Lot 11, Conc. 6 Crowland Twp.	Domestic	625'	608' ^a 607' ^b	600'	Pumping Level 22'. Shallow well pump		*(1) 484 (2) 559 (3) 139 (4) 8 (5) 137	This well supplies two houses.

[illegible]

WELL NO.	SAMP NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
41	49	Drilled (1953) 6 3/4" casing extends 80' to bedrock.	Mrs. Burns 79 Cozy St. Welland	Ontario-Co. Rd. 16 Lot 13, Conc. 7 Crowland Twp.	Domestic	630'	571' ^a 577' ^b	513'	Pumping level 66'. Jet pump	Fresh Hard Sulphur	*(1) 2269 (2) 1905 (3) 1460 (4) 15 (5) 639	New jet pump installed because of lack of water 2 months before the first survey. No recent change in the water since the first survey.
42		Drilled (1957) 5 5/8" casing extends to the rock. Casing appears to be in good condition.	J. Kram R.R. #4 Welland	Co. Rd. 16 Lot 13, Conc. 7 Crowland Twp.	Irrigating garden only.	600'	- 566' ^b	501'	Pumping level 45'. Jet pump	Fresh Sulphur Hard		Jet is withdrawn for the winter.
43 (SLSA) 70	42	Drilled (1928±) 5 1/2" casing in poor condition.	W. McQueen	Townline Rd. Lot 14, Conc. 7 Crowland Twp.	Stock	600'	585' (est.) Type of pump pre- vents measurement.	485'	Pumping level 15'. Hand pump.	Sulphur Hard	*(1) 2852 (2) 2350 (3) 1885 (4) 10 (5) 627	Recently well appears to be silting up. Some discolor- ation noted at the time of first survey. Pumping problems at the time of second survey.
44	41	Drilled (1918±) 1 1/2" casing placed inside old casing Casing extends to the bedrock. Casing is in poor condition.	Mr. Cebrynski	Townline & Yager Lot 15, Conc. 5 Humberstone Twp.	Stock	600' Pump prevents measurement.	590'	500'	Pumping level 80'. Shallow well pump	Fresh Hard Sulphur		Possibility of expropriation. Older casing caved in. Well was re- paired by installing 1 1/2" casing.
45	39	Drilled (1928±) 5" casing extends to the rock. Casing is in fair condition.	C. Schyff	Townline at Moore Lot 16, Conc. 5 Humberstone Twp.	Stock	590'	567' ^a 563' ^b	505'	Pumping level 53'. Shallow well pump.	Hard Sulphur Fresh		Well extends into bedrock. Since the first survey the cattle will not drink the water.

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
46	40	Drilled. Well may extend to the rock.	T. Wiczorek	Townline Rd. Lot 16, Conc. 5 Humberstone Twp.	Domestic Stock	590'	575' (est.) Platform cover prevents measurement.	525'	Jet Pump	Hard Sulphur		Possibility of expropriation.
2 1/2 - 3 MILE												
47	11	Drilled (1960) 6" casing extends 100' to bedrock. Casing appears in good condition.	J. Hagar R.R.#1 Port Robinson	Darey Rd. at Bigger Rd. Lot 14, Conc. 1 Crowland Twp.	Domestic Stock	587'	564' ^a 563' ^b	484'	Pumping level 30'. Shallow well pump replaced by Jet Pump at time of second survey	Slightly sulphur Hard	*(1) 2856 (2) 2380 (3) 1805 (4) 101 (5) 764	No noticeable change in quality of the water. Well extends 3' into bedrock. Owner gives original water level as 14'. Pump was replaced because of low water level Sept. 28/68.
48	13	Drilled 6" casing extends 103' to gravel. Casing appears in good condition.	S. Shumlick R.R. #1 Port Robinson	Moyer Rd. Lot 12, Conc. 1 Crowland Twp.	Domestic	594'	583' ^a 568' ^b	491'		Hard Sulphur		Water is commercially softened & supplied to two households. No noticeable change in the quality of the water.
49		Drilled 5" casing extends 60' to bedrock. Casing appears in good condition.	Mr. Eggleton	Matthew Rd. at Cambridge Rd. Lot 10, Conc. 2 Crowland Twp.	Stock	600'	567' ^a 566' ^b	517'	Pumping level 27'. Shallow well pump	Fresh Hard Sulphur		Detailed well log available from OMRC. At the time of surveys the well could not be pumped. Water level orig. 10'. Owner now buying water for cattle.
50		Drilled 6" casing appears to be in good condition.	P. Dube	Matthew Rd. at Cambridge Rd. Lot 11, Conc. 2 Crowland Twp.	Plan to use for stock.	600'	567' ^a 565' ^b	467'	Pumping level 85'. Shallow well pump. Not connected.	Sulphur	*(1) 2695 (2) 2175 (3) 1710 (4) 23 (5) 786	Well was used for drinking at one time. Well has never gone dry.

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
51	10	Drilled (1964) 6 1/2" casing extend 85' to gravel. Casing is in good condition.	J. Majeros R.R.#1 Welland	Cambridge Rd. Lot 10, Conc. 3 Crowland Twp.	Stock	600'	565' ^a 564' ^b	517'	Pumping Level 40'. Jet pump	Sulphur Hard		Bottom of well terminates in a sand deposit. Water level originally 23' from the surface.
52		Drilled (1964) 6" casing extend 21' to sand.	V. Clark R.R.#1 Welland	McKenney Rd. Lot 8, Conc. 5 Crowland Twp.	Not in use	610' Casing covered with earth.	-	519'	No pump	Sulphur Rusty Undrinkable		Well is 4 years old.
53		Drilled 8" casing. Casing appears to be in poor condition.	C. Clark	McKenney Rd. Lot 8, Conc. 5 Crowland Twp.	Not used since 1947.	620' Type of pump pre- vents measurement.	601' (est.)	460'	Pumping Level Hand pump	Sulphur Potash Black		
54		Dug Spring Fed. 5' Diameter. Stone lined. Well is in good condition.	"	"	Domestic	620'	611' ^a 611' ^b	605'	Shallow Well pump	Fresh		No noticeable change in quality of water. Owner has other dug wells of limited use.
55	35	Dug Spring Fed. 5' Diameter. Brick lining.	McKenney	McKenney Rd. Lot 8, Conc. 6 Crowland Twp.	Domestic	635'	625' ^a 627' ^b	621'	Shallow Well pump			No recent change noticed in the water

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
56		Dug Spring Fed. 5' Diameter. Line with well tile.	McKenney	McKenney Rd. Lot 6, Conc. 6 Crowland Twp.	Stock	635'	630' ^a 629' ^b	625'	Hand pump			No recent changes in the water level.
57		Dug 5' diameter. Stone lining.	S. Gill	McKenney Rd. Lot 9, Conc. 6 Crowland Twp.	Reserve	640'	631' (est.)	628'	Hand Pump			
58	20	Dug (1953) 14' diameter. Concrete tile lining. Well is in good condition. Sandy bottom.	"	"	Stock Domestic 1000 Gal/day	640'	629' ^a 629' ^b	626'	Shallow Well pump	Hard	*(1) 938 (2) 1222 (3) 103 (4) 65 (5) 141	No recent change in the water level.
59	36	Drilled (1960) 5" Casing extends 105' to sand. Casing is in good condition.	Walker Bros.	Ontario Rd. Lot 9, Conc. 7 Crowland Twp.	Domestic (treated)	620'	589' ^a 587' ^b	515'	Jet pump	Fresh Hard		Well supplies the house of two tenants.
60		Drilled (1962) 6" Casing extends 102' to shale. Casing is in good condition	J. Fazekas R.R.#1 Welland	Cope Rd. Lot 10, Conc. 7 Crowland Twp.	Domestic	620'	590' (est.) Casing has metal cap.	515'	Pumping Level 80'. Jet pump	Fresh Hard Clear		

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
61	h7	Dug h' Diameter. Stone lined. Well is in good condition.	Mrs. Cope	Cope Rd. Lot 10, Conc. 7 Crowland Twp.	Domestic	610'	596' ^a 598' ^b	592'	Shallow Well pump		*(1) 2919 (2) 2440 (3) 1742 (4) 134 (5) 772	Well has gone dry since first survey & owner has had to buy water. Well has gone dry in previous years.
62 (SISA) 90	h4	Drilled (1860) 5" Casing extends 107' to sand. Casing is in good condition.	M. Stevens R.R.#4 Welland	Lot 12, Conc. 5 Humberstone Twp.	Domestic	600'	580' ^a 561' ^b	490'	Jet pump	Sulphur Drinkable		
63	h5	Dug Spring Fed. 12" Concrete tile extends 16' to sand. Well is in good condition.	B. Steernyng	Lot 12, Conc. 5 Humberstone Twp.	Domestic	600'	594' (est.) Type of pump prevents measurement	584'	Hand pump			
64	h6	Dug Spring Fed. h' diameter Stone lined. Well is in fair condition. Sandy bottom.	C. F. Sinclair R.R.#4 Welland	Townline Rd. Lot 12, Conc. 5 Humberstone Twp.	Domestic	600'	594' ^a 597' ^b	585'	Shallow well pump and hand pump	Chlorinated		Owner chlorinates well after rain to settle it.
<u>3-3/4 MILE</u>												
65	15	Drilled (1868) 3/4" casing extends approximately 90' to bedrock. Casing appears to be in poor cond.	W. B. Bigger	Chippewa Creek Rd. Lot 13, Conc. B.F. Crowland Twp.	Stock	580'	566' (est.)	489'	Pumping level 20' Rotary pump.	Clear Drinkable Sulphur Hard		Well flowed until March/68, following this date it had to be pumped. No noticeable change in the quality of the water.

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
66	14	Drilled 6" casing extends to bedrock. Casing appears to be in fair cond.	F. Smerk	Bigger Rd. Lot 11, Conc. 1 Crowland Twp.	Domestic	590'	571' ^a 570' ^b	486'	Pumping Level 75'. Jet pump.	Hard Drinkable Sulphur	*(1) 2919 (2) 2440 (3) 1742 (4) 134 (5) 772	Problems with sand in the water. No recent changes in quality of water.
67	17	Drilled 6" Casing extends to bedrock. Casing appears to be in fair cond.	A. Hazelton	Carl Rd. Lot 10, Conc. 1 Crowland Twp.	Stock Domestic	590'	570' ^a 568' ^b	490'	Pumping level 30'. Jet pump.	Hard Sulphur Drinkable		Owner claims water is hard on pumps & metal. No recent changes in quality of water.
68	4	Drilled (1961) 6 5/8" casing extends 77' to bedrock.	Mrs. Asminskas 245 Marshall Welland Tenant: Mr. Hosper	Younge Rd. at Cooks Mills Rd. Lot 6, Conc. 4 Crowland Twp.	Domestic Not used for drinking.	600' Casing is covered with earth.		512'	Pumping Level 80'. Jet pump	Fresh Hard Sulphur		Well extends 11 ft. into bedrock
69	5	Drilled (1916?) Artesian Well 2 1/2" casing	T. Williams R.R.#1 Welland	Cooks Mills Rd. Lot 7, Conc. 4 Crowland Twp.	Stock	590'	590' ⁺	559'	Flowing, Capped Pumping Level 10'. Double action piston pump	Very hard Drinkable	*(1) 2479 (2) 2130 (3) 1580 (4) 55 (5) 522	Pump not in working order at time of second survey.
70	6	Drilled 3" Casing	V. Bielunas	Lot 6, Conc. 4 Crowland Twp. Cooks Mills Rd.	Stock	585' Casing is covered with earth.	589' (est.) Casing is covered with earth.		Pumping Level 25'. Shallow well pump	Drinkable Very hard Sulphur		No noticeable change in the water recently

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
71		Dug 4' Diameter. concrete tile lining. Good condition.	R. Santero	Morris Rd. Lot 7, Conc. 6 Crowland Twp.	Domestic Stock 200 Gal/day	620'	612'	606'	Shallow Well pump	Fresh		Combination cistern and spring fed well. Spring yields little water.
72	33	Dug Spring Fed. 4' Diameter. Stone lined.	B. Morris	Morris Rd. Lot 6, Conc. 6 Crowland Twp.	Domestic Stock 200 Gal/day	620'	612' (est.) Well covered pre- vents measurement.	606'	Hand Pump	Fresh		
73	34	Drilled (1956) 6" casing extends 123' to bedrock.	McKenney School	McKenney Rd. at Ontario Rd. Lot 8, Conc. 7 Crowland Twp.	Domestic 1000 Gal/day	620'		485' Pump prevents measurements.	Jet Pump		*(1) 2730 (2) 2150 (3) 1806 (4) 1857 (5) 714	
74		Drilled (1939 ¹) 8" casing	J. Sibbald R.R.#1, Welland	Lincoln Rd. Lot 7, Conc. 5 Crowland Twp.	Domestic Stock	600'	584' ^b	428'	Shallow Well pump	Fresh		
75		Drilled 6" casing. Casing appears in good condition.	F. Hunt	Morris Rd. Lot 6, Con. 7 Crowland Twp.	Not in use at present.	620'	581' ^b	556'				Owner plans to use well for stock & domestic purposes.

TABLE #1

SUMMARY OF WELLS IN THE VICINITY
OF THE TUNNEL CROSSING

Distance From Tunnel Crossing	Drilled Wells			Dug Wells			Remarks
	No.	Groundwater Elev. (Range)	Depth of Well (Range)	No.	Groundwater Elev. (Range)	Depth of Well (Range)	
0 - 1 Mile	2	-	-	-	-	-	Wells not used.
1 - 1-1/2 Miles	7	545 - 568	64' - 124'	5	565 - 608	13' - 27'	Drilled wells with water levels in the Elev. range 545 - 550 are in the vicinity of Sections 2, 3 and 4, presently under construction.
1-1/2 - 2 Miles	5	578 - 587	75' - 110'	3	595 - 602	15' - 24'	-
2 - 2-1/2 Miles	15	559 - 590	65' - 118'	9	608 - 633	13' - 25'	-
2-1/2 - 3 Miles	10	587 - 564	83' - 160'	8	594 - 631	10' - 18'	-
3 - 3-1/2 Miles	9	566 - 590	64' - 170'	2	612	14'	
Total --	<u>48</u>		Total --	<u>27</u>			

TABLE #2 -- TYPICAL RECORD OF PIEZOMETRIC GROUNDWATER LEVEL READINGS
EAST MAIN STREET TUNNEL CROSSING

<u>Piez. No.</u>	<u>B.H. No.</u>	<u>Station</u>	<u>Ground Elev.</u>	<u>Tip Elev.</u>	<u>Water Level (Date)</u>	
47	T-101	39+98, O/S 51' Rt.	604.7	478	575.8	(1/23/68)
					558.3	(9/13/68)
43	T-6	33+03, 53' Rt.	604.2	476	576.3	(12/10/67)
					565.3	(9/13/68)
33	T-123	28+91, O/S 71' Rt.	603.2	488	575.2	(12/10/67)
34				473		
35				452	560.0	(9/17/68)
59	S-1A	25+83, O/S 65' Rt.	601.7	476	576.0	(12/10/67)
					560.0	(9/17/68)

Note: Readings taken in 6 other piezometers in this area on July 15/68, indicate that the groundwater level in the aquifer was approximately at elevation 570. This indicates a drop of 5 to 6 feet from the date of completion of the foundation investigation.

TABLE #3
WELLAND CANAL RE-ALIGNMENT
WELLAND, ONTARIO
PROJECTED SEQUENCE OF CONSTRUCTION

Section No.	Contract No.	Contract Award Date	Contractor	Progress to Date	REMARKS
1	807	Oct. 1968	-	-	-
2	743	Sept. 1968	Peter Kiewit Sons Co. of Canada, Toronto	80% Completed	Excavation extends into till and bedrock.
3	783	May 1968	Allnor Construction	20% Completed	Excavation will not extend into till or bedrock.
4	794	June 1968	C. A. Pitts, General Contractor Ltd., Toronto	30% Completed	Relief wells will be required below Elev. 550.
5 & 6	863	Sept. 1968	Peter Kiewit Sons Co. of Canada, Toronto	10% Completed	Excavations for the Townline Tunnel Crossing will extend into bedrock. Dewatering of the aquifer, by sumping from 4 deep wells extending into bedrock, was started on Sept. 29, 1968. At the site the water level in the aquifer has been lowered by 24 ft.
7A	907	Not Awarded	-	-	-
7B	907	June 1967	Keystone Construction Windsor, Ont.	90% Completed	Excavation will not extend into rock - no pumping required.
8	-	Spring 1969	-	-	Excavation will extend to bedrock - pumping may be required.

APPENDIX II

TABLE #4

SUMMARIZED RESULTS OF LABORATORY CHEMICAL ANALYSES

WATER SAMPLES FROM EXISTING WELLS

<u>Well No.</u>	23	27	10	41	47	73	3	69	14	4
<u>Type of Well</u>	Drill	Drill	Drill	Drill	Drill	Drill	Drill	Drill	Dug	Drill
<u>Sample No.</u>	20	18	25	49	11	34	1	5	9	2
<u>ppm Sulphide (S²⁻)</u>	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
<u>ppm Sulphate (SO₄²⁻)</u>	1840	109	1630	1460	1805	1806	1927	1580	202	1840
<u>ppm Chloride (Cl⁻)</u>	89	31	18	15	101	10	50	55	54	95
<u>ppm Hardness (CaCO₃)</u>	1797	285	1823	1513	1808	1857	1862	1455	513	1787
<u>ppm Sol. Iron (Fe)</u>	1.8	1.8	3.0	0.4	0.9	0.4	0.1	0.1	0.5	0.4
<u>ppm Calcium (CaO)</u>	743	285	805	639	764	714	742	522	151	763
<u>ppm Magnesium (MgO)</u>	189	36	139	149	178	235	205	208	97	170
<u>ppm Dissolved Solids</u>	2863	551	2611	2269	2856	2730	2853	2479	684	2846
<u>Total Alkalinity (g/ltr CaCO₃)</u>	0.072	0.129	0.210	0.096	0.071	0.091	0.078	0.068	0.262	0.073
<u>Conductivity at 18°C</u> (μ Mho/cm)	2490	643	2110	1905	2380	2150	2440	2130	794	2370
<u>pH</u>	7.49	7.54	7.82	7.50	7.57	7.75	7.62	7.12	7.88	7.77

cont'd. 2

TABLE #4
SUMMARIZED RESULTS OF LABORATORY CHEMICAL ANALYSES
WATER SAMPLES FROM EXISTING WELLS

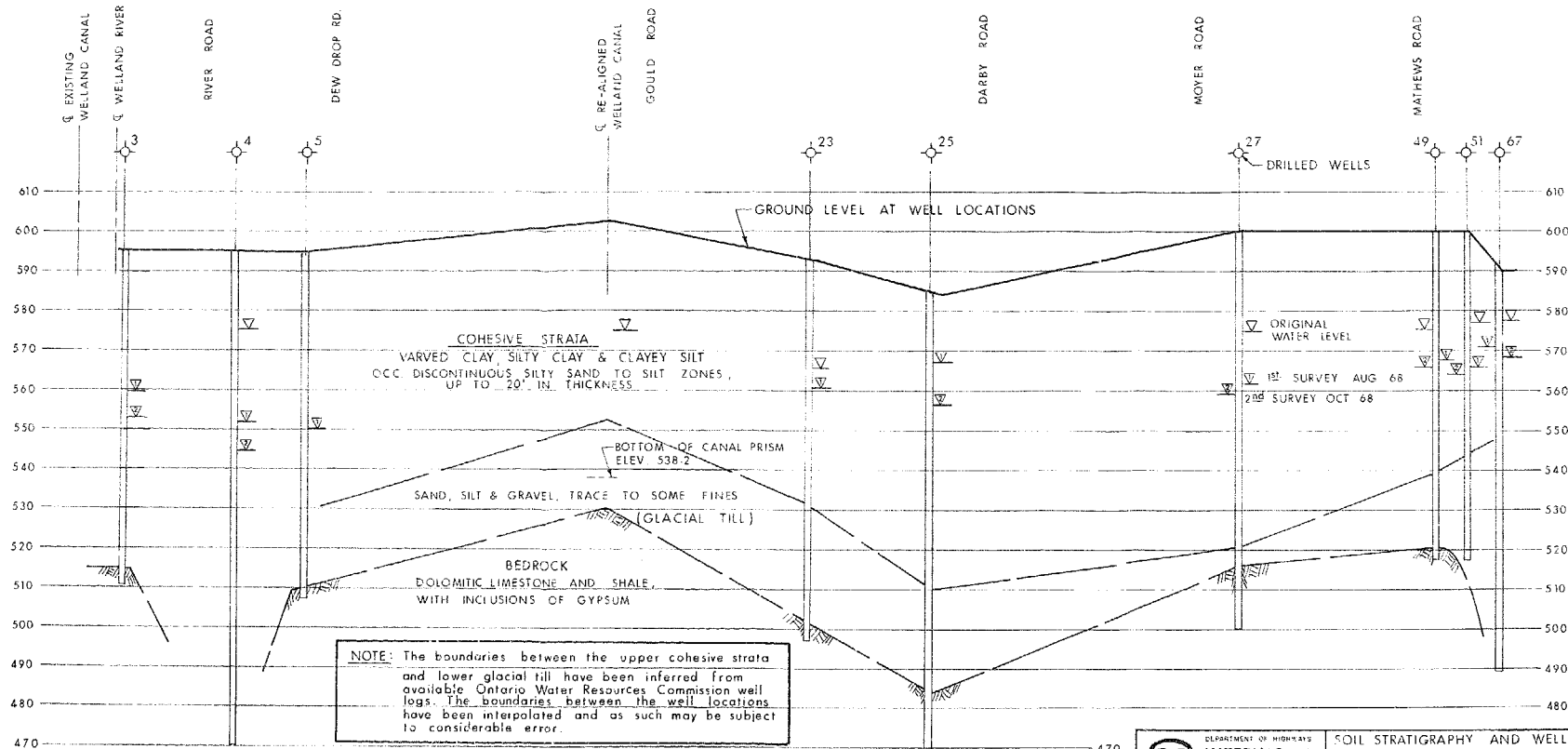
<u>Well No.</u>	6	21	19	16	43	58	34	66	61	51
<u>Type of Well</u>	Drill	Drill	Dug	Drill	Drill	Dug	Dug	Drill	Dug	Drill
<u>Sample No.</u>	27	31	30	37	42	29	27	14	47	10
<u>ppm Sulphide (S²⁻)</u>	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
<u>ppm Sulphate (SO₄²⁻)</u>	2038	1650	170	2160	1885	103	139	1742	218	1710
<u>ppm Chloride (Cl⁻)</u>	470	1650	16	590	10	65	8	134	33	23
<u>ppm Hardness (CaCO₃)</u>	1929	1700	548	2292	1660	429	425	1653	609	1778
<u>ppm Sol. Iron (Fe)</u>	1.7	1.5	0.6	0.2	1.6	0.1	0.1	0.15	0.1	5(approx.)
<u>ppm Calcium (CaO)</u>	921	782	132	833	627	141	137	772	194	786
<u>ppm Magnesium (MgO)</u>	271	122	125	329	216	71	74	189	105	163
<u>ppm Dissolved Solids</u>	3907	2500	671	4331	2852	938	484	2919	794	2695
<u>Total Alkalinity (g/ltr CaCO₃)</u>	0.106	0.104	0.356	0.049	0.039	0.432	0.227	0.079	0.283	0.139
<u>Conductivity at 18°C (μ Mho/cm)</u>	3570	2030	800	3850	2350	1222	559	2440	878	2175
<u>pH</u>	7.41	8.06	7.92	7.36	7.61	8.02	7.96	7.32	7.97	7.36

TABLE #5

COMPARISON OF CHEMICAL ANALYSES
CARRIED OUT ON WATER SAMPLES FROM:

- 1) Private Wells, and
- 2) Pumped Boreholes - Tunnel Site

		<u>Tunnel Bore Holes</u>	<u>Private Wells</u> (drilled)	<u>Private Wells</u> (dug)
<u>ppm Calcium</u>	(CaO)			
	Range	734 - 802	522 - 921	132 - 285
	Vicinity	757	751	260
<u>ppm Sulphate</u>	(SO ₄)			
	Range	2020 - 2270	1580 - 2160	103 - 218
	Average	2089	1792	157
<u>ppm Dissolved Solids</u>				
	Range	3134 - 3453	2269 - 4331	484 - 938
	Average	3290	2775	675
<u>Conductivity at 18°C</u>				
	(micro mho/cm)			
	Range	2530 - 2670	1905 - 3850	559 - 1222
	Average	2570	2456	816



SEE DWG. NO. 68-F-71B



DATE Oct. 15, 1968

SOIL STRATIGRAPHY AND WELL WATER LEVELS

SECTION A-A

W.P. 240-66 DIST. 4 JOB 68-F-71

APPROVED *[Signature]* FIG. NO. 1

MEMORANDUM

To: Mr. B. R. Davis,
Bridge Engineer,
Bridge Office,
Admin. Bldg.

FROM: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

ATTENTION: Mr. F. I. Hewson,
Executive Bridge Engr.

DATE: April 24, 1970

OUR FILE REF.

IN REPLY TO

SUBJECT:

Piezometric Water Levels at the Proposed Crossing of
The Realigned Welland Canal - Main St. East Tunnel -
W.P. 240-66 - District No. 4 (Hamilton) - W.J. 68-F-71

Attached, please find two prints of our Drawing #68-F-71D showing the piezometric water levels at the above mentioned tunnel location, from December, 1967 to April, 1970. This information should be included with our Foundation Report No. W.J. 68-F-71.

This data will also be applicable to the Final Foundation Investigation Report (Volume II, Groundwater Conditions and Pumping Test Results), prepared by Golder & Associates, Soil Consultants for the above mentioned Work Project 240-66.

Should you have any queries with regard to piezometric water level data, please feel free to contact our Office.

MD/MdeF
Attach.

A. G. Stermac
A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

cc: Messrs. B. R. Davis (2)
H. A. Tregaskes
D. W. Parren
G. K. Hunter (2)
C. R. Robertson
W. S. Melinyshyn (2)
T. J. Kovich
B. A. Singh
G. Tustin (St. Lawrence Seaway Authority)

Foundations Files
Gen. Files

Addition Drawings Inserted.

MAY 5 1970

C. Kay

DRILLED WATER WELLS -- WELLAND AND VICINITY

SUMMARIZED RESULTS OF THE EFFECTS OF CORROSION ON STEEL CASINGS AND PUMPS

W.J. 68-F-71

WELL D.H.O.	NUMBER S.I.S.A. ****	OWNER	DIA. ** (I.D.)	DEPTH * OF CASING	YEAR DRILLED	TYPE *** OF PUMP	REMARKS WITH RESPECT TO THE CONDITION OF CASING AND PUMP DUE TO CORROSION
3	103	C. Schmanz River Rd. Crowland Twp.	5"	80'	1947	Shallow Well Pump	Casing appears to be in good condition, neither casing nor pump has been replaced.
4	19	P. Gerbhart Lot 21, Conc.3 Crowland Twp.	6"	70'	Before 1926	Jet Pump	Casing has never been replaced by present owner. There has been no noticeable pumping problem because of corrosion.
5	105	W. Horton Lot 21, Conc.3 Crowland Twp.	6"	87' Est.	1953 ±	Jet Pump	Casing has never been replaced and appears to be in good condition. Pump has never been replaced because of corrosion.
6	50	C. Morin Lot 17, Conc.3 Crowland Twp.	6"	105'	1949	Jet Pump	Casing has never been replaced and appears to be in good condition. Pump has never been replaced because of corrosion.
7	11	E. Carl Lot 15, Conc.3 Crowland Twp.	6"	119'	1955	Jack Pump	Casing has never been replaced and appears to be in good condition. Pump has never been replaced because of corrosion.
10	110	G. Sibbald Lot 15, Conc.3 Crowland Twp.	6"	126'	1923±	Jet Pump	Casing has never been replaced and appears to be in good condition. This casing has a thicker wall than the average casing.
12	44	F. Roberts Lot 15, Conc.4 Crowland Twp.	6"	120'	1910 to 1920	Jet Pump	Casing has never been replaced by the present owner. Appears to be in fair condition but rusted and pitted.
15	51	Schomberger Lot 14, Conc.3 Crowland Twp.	5"	100' Est.		Jack Pump	Casing has never been replaced by the present owner. Casing appears to be in fair condition although rusted.

WELL D.H.O.	NUMBER S.L.S.A. ****	OWNER	DIA. ** (I.D.)	DEPTH * OF CASING	YEAR DRILLED	TYPE *** OF PUMP	REMARKS WITH RESPECT TO THE CONDITION OF CASING AND PUMP DUE TO CORROSION
16	116	Cheshire Lot 11, Conc.4 Crowland Twp.	6 $\frac{1}{2}$ "	100'	1962	Jet Pump	Casing has never been replaced by the present owner. Casing appears to be in good condition.
17	117	P. Protop Lot 14, Conc.6 Crowland Twp.		75'	1968	Jet Pump	New well.
20	12	O. Haerberle Lot 15, Conc.7 Crowland Twp.	5"	102'	1965	Jack Pump	This well was drilled to replace a previous well. Casing of the previous well apparently caved with age, age unknown.
21	56A	E. Alward Lot 14, Conc.7 Crowland Twp.	6"	82'	1965	Jet Pump	Casing has never been replaced. Pump has never been replaced because of corrosion.
23	6	A. Hern Lot 16, Conc.2 Crowland Twp.	5"	90'	1960	Jet Pump	Casing has never been replaced. Pump has never been replaced because of corrosion.
24	124	P. Hervath	6 $\frac{1}{2}$ "	87'	1956	Shallow Well Pump	
25	10	School Section #6 Crowland	6"	100'	1954		Casing appears to be in good condition. Casing appears to be thinner than other well casings in this area.
26	54	K. Mansikka Lot 13, Conc.2 Crowland Twp.			1940*	Jack Pump	Present owner has not replaced the casing. Combination of steel and tile. Information not reliable.
27	127	Nat Roik Conc.3, Lot 12 Crowland Twp.	6"	85'	1957	Hand Pump	Well was drilled to replace a previous well. Casing of previous well has caved, age of well unknown.

WELL D.H.O.	NUMBER S.L.S.A ****	OWNER	DIA. ** (I.D.)	DEPTH * OF CASING	YEAR DRILLED	TYPE *** OF PUMP	REMARKS WITH RESPECT TO THE CONDITION OF CASING AND PUMP DUE TO CORROSION
28	128	C. Horton Lot 14, Conc.2 Crowland Twp.					Well not used.
29	129	C. Mathews Lot 10, Conc.4 Crowland Twp.		Abandoned Gas Well Flows continuously			Casing has rusted away. Age of the well is unknown - 50 years plus.
30		M. Johnson Lot 13 Conc.5 Humberstone	5"	118'	1925±	Hand Pump	Casing is in poor condition but has never been replaced. Pump was recently replaced, possibly due to wear and/or corrosion.
38	138	D. Mathews Lot 12, Conc.6 Crowland Twp.	6"				Well presently not in use.
41	141	D. Burns Lot 13, Conc.7 Crowland Twp.	6 3/4"	80'	1953	Jet Pump	Casing is in good condition and has never been replaced. No pumping problems because of corro- sion.
42	142	J. Kram Lot 13, Conc.7 Crowland Twp.	5 5/8"	86'	1957	Jet Pump	Casing is in good condition and has never been replaced. No pumping problems because of corrosion.
43	70	W. McQueen Lot 14, Conc.7 Crowland Twp.	5 1/2"	105' Est.	1928±	Hand Pump	Casing is in very poor condition, however still performing satisfactorily.
44	144	Cebrynski	1 1/2"	85' Est.	1918±	Shallow Well Pump	Old casing caved in. A 1 1/2" casing was installed.
45	145	G. Schyff Lot 16, Conc.5 Crowland Twp.	5"	85' Est.	1928±		Casing is in poor condition, however still performing satisfactorily.

WELL D.H.O.	NUMBER S.L.S.A. ****	OWNER	DIA. ** (I.D.)	DEPTH * OF CASING	YEAR DRILLED	TYPE *** OF PUMP	REMARKS WITH RESPECT TO THE CONDITION OF CASING AND PUMP DUE TO CORROSION
46	146	T. Wiczorek		50' Est.		Jet Pump	Casing not visible because of well cover.
47	147	J. Hager Lot 14, Conc.1 Crowland Twp.	5"	100'	1960	Jet Pump	Casing has never been replaced and appears to be in good condition. No pumping problems due to corrosion.
48	148	S. Shumlick Lot 12, Conc.1 Crowland Twp.	6 1/4"	103'	1965	Jet Pump	Casing has never been replaced and appears to be in good condition. No pumping problems due to corrosion.
49	149	Eggleton Lot 10, Conc.2 Crowland Twp.	5"	80'	1959	Shallow Well Pump	Casing has never been replaced and appears to be in good condition. No pumping problems due to corrosion.
50	150	P. Dube Lot 11, Conc.2 Crowland Twp.	6"	133' Est.	1910+	Shallow Well Pump	Owner feels that casing is in poor condition. Well is still open.
51	151	J. Majoros Lot 9, Conc.3 Crowland Twp.	6 1/4"	85'	1964	Jet Pump	Casing has never been replaced and appears in good condition. No pumping problems due to corrosion.
52	152	V. Clark Lot 8, Conc.5 Crowland Twp.	6 1/4"	92'	1964		Not used because of high mineral content.
53	153	C. Clark Lot 8, Conc.5 Crowland Twp.	8"			Jack Pump	Well is not used, casing is in poor condition. Casing has never been replaced but may have caved in.
59	159	Walker Bros. Lot 9, Conc.7 Crowland Twp.	5"	105'	1960	Jet Pump	Casing has never been replaced and appears in good condition.
60	160	J. Fazekas Lot 10, Conc.7 Crowland Twp.	6"	103'	1962	Jet Pump	Casing has never been replaced.

WELL D.H.O.	NUMBER S.L.S.A. ****	OWNER	DIA. ** (I.D.)	DEPTH * OF CASING	YEAR DRILLED	TYPE *** OF PUMP	REMARKS WITH RESPECT TO THE CONDITION OF CASING AND PUMP DUE TO CORROSION
62	80	M. Stevens Lot 12, Conc. 5 Humberstone	5"	107'	1960		Casing appears to be in good condition.
65	165	W. Biggar Lot 13, Conc. B.F. Crowland Twp.	3 $\frac{1}{2}$ "		1868 \pm	Rotor Pump	Casing has never been replaced but is in very poor condition. Well originally flowed. No pumping problems due to corrosion.
66	166	F. Smrek Lot 10, Conc. 1 Crowland Twp.	6"	103 Est.		Jet Pump	Casing has never been replaced. Casing is in fair condition but has a thick scale of rust on the inside surface.
67	167	A. Hazelton Lot 10, Conc. 1 Crowland Twp.	6"	100 Est.		Jet Pump	Owner claims <u>water is hard on pumps and metal.</u>
68	168	Asminskas Lot 6, Conc. 4 Crowland Twp.	6 5/8"	77'	1961	Deep Well	Casing has not been replaced.
69	169	T. Williams Lot 7, Conc. 4 Crowland Twp.	2 $\frac{1}{4}$ "		1918 \pm		Flowing well. No information.
70	170	V. Bielunas Lot 6, Conc. 4 Crowland Twp.	3"			Shallow Well	No information. Casing is buried.
73	99	McKenney School Crowland Twp.	6"	123	1956	Jet Pump	Casing has not been replaced and appears in good condition.
74		J. Sibbalb Lot 7, Conc. 5 Crowland Twp.	8"		1939 \pm	Shallow Well	Casing has never been replaced. Estimated well depth 170'.

WELL D.H.O.	NUMBER S.L.S.A. ****	OWNER	DIA. ** (I.D.)	DEPTH * OF CASING	YEAR DRILLED	TYPE *** OF PUMP	REMARKS WITH RESPECT TO THE CONDITION OF CASING AND PUMP DUE TO CORROSION
75		F. Hunt Lot 6, Conc. 7 Crowland Twp.	6"	64'		No Pump	Casing appears to be in good condition.

NOTE:

- * Casing extends to bedrock or to a water bearing sand and/or gravel stratum.
- ** Casing thickness varies from well to well. Approximate range 1/8" to 3/16". The casings appear to be steel in all cases.
- *** The present pump used in any well is not necessarily the original pump installed. Although this is most likely the case for newer wells, older wells have often been converted to a newer pumping system.
- **** Proposed Unified System Numbers

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
0 - 1 MILE		- (DISTANCE FROM TUNNEL LOCATION)										
1	-	Drilled	D. Moteak	Oxford Rd., Welland	Dry							Taken from OWRC records.
2	-	Drilled Casing not visible because of pump. Well is in poor condition.	J. Carl R.R.#1, Welland	Lot 16, Con. 4 Crowland Twp.	Not used for 15 years.				Hand pump not working			Owner buys water for house.
1 - 1 1/2 MILE												
3	1	Drilled (1947) 5" casing extending into bedrock. Casing appears in good condition.	C. Schmanz R.R.#1, Welland	River Rd. Crowland Twp.	Domestic Stock	595'	560' ^a 553' ^b	510'	Pumping Level 40'. Shallow well double action piston pump	Hard Sulphur	*(1) 2853 (2) 2440 (3) 1927 (4) 50 (5) 742	Pumping problems due to a recent lowering of the water level. Owner is now trucking water for his stock.
4 (SLSA) 49	2	Drilled (before 1926) 6" Casing to 70', 2" diameter hole down to .125'. Casing appears in good condition.	P. Gerbhart R.R.#1, Welland	Cambridge Rd. Crowland Twp.	Industry Domestic 500 Gal/day	595'	552' ^a 545' ^b	528'	Pumping Level 60'. Jet pump.	Hard Sulphur	*(1) 2846 (2) 2370 (3) 1848 (4) 95 (5) 763	Has installed a new pump because of lowering of the water level from 20' to 44'. Odour has developed recently, owner now has to chlorinate his water.
5 4010	3	Drilled (1953) 6" casing extending to the bedrock. Casing appears in good condition.	W. Horton R.R.#1, Welland	Cambridge Rd. Crowland Twp.	Domestic	595'	550' ^a (Est.)	503'	Original Pumping level 50'. New jet pump installed at 70' depth.	Fresh Hard Sulphur		Owner out of water at the time of survey because of a recent lowering of the water level. Owner feels this has burnt out his original pump and has bought a new pump.
			a) First survey, August 15 to August 23, 1966. b) Second survey, September 25 to October 3, 1968			<u>LEGEND</u> *(1) Dissolved Solids (ppm) (2) Conductivity at 18 °C (micro Mho/cm) (3) Sulphate (SO ₄) (ppm) (4) Chloride (CL) (ppm) (5) Calcium (CaO) (ppm)						

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WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
18	-	Dug 4' Concrete Tile Well is in good condition.	P. Protz	Ontario Rd. Lot 14, Conc. 6 Crowland Twp.	Domestic	610'	600' ^a 600' ^b	586'	Shallow Pump	Fresh Hard		Bottom of well terminated in sand deposit. Water is murky at times since first survey.
19 (SLSA) 58 4649	30	Dug 4' Diameter. Stone lined. Well is in good condition	Gerald Haynes	Ontario Road Lot 13, Conc. 6 Crowland Twp.	Domestic	605'	595' ^a 596' ^b	590'	Shallow well pump and hand pump.	Fresh	*(1) 671 (2) 800 (3) 170 (4) 16 (5) 132	Water has developed odour and dark color since the first survey.
20	43	Drilled (1965) 5" casing extends 102' to gravel. Casing is in good condition.	O. Haeberle R.R. #4, Welland	Strawn Rd Lot 15, Conc. 7 Crowland Twp.	Stock	597'	583' (est.) Type of pump prevents measurement	497'	Pumping Level 28' Hand Pump	Fresh Sulphur Hard		Water level obtained from OWRC data. No recent changes.
21 (SLSA) 56	31	Drilled (1965) 6" casing extend- ing 82' to gravel. Casing is in good condition.	E. Alward	Ontario Rd. Lot 14, Conc. 7 Crowland Twp.	Stock Domestic	610'	587' (est.)	528'	Pumping level 70' Jet pump	Fresh Hard Sulphur	*(1) 2500 (2) 2030 (3) 1650 (4) 1650 (5) 782	Bottom of well terminated in gravel deposit. No noticeable change in quality of water.
22	-	Dug 4' Diameter Stone lined. Well is in good condition	E. Alward	Ontario Rd. Lot 14, Conc. 7 Crowland Twp.	Stock	610'	602' ^a 596' ^b	590'	Two hand pumps.	Fresh Hard		Owner has started watering stock from this well since first survey.
<u>2 - 2 1/2 MILE</u>												
23	20	Drilled (1960) 5" casing extend- ing 90' to bedrock	Mr. Hern R.R. #1, Port Robinson	Carl Rd. Lot 16, Con. 2 Crowland Twp.	Domestic	593'	561' (est.) Casing covered with earth.	497'	Pumping level 27'	Iron Hard	*(1) 2863 (2) 2490 (3) 1840 (4) 89 (5) 743	Water level obtained from OWRC data. Well founded 6' into bed- rock. Water noted to become muddy after heavy rain due to infiltration. No recent changes.

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WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	SOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
29 4014	-	Drilled (Abandoned gas well) No casing visible.	C. Matthews R.R.#1, Welland	Cooks Mills Rd. at Matthew Lot 10, Conc. 8 Crowland Twp.	Stock	-	-	-	Flowing	Fresh Sulphur Hard		Well flowed continuously up until about July 1968.
30 4020	-	Drilled (1925) 5" casing extends 106' to rock. Casing is in poor condition.	M. Johnson	Townline Twp. Lot 13 Conc. 56 Humberstone Rd.	Domestic Stock	600'	-	488'	Hand Pump	Fresh Sulphur Hard		No noticeable change in water recently.
31	-	Dug Spring Fed 4' Diameter. Stone lined. Good condition.	E. Warner	Lincoln Rd. Lot 10, Conc. 5 Crowland Twp.	Stock Domestic	640'	-	-	Shallow Well pump	Fresh Hard		No noticeable change in the water
32	38	Dug Spring Fed 6' Diameter. Stone lined. Good condition.	J. Myers	Lincoln Rd. Lot 10, Conc. 6 Crowland Twp.	Domestic	640'	631' ^a 631' ^b	623'	Hand Pump	Fresh Hard		No noticeable change in the water.
33		Dug Spring Fed 4' diameter. Stone lined. Good Condition.	"	"	Domestic	640'	633' ^a 633' ^b	623'	No pump			No noticeable change in the water. This well is used as a reserve well.
34	27	Dug Well Spring Fed. 5' diameter. Stone lined. Sandy bottom.	G. Pearson	Pearson Rd. Lot 11, Conc. 6 Crowland Twp.	Domestic	625'	608' ^a 607' ^b	600'	Pumping Level 22'. Shallow well pump		(1) 484 (2) 559 (3) 139 (4) 8 (5) 137	This well supplies two houses.

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

[illegible]

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
41	49	Drilled (1953) 6 $\frac{1}{4}$ " casing extends 80' to bedrock.	Mrs. Burns 79 Cozy St. Welland	Ontario-Co. Rd. 16 Lot 13, Conc. 7 Crowland Twp.	Domestic	630'	571' ^a 577' ^b	513'	Pumping level 66'. Jet pump	Fresh Hard Sulphur	*(1) 2269 (2) 1905 (3) 1460 (4) 15 (5) 639	New jet pump installed because of lack of water 2 months before the first survey. No recent change in the water since the first survey.
42		Drilled (1957) 5 5/8" casing extends to the rock. Casing appears to be in good condition.	J. Kram R.R. #4 Welland	Co. Rd. 16 Lot 13, Conc. 7 Crowland Twp.	Irrigating garden only.	600'	- 566' ^b	501'	Pumping level 45'. Jet pump	Fresh Sulphur Hard		Jet is withdrawn for the winter.
43 (SLSA) 70	42	Drilled (1928 $\frac{1}{2}$) 5 $\frac{1}{2}$ " casing in poor condition.	W. McQueen	Townline Rd. Lot 14, Conc. 7 Crowland Twp.	Stock	600'	585' (est.) Type of pump prevents measurement.	485'	Pumping level 15'. Hand pump.	Sulphur Hard	*(1) 2852 (2) 2350 (3) 1885 (4) 10 (5) 627	Recently well appears to be silting up. Some discoloration noted at the time of first survey. Pumping problems at the time of second survey.
44 72-8	41	Drilled (1918 $\frac{1}{2}$) 1 $\frac{1}{4}$ " casing placed inside old casing. Casing extends to the bedrock. Casing is in poor condition.	Mr. Cebrynski	Townline & Yager Lot 15, Conc. 5 Humberstone Twp.	Stock	600'	590' Pump prevents measurement.	500'	Pumping level 80'. Shallow well pump	Fresh Hard Sulphur		Possibility of expropriation. Older casing caved in. Well was repaired by installing 1 $\frac{1}{4}$ " casing.
45	39	Drilled (1928 $\frac{1}{2}$) 5" casing extends to the rock. Casing is in fair condition.	C. Schyff	Townline at Moore Lot 16, Conc. 5 Humberstone Twp.	Stock	590'	567' ^a 563' ^b	505'	Pumping level 53'. Shallow well pump.	Hard Sulphur Fresh		Well extends into bedrock. Since the first survey the cattle will not drink the water.

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
46 4039	40	Drilled. Well may extend to the rock.	T. Wiczorek	Townline Rd. Lot 16, Con. 5 Humberstone Twp.	Domestic Stock	590'	575' (est.) Platform cover prevents measurement.	525'	Jet Pump	Hard Sulphur		Possibility of expropriation.
<u>2 1/2 - 3 MILE</u>												
47	11	Drilled (1960) 6" casing extends 100' to bedrock. Casing appears in good condition.	J. Hagar R.R. #1 Port Robinson	Darey Rd. at Bigger Rd. Lot 14, Conc. 1 Crowland Twp.	Domestic Stock	587'	564' ^a 563' ^b	484'	Pumping level 30'. Shallow well pump replaced by Jet Pump at time of second survey	Slightly sulphur Hard	* (1) 2856 (2) 2380 (3) 1805 (4) 101 (5) 764	No noticeable change in quality of the water. Well extends 3' into bedrock. Owner gives original water level as 14'. Pump was replaced because of low water level Sept. 28/68.
48 4064	13	Drilled 6" casing extends 103' to gravel. Casing appears in good condition.	S. Shumlick R.R. #1 Port Robinson	Moyer Rd. Lot 12, Conc. 1 Crowland Twp.	Domestic	594'	583' ^a 568' ^b	491'		Hard Sulphur		Water is commercially softened & supplied to two households. No noticeable change in the quality of the water.
49 4008		Drilled 5" casing extends 80' to bedrock. Casing appears in good condition.	Mr. Eggleton	Matthew Rd. at Cambridge Rd. Lot 10, Conc. 2 Crowland Twp.	Stock	600'	567' ^a 566' ^b	517'	Pumping level 27'. Shallow well pump	Fresh Hard Sulphur		Detailed well log available from OWRC. At the time of surveys the well could not be pumped. Water level orig. 10'. Owner now buying water for cattle.
50		Drilled 6" casing appears to be in good condition.	P. Dube	Matthew Rd. at Cambridge Rd. Lot 11, Conc. 2 Crowland Twp.	Plan to use for stock.	600'	567' ^a 565' ^b	467'	Pumping level 85'. Shallow well pump. Not connected.	Sulphur	* (1) 2695 (2) 2175 (3) 1710 (4) 23 (5) 786	Well was used for drinking at one time. Well has never gone dry.

WELL NO.	SAMP NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.I. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
51	10	Drilled (1964) 6 1/2" casing extend 85' to gravel. Casing is in good condition.	J. Majors R.R.#1 Welland	Cambridge Rd. Lot 10, Conc. 3 Crowland Twp.	Stock	600'	565' ^a 564' ^b	517'	Pumping Level 40". Jet pump	Sulphur Hard		Bottom of well terminates in a sand deposit. Water level originally 23' from the surface.
52		Drilled (1964) 6 1/2" casing extend 91' to sand.	V. Clark R.R.#1 Welland	McKenney Rd. Lot 8, Conc. 5 Crowland Twp.	Not in use	610' Casing covered with earth.	-	519'	No pump	Sulphur Tasty Undrinkable		Well is 4 years old.
53		Drilled 8" casing. Casing appears to be in poor condition.	C. Clark	McKenney Rd. Lot 8, Conc. 5 Crowland Twp.	Not used since 1947.	620' Type of pump pre- vents measurement.	601' (est.)	460'	Pumping Level Hand pump	Sulphur Potash Black		
54		Dug Spring Fed. 5' Diameter. Stone lined. Well is in good condition.	"	"	Domestic	620'	611' ^a 611' ^b	605'	Shallow Well pump	Fresh		No noticeable change in quality of water. Owner has other dug wells of limited use.
55	35	Dug Spring Fed. 5' Diameter. Brick lining.	McKenney	McKenney Rd. Lot 8, Conc. 6 Crowland Twp.	Domestic	635'	625' ^a 627' ^b	621'	Shallow Well pump			No recent change noticed in the water

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.I. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
56		Dug Spring Fed. 5' Diameter. Line with well tile.	McKenney	McKenney Rd. Lot 8, Conc. 6 Crowland Twp.	Stock	635'	630' ^a 629' ^b	625'	Hand pump			No recent changes in the water level.
57		Dug 5' diameter. Stone lining.	S. Gill	McKenney Rd. Lot 9, Conc. 6 Crowland Twp.	Reserve	640'	631' (est.)	628'	Hand Pump			
58	29	Dug (1953) 4' diameter. Concrete tile lining. Well is in good condition. Sandy bottom.	"	"	Stock Domestic 1000 Gal/day	640'	629' ^a 629' ^b	626'	Shallow Well pump	Hard	*(1) 938 (2) 1222 (3) 103 (4) 65 (5) 141	No recent change in the water level.
59	36	Drilled (1960) 5" Casing extends 105' to sand. Casing is in good condition.	Walker Bros.	Ontario Rd. Lot 9, Conc. 7 Crowland Twp.	Domestic (treated)	620'	589' ^a 587' ^b	515'	Jet pump	Fresh Hard		Well supplies the house of two tenants.
60		Drilled (1962) 6" Casing extends 102' to shale. Casing is in good condition	J. Fazekas R.R.#4 Welland	Cope Rd. Lot 10, Con. 7 Crowland Twp.	Domestic	620'	590' (est.) Casing has metal cap.	515'	Pumping Level 90'. Jet pump	Fresh Hard Clear		

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
61	47	Dug 4' Diameter. Stone lined. Well is in good condition.	Mrs. Cope	Cope Rd. Lot 10, Conc. 7 Crowland Twp.	Domestic	610'	596' ^a 598' ^b	592'	Shallow Well pump		*(1) 2919 (2) 2440 (3) 1742 (4) 134 (5) 772	Well has gone dry since first survey & owner has had to buy water. Well has gone dry in previous years.
62 (SLSA) 80 1/022	44	Drilled (1960) 5" Casing extends 107' to sand. Casing is in good condition.	M. Stevens R.R.#4 Welland	Lot 12, Conc. 5 Humberstone Twp.	Domestic	600'	580' ^a 581' ^b	490'	Jet pump	Sulphur Drinkable		
63	45	Dug Spring Fed. 12" Concrete tile extends 16' to sand. Well is in good condition.	B. Steernyngy	Lot 12, Con. 5 Humberstone Twp.	Domestic	600'	594' (est.) Type of pump prevents measurement.	584'	Hand pump			
64	46	Dug Spring Fed. 4' diameter Stone lined. Well is in fair condition. Sandy bottom.	C. F. Sinclair R.R.#4 Welland	Townline Rd. Lot 12, Conc. 5 Humberstone Twp.	Domestic	600'	594' ^a 577' ^b	585'	Shallow well pump and hand pump	Chlorinated		Owner chlorinates well after rain to settle it.
<u>3-3 1/2 MILE</u>												
65 1005	15	Drilled (1868*) 3 1/2" casing extends approximately 90' to bedrock. Casing appears to be in poor cond.	W. B. Bigger	Chippewa Creek Rd Lot 13, Con. B.F. Crowland Twp.	Stock	580'	566' (est.)	489'	Pumping level 20'. Rotary pump.	Clear Drinkable Sulphur Hard		Well flowed until March/68, following this date it had to be pumped. No noticeable change in the quality of the water.

WELL NO.	SAMP NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.L. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
66 4054	14	Drilled 6" casing extends to bedrock. Casing appears to be in fair cond.	F. Smerk	Bigger Rd. Lot 11, Conc. 1 Crowland Twp.	Domestic	590'	571' ^a 570' ^b	486'	Pumping Level 75'. Jet pump.	Hard Drinkable Sulphur	*(1) 2919 (2) 2440 (3) 1742 (4) 134 (5) 772	Problems with sand in the water. No recent changes in quality of water.
67	17	Drilled 6" Casing extends to bedrock. Casing appears to be in fair cond.	A. Hazelton	Carl Rd. Lot 10, Conc. 1 Crowland Twp.	Stock Domestic	590'	570' ^a 568' ^b	490'	Pumping level 30'. Jet pump.	Hard Sulphur Drinkable		Owner claims water is hard on pumps & metal. No recent changes in quality of water.
68	4	Drilled (1961) 6 5/8" casing extends 77' to bedrock.	Mrs. Asminskas 245 Marshall Welland Tenant: Mr. Hopper	Younge Rd. at Cooks Mills Rd. Lot 6, Conc. 4 Crowland Twp.	Domestic Not used for drinking.	600'		512'	Pumping Level 80'. Jet pump	Fresh Hard Sulphur		Well extends 11 ft. into bedrock
69	5	Drilled (1918?) Artesian Well 2 1/2" casing	T. Williams R.R.#1 Welland	Cooks Mills Rd. Lot 7, Conc. 4 Crowland Twp.	Stock	590'	590'+	559'	Flowing, Capped, Pumping Level 10'. Double action piston pump	Very hard Drinkable	*(1) 2479 (2) 2130 (3) 1580 (4) 55 (5) 522	Pump not in working order at time of second survey.
70	6	Drilled 3" Casing	V. Bielunas	Lot 6, Con. 4 Crowland Twp. Cooks Mills Rd.	Stock	595'	589' (est.) Casing is covered with earth.		Pumping Level 25'. Shallow well pump	Drinkable Very hard Sulphur		No noticeable change in the water recently

WELL NO.	SAMP. NO.	WELL DESCRIPTION	OWNER	LOCATION	USE & YIELD	G.I. ELEV.	W.L. ELEV.	BOT'M. ELEV.	PUMPING DETAILS	WATER DESCRIPTION	LAB. RESULTS	REMARKS
71		Dug 4' Diameter. concrete tile lining. Good condition.	R. Santoro	Morris Rd. Lot 7, Conc. 6 Crowland Twp.	Domestic Stock 200 Gal/day	620'	612'	606'	Shallow Well pump	Fresh		Combination cistern and spring fed well. Spring yields little water.
72	33	Dug Spring Fed. 4' Diameter. Stone lined.	B. Morris	Morris Rd. Lot 6, Conc. 6 Crowland Twp.	Domestic Stock 200 Gal/day	620'	612' (est.) Well covered pre- vents measurement.	606'	Hand Pump	Fresh		
73	34	Drilled (1956) 6" casing extends 123' to bedrock.	McKenney School	McKenney Rd. at Ontario Rd. Lot 8, Conc. 7 Crowland Twp.	Domestic 1000 Gal/day	620'		485'	Jet Pump		*(1) 2730 (2) 2150 (3) 1806 (4) 1857 (5) 714	
74		Drilled (1939?) 8" casing	J. Sibbald R.R.#1, Welland	Lincoln Rd. Lot 7, Conc. 5 Crowland Twp.	Domestic Stock	600'	584' ^b	428'	Shallow Well pump	Fresh		
75		Drilled 6" casing. Casing appears in good condition.	F. Hunt	Morris Rd. Lot 6, Conc. 7 Crowland Twp.	Not in use at present	620'	581' ^b	556'				Owner plans to use well for stock & domestic purposes.

MEMORANDUM

To: Mr. B. E. Davis,
Bridge Engineer,
Bridge Office, Admin. Bldg.

From: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

Attention: Mr. P. I. Hewson,
Sr. Bridge Liaison Engr.

Date: January 3, 1969

Our File Ref:

In Reply To

SUBJECT: Re: Proposed Crossing of the Re-aligned Welland Canal
Main Street East Tunnel, Welland, Ontario -
W.J. 68-F-71 -- W.P. 240-66

Please insert attached summarized results of the effects of corrosion on steel casings and pumps - Drilled Water Wells - Welland and Vicinity, into your copy(s) of the above mentioned report.

MD/MdeF
Attach.

cc: Messrs. B. E. Davis (2)
E. A. Tregaskes
D. W. Parren
G. K. Hunter
W. S. Melnyshyn
P. J. Kovion
B. A. Singh
Foundations Files
Gen. Files

M. Devata

M. Devata,
SUPERVISING FOUNDATION ENGR.

For:

A. G. Stermac,
PRINCIPAL FOUNDATION ENGR.

H. Greenland
G. Tustin (S.L.S.A.) - 4
H. Q. Golder & Assoc. Ltd.
Gibb, Albery, Pullerits & Dickson
R. G. Tanner, Executive Engr. -
(H. G. Acres Ltd.)



1972 SEP 25 AM 10:29

WP-
240-66-01, 2, 3, 4
68-F-71

(2108)

B

HAMN DOWN 5 SEPT 26/72 10.15A VR

D A WALLER DIST CONST ENGR

RE PERMANENT PIEZOMETERS EAST MAIN STREET TUNNELL CONTRACT 70-10

DISTRICT NO.4

FURTHER TO YOUR MEMO OF SEPT 21 /72 AND OUT TELEPHONE

CONVERSATION OF SEPT 25/72 THIS IS TO ADVISE YOU THAT CEMENT

FONDU AND SAND GROUT WAS SPECIFIED IN THE CONTRACT HOWEVER CEMENT

FONDU GROUT WAS USED DURING CONSTRUCTION

MDAVATA SUPERVISING FOUNDATION ENGR

CC TO J J RYAN HAMN DIST

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MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. M. Devata
Foundations Section
Downsview, Ontario

FROM: D. A. Waller
District Construction Engineer
District #4, Hamilton

ATTENTION:

DATE: September 21, 1972

OUR FILE REF.

IN REPLY TO

SUBJECT:

Permanent Piezometers
Contract 70-10

68-F-71

This is further to mine of September 15, 1972 and our recent telephone conversation.

As I understood your conversation, you said that the contract stated the use of cement sand grout whereas on page 18 of the contract drawings it states stiff cement fondue and sand grout in two notes on the piezometer installation detail. Therefore, I would assume that it was not a later decision to use cement fondue but it was a contract requirement.

Would you kindly advise.

DAW:lo


D. A. Waller
District Construction Engineer

c.c. J. J. Regan

Mr. D. A. Waller,
Construction Engineer,
District #4,
Hamilton, Ontario.

Foundations Office,
Design Services Branch,
West Bldg., Downsview.

October 4, 1972.

Sealing of Temporary Piezometers Within Canal
Prism, Main Street East Tunnel, Welland, Ontario.
W.P. 240-66 -- Cont. 70-10

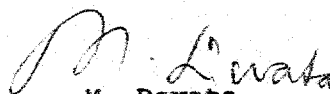
68-F-71

We are enclosing a copy of the letter submitted by H. Q. Golder & Associates to Alberty, Pullerits & Dickson, dated September 29, 1972, for your information.

As the flooding of relocated Welland Canal is imminent, we are in complete agreement with the suggested procedure outlined by H. Q. Golder & Associates with regard to sealing of temporary piezometers located within the canal prism. Recently this Office discussed the above subject with Mr. K. Mullerbeck of Alberty, Pullerits & Dickson, Consulting Engineers, and it was agreed that the necessary positive measures will be carried out by their Office in Welland.

Should you have any queries with regard to this, please feel free to contact our Office.

MD/ao
Encl.


M. Devata,

SUPERVISING FOUNDATIONS ENGINEER.

cc: K. Mullerbeck, Alberty, Pullerits & Dickson
J. E. Davis, H. Q. Golder & Associates
F. I. Hewson

Foundations Files ✓
Documents

AGS.

Golder Associates

CONSULTING GEOTECHNICAL ENGINEERS

H. Q. GOLDER
V. MILLIGAN
J. L. SEYCHUK
C. O. BRAWNER
D. L. TOWNSEND

F. J. HEFFERNAN
B. E. W. DOWSE
J. B. DAVIS

September 29, 1972

Albery, Pullerits & Dickson,
29 Gervais Drive,
Don Mills, Ontario.

Attention: Mr. K. Mullerbeck, P.Eng.

RE: SEALING OF TEMPORARY PIEZOMETERS,
MAIN STREET EAST TUNNEL,
WELLAND, ONTARIO.

68-F 71

W P 240-66

Cont 70-10

Dear Sirs:

During a visit to the above site on September 21, 1972, the writer had the opportunity to discuss the above piezometers with your Mr. A. King at the site, and subsequently, with your Mr. K. Mullerbeck. The results of these discussions are summarized in this letter.

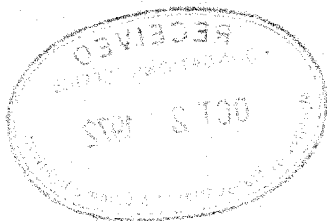
As the flooding of the relocated Welland Canal is imminent, the temporary piezometers within the canal prism should be fully and properly sealed to prevent direct ingress of canal water into the bedrock aquifer. To this end, we suggest the following procedure:-

- 1) Concrete sand or the equivalent should be placed inside the piezometer casing to a level of 5 to 10 ft. above the top of the piezometer screen.
- 2) The casing should be grouted with a grout containing an expanding agent. The grout should be pumped down to the bottom of the open casing through a suitable hose which should be withdrawn as grouting proceeds. (We understand that you will provide comments regarding a suitable grout).

- 3) The casing should be cut off at a level 5 ft. below the canal bottom, and the excavation necessary for this work should be backfilled with highly plastic clay (liquid limit greater than 50 and plasticity index greater than 20). The clay should be placed in 2 to 3 in. thick layers and each layer should be well compacted and kneaded using a hand controlled pneumatic tamper.

The essential requirement for treating the temporary piezometers is that a positive seal should be provided in the piezometer casing. An alternative procedure which incorporates a positive seal may be considered, but it will not be acceptable to merely cut the piezometer casing at a depth of 5 ft. and then to backfill the resulting pit with clay without providing a positive seal in the casing. All piezometer casings should be provided with a positive seal prior to flooding the canal.

Should you have any questions regarding this matter, please call us.



Yours truly,

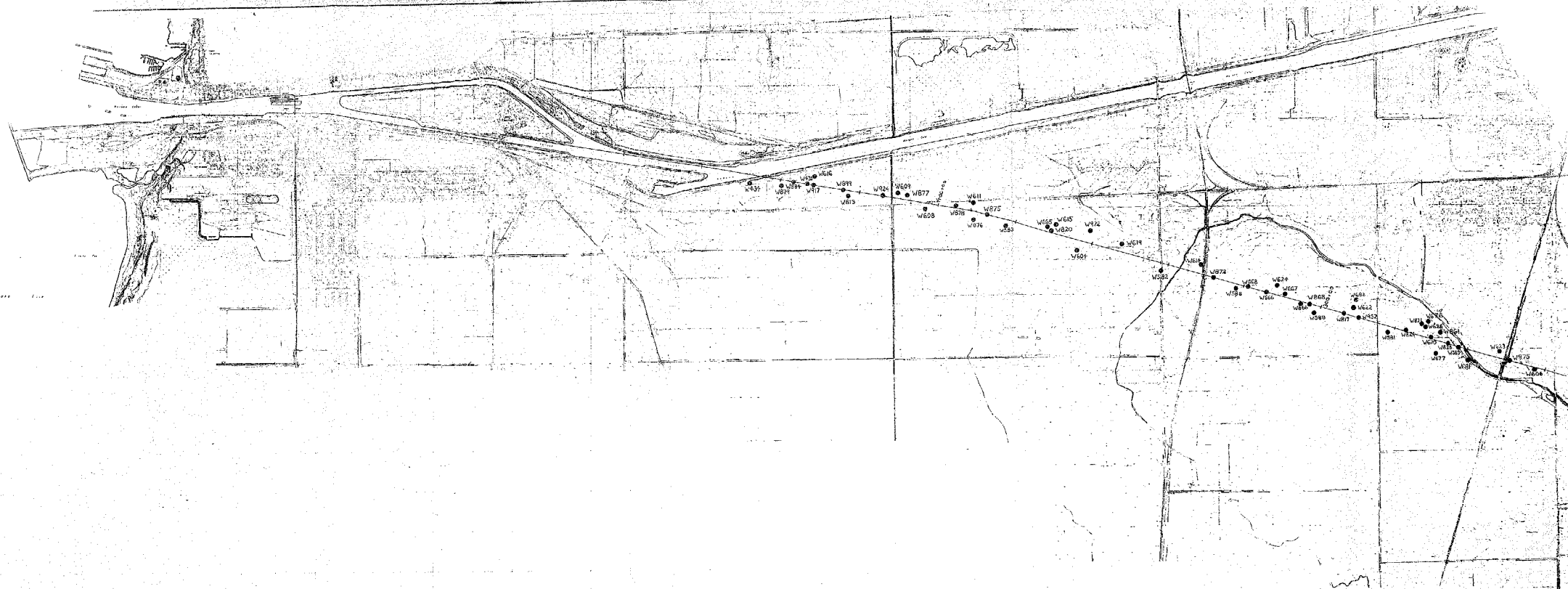
H. Q. GOLDER & ASSOCIATES LTD.

A handwritten signature in dark ink, appearing to read 'W. S. Freeman', is written over the typed name.

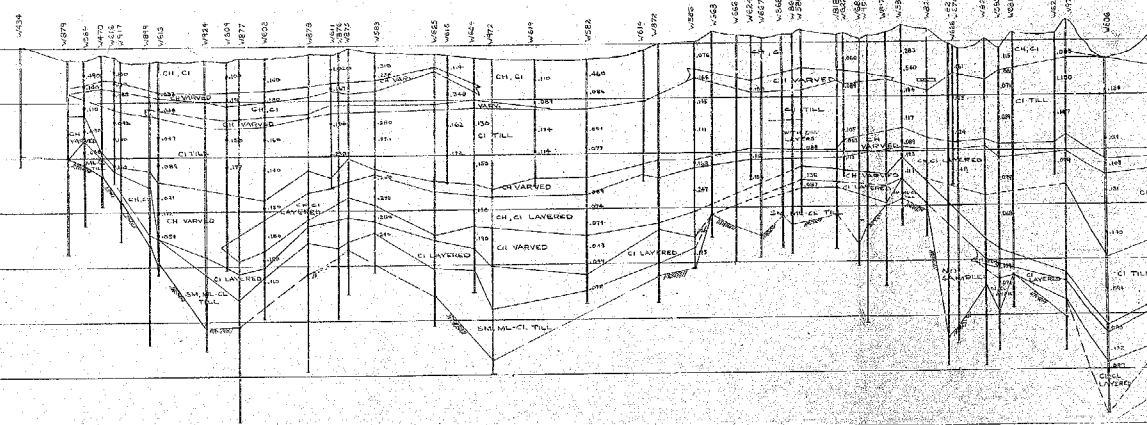
W. S. Freeman, P.Eng.

WSF:sm
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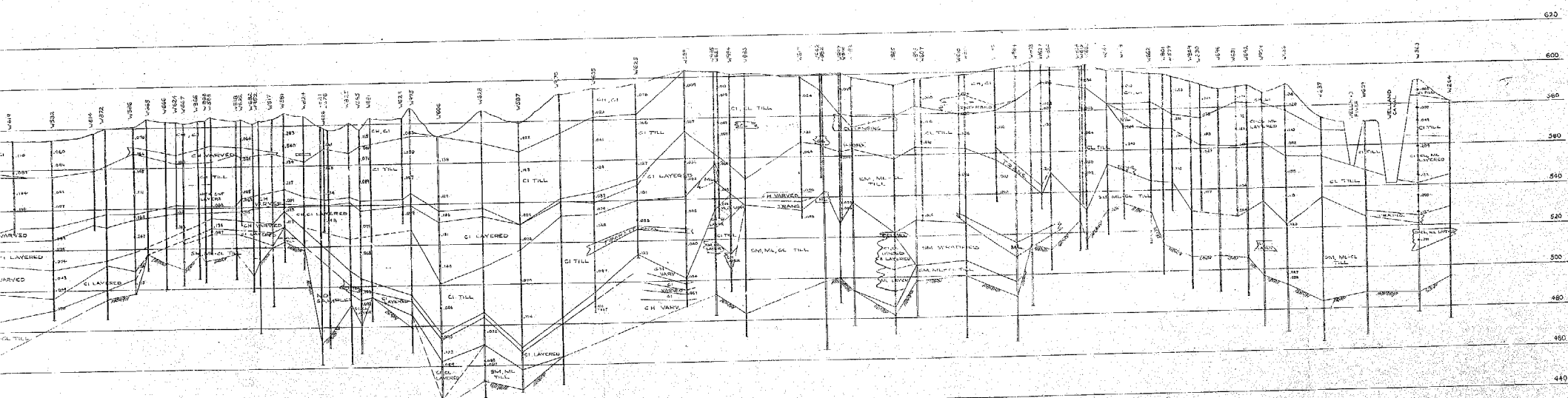
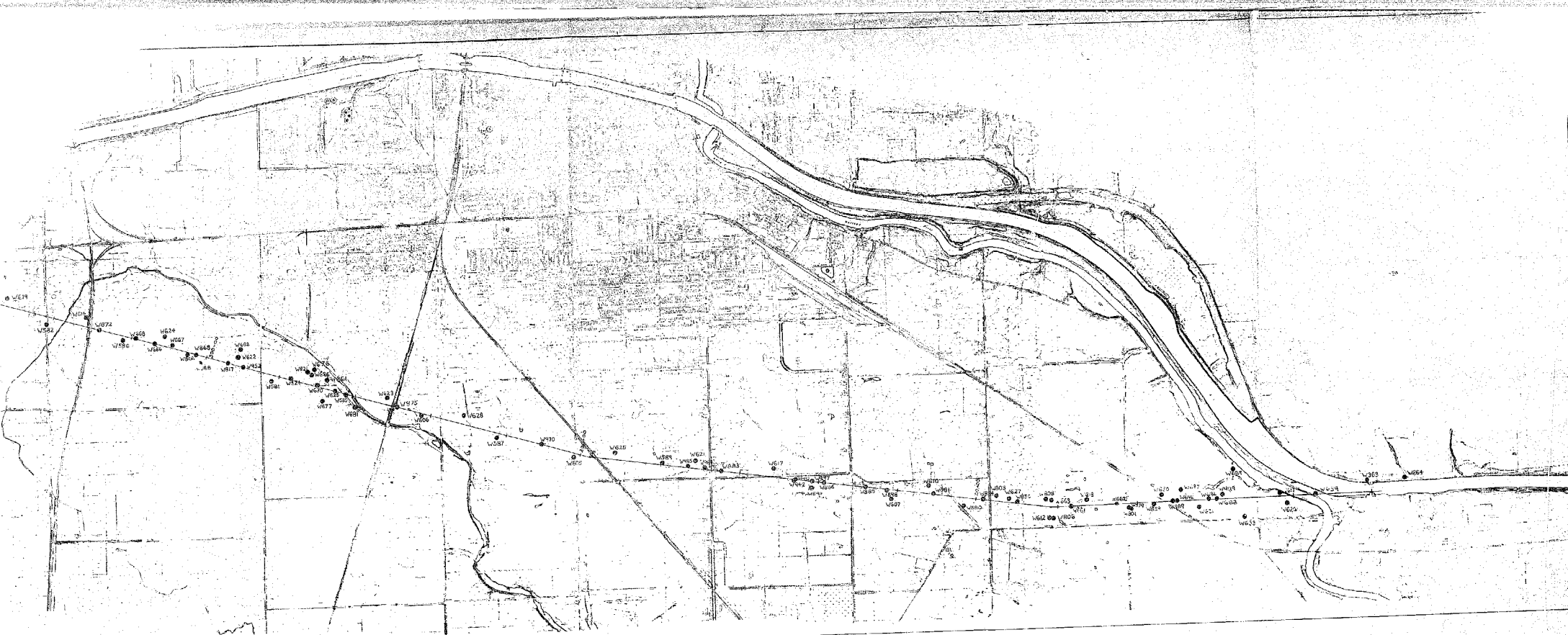
cc: Ministry of Transportation & Communications
Attn: Mr. S. M. Devata



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SOME DEFECTS IN NEGATIVE DUE
TO CONDITION OF ORIGINAL DOCUMENTS



SOME DEFECTS IN NEGATIVE DUE
TO CONDITION OF ORIGINAL DOCUMENTS

THE ST. LAWRENCE SEAWAY AUTHORITY			
WETLAND CHANNEL RELOCATION			
GEOLOGICAL PROFILE			
SAMPLING STATIONS			
DATE	BY	CHECKED	APPROVED
DEC 23, 1968	W. J. H. H.	W. J. H. H.	W. J. H. H.