Hydrotechnical Report Update
Ferma Aggregates Inc.
Carden Quarry

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1.0 Introduction

Ferma Aggregates Inc. is proposing a limestone quarry development on Lots 7, 8, 9, and Part of Lots 6 and 10, Concession IX, Carden Township in Victoria County as shown on Figure SK1 found in Appendix "A".

The April 1995, Hydrotechnical Report prepared by Oliver, Mangione, McCalla & Associates Limited provided an assessment of the impact of quarry dewatering on local domestic water supplies, and surface water quantity and quality.

In 1995 the Ferma Aggregate Licence Application, and applications for land use planning amendments, were circulated for comment.

Since then the following has occurred:

1) As part of this circulation process the Ministry of Environment requested that an application be made for a Permit to Take Water before they would consider commenting on the development proposal. The Ministry of Environment subsequently granted a Permit to dewater the first lift of Phase 1 – North Part.

2) The Applications for an Aggregate License and Official Plan and zoning By-Law amendments have been referred to the Ontario Municipal Board. During public meetings conducted at the direction of the Board, inquiries were made with respect to the potential impact dewatering would have on livestock water supplies. This was not specifically addressed in the 1995 Report.

3) Provincial restructuring has seen the delegation of approval under the Federal Fisheries Act removed from MNR and returned to the Federal Department of Fisheries and Oceans (DFO). DFO have indicated that dewatering discharge will require Approval under the Fisheries Act, and will require that the impact of dewatering on fish habitat stream flow be examined.

This addendum addresses each of the above with respect to hydrotechnical issues. The April 1995, Hydrotechnical Report is referenced for relevant background information.

2.0 Corrections to the 1995 Hydrotechnical Report

The following corrections in the 1995 Report are noted.

1) Table 1, on Page 22, Ground Elevation (masl) at Borehole No. 5 Piezometers A, B and C should be "269.6" and not "279.6".

2) Table 12, on Page 56, the heading on the fourth column should be "Discharge Velocity" and not "Settling Velocity".

3) Appendix "J" – Part B – Three Dimensional Model, the lower aquifer occurs between 225 and 236 masl, not 225 and 250 masl. Aquifer transmissivity should have units of m^2/s.

The following clarification to the 1995 Report is provided.

1) Table 8, Page 4, proportions surface drainage between Sumps A and B according to the corresponding final drainage areas before extraction is complete. However, groundwater flow has been proportioned based on Phase areas.

2) Page 54, last paragraph, the area that will be lost draining to Canal Lake is 27 hectares not 30.

3.0 Permit to Take Water

A Permit to Take Water was received by Ferma Crushed Stone and is dated May 15, 1998. The Permit allows for the withdrawal; of 120 L/min or 172,000 L/d groundwater from proposed quarry Sump "A" located within Phase 1 of the North Part. The Permit expires on May 15, 2008.

The Permit and relevant correspondence pertaining to it is found in Appendix "B".

The General Condition of the Permit are summarized as follows:

- Item 1 and 2 within the General Conditions pertains to definitions and ownership.
- Item 3 of the Permit pertains to the obligation of the Permit holder to measure, and keep records and report any water taking.
- Item 4 pertains to the requirement to notify the Director of MOE of any complaints of water taking authorized by the Permit and report any action taken or to be taken in regards to same.
- Item 5 relates to surface water taking, and states that stream flow is not to be blocked or reduced to a rate that will cause interference with its use or natural functions of the stream.
- Item 6 pertains to groundwater taking and spells out the obligation of the Permit holder to restore any negative impact to water supplies that has occurred to an equivalent quantity and quality, or compensate those impacted at a reasonable cost, or reduce the rate of water taking to prevent any negative impact. Further, it requires that the Permit holder provide temporary water supply to meet the requirements of those affected, and that they (those affected) are to be compensated at a reasonable cost.
- Items 7 and 8 require the Permit holder to obtain Approval under Section 52 of the Ontario Water Resources Act (OWRA), R.S.O. 1990 and Section 53 of the OWRA, R.S.O. 1993, prior to the taking of water.
- Items 9, 10, 11 and 12 are administrative items pertaining to the permit.

The Special Conditions of the Permit include:

- Item 13 states that the measuring and reporting criteria shall be kept daily when pumping.

- The Permit is only valid for the first lift of the Phase 1 in the North Part.
- Item 15 pertains to the locations of wells to be monitored and the monitoring program that should be undertaken.
- Item 16 pertains to the specifics of the reporting requirements.
- Item 17 pertains to contingency measures and provisions of alternate water supply.
- Item 18 pertains to the responsibility of the Permit holder to investigate water supply interference complaints.

The proposed conditions to be added to the Site Plans relative to the Permit to Take Water are described as follows and are supported by Figures 1 and 2.

Condition 1 – Water Taking

The Permit to Take Water applies to dewatering the first lift of Phase 1, North Part, Ferma-Carden Quarry which is defined as a limestone excavation limited to a minimum floor elevation of 255.0 masl over the east half of Lots 8 and 9, Concession IX, Carden Township. Subsequent lifts or Phases will require a new Permit to Take Water.

(**Condition 1 Explanation**: The base of the upper bedrock aquifer within and surrounding Phase 1 is approximately 251.0 masl. Computer simulation of dewatering (steady state) to this elevation results in a predicted drawdown of one to two metres at closest domestic wells W1 and W2 as shown on Figure 1. If upper aquifer dewatering is reduced to elevation 255.0 masl, the simulated drawdown (transient solution, 20 years) is predicted to be between 0.75 and 1.9 metres at wells W1 and W2, respectfully.

The depth of excavation would be controlled by constructing the top of Sump "A" to elevation 255.0 masl and sloping the quarry floor towards the sump at 0.5% grade. This would result in first lift floor elevations at the north and west limits of Phase 1 of 257.0 masl, and 258.0 masl at the south limit of Phase 1. The corresponding depth of excavation is between 11.0 and 15.0 metres. The amount of limestone reserve is approximately 15 million tonnes.

There would remain approximately 15 metres of formation between the base of excavation and the top of the lower bedrock aquifer.

The estimated maximum groundwater taking is predicted to be approximately 144 m^3/day, or 100 L/min. To accommodate both groundwater and surface water collected when Phase 1 is fully excavated, pumping facilities should be capable of pumping 910 L/min (200 IGPM).)

Condition 2 – Monitoring Wells

Monitoring wells containing bi-level piezometers at locations WA (mid north part of east limit of Phase 1), WB (mid south part of east limit of Phase 1), WC (mid south limit of Phase 1), WD (mid south part of west limit of Phase 1), WE (mid north part of west limit of Phase 1), WF (opposite side of road from domestic well W2), and WG (southwest corner of site) are to be constructed six months prior to commencing dewatering. Upper and lower bedrock aquifer piezometers are to have base elevations at approximately 250 masl and 230 masl, respectively. Each bi-level monitoring well will have two 50 mm diameter piezometers each having a 1.0 meter long slotted screen section located within the water bearing zone of respective aquifers. The annulus surrounding the screens and casings are to be backfilled with silica sand with upper and lower aquifers isolated by a 3.0 metre thick bentonite seal placed using a tremie pipe or by pumping. Surface protection is also required per Regulation 901. On a quarterly basis commencing six months prior to dewatering, static water levels are to be recorded within the above monitors, and at existing piezometers which include: BH 1A, 1B, 1C; BH 2A, 2B, 2C; BH 3A, 3B, 3C; BH 4A, 4B, 4C; BH 5A, 5C; W9; and W22. All piezometers destroyed by quarry operations are to be replaced.

(**Condition 2 Explanation:** Well locations will be added to the Operational Plan and Staging Diagrams.

The purpose of recording static level observations at wells WA through WF are as follows:

- to measure compliance with Permit to Take Water Condition 1;
- to measure drawdown at distance due to dewatering in both upper and lower aquifers;
- to permit calibration of any future computer simulations;
- to validate complaints of adverse impacts by surrounding landowners; and
- provide more data relating to aquifer characteristics and groundwater flow.

The purpose of recording static level observations at existing multilevel piezometers, proposed well WG, and existing wells W9 and W22 are:

- to determine if there is any impact at distance due to dewatering Phase 1;

- to determine if there is any impact as a result of other nearby quarry dewatering operations;
- to determine if there is any impact on the lower bedrock aquifer as a result of dewatering the upper aquifer; and
- to validate complaints of adverse impacts by surrounding land owners.)

Condition 3 – Monitoring and Reporting

Within 90 days following the first anniversary of commencing dewatering activities, the Operator will submit a report to the Ministries of Environment and Natural Resources summarizing for the previous year: static water level observations; pumping rates; water budget calculations; the extent of drawdown; anticipated pumping rates and corresponding drawdown within the next operating year; well logs of constructed wells; a sketch showing well locations, extent of excavation and equipotential contours of the upper and lower aquifer; water supply complaints received and steps taken to resolve same; contingency measures implemented; and, any out of the ordinary observations made.

Condition 4 – Contingency Measures

The Operator will maintain a potable water supply source to surrounding wells adversely affected by dewatering operations. Contingency measures include, but are not limited to, the construction of a new well(s) within the upper bedrock aquifer at a location(s) unaffected by quarry dewatering and the delivery of water from the new well(s) by pressurized piped system to each affected residence. Dewatering mechanisms will be shut down failing the resolution of water supply problems caused by quarry dewatering.

Condition 5 – Trigger Mechanism

A drop in minimum static level at BH1A by 2.0 metres (to approximately 270 masl), and a corresponding drop of greater than 2.0 metres in static water level at proposed observation wells WD and/or WE, shall initiate contingency measures for water supply at domestic well W1 upon confirmation that W1 supply is inadequate. Similarly, a drop in minimum static water level at proposed monitoring well WF of 2.0 metres (to approximately 265 masl), and a corresponding drop in static level at proposed monitoring well WD and/or WE of greater than 2.0 metres, shall initiate contingency measures for water supply at domestic well W2 upon confirmation that W2 supply is inadequate.

(**Condition 5 Explanation:** The static water level at W1 is estimated to be between 271 and 272 masl, and at W2 it is 267 masl.

The above invokes contingency measures upon confirmation that a 2.0 metre decline in static water levels at observation wells corresponds with an adversely affected water supply at respective adjacent domestic wells. It is not known if a two metre drop in static levels would effect either wells W1 of W2 without obtaining further well information pertaining to pump settings.

4.0 Changes in Surrounding Land Use

Surrounding land use continues to be used as cattle range, and rural residential. There has been no significant change in surrounding land use or new wells within one kilometre of the site.

Limestone mining operations continue at the Preston Quarry which is now operated by LaFarge, and mining of limestone has begun at the Webster site as shown on Sketch SK-1.

5.0 Static Water Level and Stream Flow Measurements

5.1 Static Water Levels

Figure 5 found in Appendix "A" provides the present status of groundwater monitoring wells.

Static water level measurements recorded since 1993 are provided on Table B1 and shown graphically in Appendix "C".

The data confirms the following:

- higher elevations are groundwater recharge areas as demonstrated by downward hydraulic gradients; and that the Talbot River Tributary stream is both an area of groundwater recharge and discharge as demonstrated by seasonal reversals in hydraulic gradients between the upper and lower bedrock aquifers;
- bedrock aquifer groundwater levels can fluctuate seasonally between two and four metres depending on location; and,
- the shallow overburden aquifer can fluctuate in static level between two and three metres depending on location.

5.2 Stream Flow

The following is a summary of Talbot River Tributary stream flow measurements recorded:

Table 1
Stream Flow Measurements

Date	Upstream (Horncastle Rd)	Downstream (Shrike Rd)
May 18, 1993	Ponded	19 L/s
Oct. 13, 1994	7 L/s (±300 m D/S)	23 L/s
Sept. 6, 2001	Ponded	24.5 L/s

There is a net increase in stream baseflow through the site of approximately 16 L/s due to groundwater discharge.

6.0 Water Balance

The water balance is used to establish the amount of precipitation that is available for groundwater recharge or surface runoff.

It is used in this application to determine the impact on changes in drainage patterns due to the change in topography caused by aggregate extraction and dewatering during extraction.

The following expresses the water balance:

Net precipitation = evapotransporation loss + recharge loss + surface runoff loss + loss to soil storage

Net precipitation is the annual amount of rainfall plus snow water equivalent melt. The two closest Environment Canada Meteorological Stations for which records are available are in Peterborough and Orillia. Available Meteorological records are found in Appendix "D".

The mean annual precipitation using the average for Orillia and Peterborough is approximately 850 mm/yr. Monthly averages are presented on Table 2.

Table 2
Mean Monthly Precipitation

Month	Mean Precipitation (mm) Average Orillia & Peterborough	Mean Lake Evap (mm) Lindsay Frost
January	67	
February	50.6	
March	55.5	
April	68.5	
May	79.5	118.1
June	73.5	130.7
July	67.6	149.5
August	86.9	146.3
September	83.2	79.9
October	72.5	
November	75.2	
December	73.9	
Total	**849.9**	**624.5**

The mean annual evapotransporation (actual) for this geographic region is 530 mm/yr (see Appendix "D"). Evaporation losses replace evapotransporation losses over open water bodies.

An approximation for loss due to surface runoff can be made by multiplying the balance of net precipitation minus evapotransporation by a runoff coefficient (runoff coefficient values are provided and in Appendix "D"). The volume remaining would be available for groundwater recharge and soil storage. The net change (loss or gain) in soil storage is taken to be zero on an annual basis.

Considering that the upper layers of bedrock are fractured, there is a layer of vegetated silty loam overburden over most areas, and that topography is imperfectly draining, a runoff coefficient of 0.25 is selected. Using this assumption, the annual surface runoff rate would be approximately 80 mm/yr ((850 – 530) (0.25)). The balance of 240 mm/yr would be available for groundwater recharge.

Using October 13, 1994 stream flow data, the baseflow increase, or groundwater discharge, on the main branch Talbot River tributary between Horncastle Road and Shrike Road is approximately 16 L/s. The corresponding increase in drainage area is approximately 415 hectares. This translates to a flow contribution of 0.0386 L/s/ha or 1,215 m^3/yr/ha or 122 mm/yr.

The difference of 118 mm/yr is attributed to be that amount lost to groundwater recharge that is not discharged to Talbot River tributary baseflow.

Upstream of Horncastle Road the drainage area is approximately 223 hectares. If the October 1994 stream flow measured downstream of Horncastle Road of 7 L/s is used, the flow contribution from this portion of the drainage area is approximately 0.0314 L/s/ha.

The following summarizes the water budget parameters used in the assessment of quarry impacts on surface water flow

Total Precipitation = 850 mm/yr (local rate may vary)
Evapotransporation Losses = 530 mm/yr
Potential Lake Evaporation = 625 mm/yr
Surface Runoff = 80 mm/yr (0.025 L/s/ha)
Total Groundwater Recharge = 240 mm/yr (0.076 L/s/ha)
Net Groundwater Recharge = 118 mm/yr (0.037 L/s/ha)
Baseflow contribution upstream of Shrike Road = 0.039 L/s/ha
Baseflow contribution upstream of Horncastle Road = 0.031 L/s/ha (main tributary)

To assess dewatering discharge volumes, seepage rates into the excavation as determined by the 1995 groundwater model are used because of the variances observed with respect to depth of extraction (hydraulic head) and hydraulic conductivity of the bedrock. The 1995 model established quarry seepage rates ranging between 0.027 L/s/ha (Phase 1 first lift) and 0.033 L/s/ha (full depth) for the North Part of the proposed quarry, to between 0.14 L/s/ha and 0.17 L/s/ha (full depth) in the South Part.

7.0 Dewatering Discharge

7.1 Description

Figure SK-1 and 3, found in Appendix "A", shows existing drainage patterns, and Figure 4 shows the potentiometric surface for upper and lower bedrock aquifers found locally. Figures 2 and 5 show proposed dewatering discharge locations, and aquifer hydraulic conductivities and all known well locations, respectively.

Dewatering of groundwater seepage and precipitation falling within the excavation will occur by draining the floor of the quarry towards sumps excavated 3.0 metres deep. Table 8 in the 1995 Hydrotechnical Report provided estimated dewatering requirements at maximum excavation for each sump just prior to letting the quarry fill with water. Maximum pumping rates were established to accommodate November and April mean monthly precipitation amounts of 75 mm, and 25 mm of precipitation occurring in one event. The size of each sump, as proposed, is based on providing 25 mm of runoff volume storage for a minimum period of 24 hours.

Upon completion of extraction the North Part of the quarry will flood to approximately 264.5 masl prior to dewatering in the South Part. Upon completion of the South Part it will flood to approximately 264.0 masl resulting in the creation of two small lakes.

Sump A
Sump A drains Phase 1 of the North Part. It will discharge to a ditch constructed to divert surface runoff flowing overland from east to west via the north tributary branch south to the main tributary branch (or south branch) at Horncastle Road as shown on Figure 2 and the Operational Plan (a reduction of this plan is provided in Appendix "A"). This will result in an increase in Talbot River tributary main branch baseflow between Horncastle Road and the existing confluence with the main and north tributary branches by approximately 5 L/s due to the diversion of 122 hectares of drainage area originating east of Horncastle Road (122 hectares at 0.039 L/s/ha), plus dewatering discharge from Phase 1. This diversion will be blocked or become dry upon flooding of the excavated North Part. Should the balance of the North Part phases/lifts not proceed, then this diversion would be left in place.

The catchment area for Sump A varies throughout the life of the quarry. The maximum catchment area occurs prior to commencement of Phase 2 of the North Part, when it has a catchment area of approximately 60 hectares. During the implementation of Phase 2 the slope of the quarry floor within the southwest portion

of Phase 1 is to be lowered. This results in a reduction in area draining to Sump A by approximately 16 hectares to 44 hectares in area.

Sump B
Sump B is located in the southwest corner of Phase 2 of the North Part. It will discharge to the north branch of the Talbot River tributary at the location immediately upstream of the existing springs. Sump B will drain Phases 2 and 3, and part of Phase 1. It will have a maximum catchment area of approximately 108 hectares that includes 103 hectares at full extraction and 5 hectares located off-site on other lands owned by Ferma. Upon completion of extraction, the subsequent 147 hectare lake that is formed will discharge at this location.

As a result of developing Phase 3 of the North Part, there will be a net drainage area increase to the Talbot River tributary stream of 27 hectares and a corresponding decrease in watershed area of a tributary of Canal Lake that is broken down as follows:

1) The diversion of approximately 10 hectares that now drains to the wetland northeast of the site which is the headwaters of the Canal Lake tributary stream; and,

2) The diversion of approximately 17 hectares that now drains to the west towards the Canal Lake tributary stream.

The recent purchase of the 42.5 hectare parcel of land consisting of the E½ of Lot 10, Concession 9 by Ferma would now allow the drainage from the five hectares that is off-site and located within the southwest corner of the 42.5 hectare parcel to be blocked by the perimeter berm used for site screening. Preventing this segment of land from draining into the excavation will reduce pumping costs. Further, according to the 1:5,000 topographic mapping, overflow from the 5 hectares will occur towards the wetland to the northeast once a maximum flooding depth of 200 mm is reached. This would partially compensate for the 10 hectare loss in drainage area described by Item #1 above and reduce the area contributing to Sump B to 103 hectares. The depth of ponding may be reduced by adjusting the natural grade of the land.

Sump C
Sump C is located in Phase 4 of the South Part and will discharge where the existing wooded swamp crosses Horncastle Road outletting to the wetland lying on the east side of the road. The existing catchment area is approximately 25 ha. Sump C will capture approximately 26 hectares of quarry floor. Should Phase 5 not proceed, then the Sump C discharge location will form the permanent outlet for the lake that will form after dewatering is ceased.

Sump D
Sump D is located in Phase 5 of the South Part and will outlet to the main tributary branch of the Talbot River. The maximum drainage area of Sump D will be approximately 32 hectares. Upon completion of extraction, the subsequent 58 hectare lake that is formed will discharge at this location.

As a result of developing Phases 4 and 5 of the South Part there will be a net drainage area increase to the main branch of the Talbot River tributary by approximately 22 hectares due to:

1) the draining of 8 hectares that does not have an existing drainage outlet, but which lies in the tributary watershed;
2) the diversion of 7 hectares that drains off-site to the south towards the tributary downstream of the site; and,
3) the diversion of 6.5 hectares that drains to the southeast towards Talbot River proper.

7.2 Dewatering Design Considerations

To reduce noise and dust emissions, the processing equipment will be located on the floor of the excavation, therefore, dewatering will occur 365 days of the year.

Precipitation constitutes the majority of water to be pumped from the quarry excavation. Monthly mean average amounts are provided on Table 2.

There are no infiltration or evapotransporation losses to be considered within the extracted area because of hydraulic head differentials and a lack of vegetation. There will be some minor evaporation losses from the proposed sumps and that detained after a rainfall or snowmelt.

The extremes in terms of dewatering rates occur in frozen conditions where only groundwater seepage would be discharged, in November when monthly precipitation is highest and evaporation is at a minimum, and in July when annual evaporation is at its peak. It is assumed for design purposed that groundwater seepage does not fluctuate significantly throughout the year. It is noted that once the quarry surface perimeter has been opened, there is no increase in surface runoff accumulation with increased extraction depth, only groundwater seepage increases in rate with depth.

The existing quarry proposal provides sumps large enough to store the first 25 mm of surface runoff from the quarry floor for a minimum period of 24 hours. However, it may be desirable to discharge over a longer period such as 72 hours. Drainage volumes in excess of the sump capacities per the Site Plans would be allowed to flood

the quarry floor. The longer detention period would allow for: more suspended solids to settle out and ultimately cleaner discharge; reduced peak pumping rates and pump costs; and, reduced impacts on downstream morphology.

Each sump should be equipped with a double pumping system. A low flow pump with the intake set within a sump within the larger sump would insure a constant minimum discharge is maintained. A larger pump should be dedicated to discharge the 25 mm or greater runoff event. It would be commissioned when there is an increase in sump water level of 500 mm above the rim elevation, or other prescribed elevation depending on storage requirements. The heavy-duty pump would shut off when water recedes to 300 mm below the rim of the sump. The area of quarry floor flooded would depend on the volume of water that needed to be handled. A large portable pump would be required for use in an emergency.

The receiving stream is warm water fish habitat (Niblett Environmental, 1995). Most of the discharge occurring will be from surface water accumulation. The detention period may cause discharge temperatures to increases, or cool, depending on weather conditions. Positioning the low flow pump intake within a sub-sump and high flow pump intake near the base of the main sump, and prolonging discharge (ie. 72 hours instead of 24), would help to reduce the shock of discharge temperature differentials.

7.3 Discharge Rates

The following are estimated discharge rates during various stages of quarry development.

Sump A – Phase 1 North Part
The 1995 Hydrotechnical Report provided the estimated discharge rates for Sump A and B, at that point in time when the North Part is at full development. At full development ±16 hectares of the quarry floor within Phase 1 is lowered and directed to Sump B. However, the maximum catchment area for Sump A will be approximately 60 hectares just prior to the commencement of Phase 2.

Previous groundwater modelling exercises estimated that the seepage rate for Phase 1 to elevation 255 masl (first lift per PTTW) would be 100 L/min (0.027 L/s/ha), and 120 L/min (0.033 L/s/ha) at full depth of ±232 masl.

There is approximately 15 million tonnes of limestone to be mined within the first lift of Phase 1. At an average extraction rate of 750,000 tonnes/yr it will take approximately 20 years to open up Phase 1 progressing at a rate of approximately three hectares per year average. Once the first lift is removed, the annual increase in dewatering discharge will be minimal.

Table 3 summarizes the dewatering requirements for Phase 1.

Table 3
Phase 1 Dewatering Schedule

Condition	Years Open				
	Lift 1				Lift 2
	5	10	15	20	40
Area Opened (ha)	15	30	45	60	60
Max. Depth (masl)	255	255	255	255	235-232
Groundwater Seepage (m^3/d)	35	70	105	144	174
Minimum Pumping Rate (L/s)	**0.4**	**0.8**	**1.2**	**1.7**	**2.0**
(Igpm)	5	11	16	22	26
Dry Season Pumping Rates					
July Precip – Ave. Day (m^3/d)	327	654	981	1,330	1,330
July Evap. – Ave. Day assuming 65 x 60 m sump (m^3/d)	19	19	19	19	19
July Ave. Daily Discharge (m^3/d)	340	705	1,070	1,435	1,465
Average Day Pumping Rate - Dry Season (L/s)	**4**	**8**	**12**	**17**	**17**
(Igpm)	50	110	160	220	220
Wet Season Pumping Rates					
November Precip. Ave. Day (m^3/d)	376	752	1,128	1,504	1,504
November Ave. Daily Discharge (m^3/d)	430	860	1,290	1,650	1,680
Average Day Pumping Rate - Wet Season (L/s)	**5**	**10**	**15**	**19**	**19**
(Igpm)	65	130	200	250	260
Peak Pumping Rates					
25 mm Rain Volume (m^3)	3,750	7,500	11,250	15,000	15,000
24 hr Detention Pump Rate (L/s)	**43**	**87**	**130**	**174**	**174**
(Igpm)	570	1,145	1,720	2,290	2,290
72 hr Detention Pump Rate (L/s)	**14.5**	**29**	**43**	**58**	**58**
(Igpm)	190	380	570	760	760
Area Flooded (1) (ha)	1.6	2.3	3.0	4.0	4.0
Maximum Depth Above Sump Rim (m)	0.5	0.6	0.7	0.8	0.8

(1) Assumes semi circular flooding from sump and quarry floor at 0.5% slope to sump

The Permit to Take Water limitation for the first lift of Phase 1 is 120 L/min or 172,000 L/d and applies to groundwater dewatering and not precipitation amounts.

Sump B – Phases 2 and 3 North Part

Subsequent to obtaining the necessary approvals, the lower lift to Phase 1 and upper/lower lifts of Phases 2 and 3 will advance. The rate of pumping at Sump A will not be reduced until the active lift of Phase 2 is equal with that completed within Phase 1.

The following dewatering schedule is based on the removal of the first lift 10 to 15 metres of Phases 2 and 3 to an average elevation 255 masl at a rate of 750,000 tonnes/yr or 3 ha/yr average followed by removal of the second lift. The depth of lifts deviates from the Site Plans, but follow the precedence set by the PTTW for Phase 1.

Table 4
Phases 2 and 3 Dewatering Schedule

	Phases 2 and 3				
	Lift 1				Lift 2
Years Open	**5**	**10 (+ 16 ha from Phase 1)**	**20 (1st Lift Phase 2)**	**30 (1st Lift Phase 3)**	**70-75 (2nd Lift)**
Sump B					
Area Opened – Phases 2 & 3 (ha)	15	30	60	87	87
Depth (masl)	255	255	255	255	238-232
Phase 1 Area Diverted to Sump B (ha)		16	16	16	16
Total Catchment	15	46	76	103	103
Groundwater Seepage (m^3/d)	35	110	180	240	330
Minimum Pumping Rate (L/s)	**0.4**	**1.3**	**2.0**	**2.8**	**3.8**
(Igpm)	5	17	26	37	50
Dry Season Pumping Rate					
July Percip. – Ave. Day (m^3/d)	327	1003	1657	2246	2246
July Evap. – Ave. Day for 100 x 90 m sump (m^3/d)	43	43	43	43	43
July Ave. Daily Discharge (m^3/d)	320	1,070	1,790	2,440	2,530
Ave. Day Pumping Rate - Dry Season (L/s)	**4**	**12**	**21**	**28**	**29**
(Igpm)	50	160	270	370	390
Wet Season Pumping Rates					
November Precip. – Ave. Day (m^3/d)	376	1153	1905	2582	2582
November Ave. Daily Discharge (m^3/d)	410	1,260	2,085	2,820	2,910
Ave. Day Pumping Rate - Wet Season (L/s)	**5**	**15**	**24**	**33**	**33**
(Igpm)	60	190	320	430	450
Peak Pumping Rate					
25 mm Rain Vol. (m^3)	3,750	11,500	19,000	25,750	25,750
24 hr Detention (L/s)	43	133	220	298	298
(Igpm)	572	1,755	2,900	3,930	3,930
72 hr Detention (L/s)	**14.5**	**44**	**73**	**99**	**99**
(Igpm)	191	585	970	1,310	1,310
Area flooded [1], (ha)	1.5	3.0	4.5	5.1	5.1
Maximum Depth Above Sump Rim (m)	0.5	0.7	0.85	0.9	0.9
Sump A					
Open Area (ha)	60	44			44
Groundwater Seepage (m^3/d)	144	103			128
Minimum Pumping Rate (L/s)	**1.7**	**1.2**			**1.5**
July Ave. Daily Discharge (m^3/d)	1,455	940			1,085
Ave. Day Pumping Rate – Dry Season (L/s)	**17**	**11**			**13**
(Igpm)	220	144			166
November Ave. Daily Discharge (m^3/d)	1,650	1,103			1,230
Ave. Day Pumping Rate – Wet Season (L/s)	**19**	**13**			**14**
(Igpm)	250	168			187
Peak Pumping Rate					
25 mm Rain Vol. (m^3)	15,000	11,000			11,000
24 hr Detention (L/s)	174	127			127
(Igpm)	2,290	1,680			1,680
72 hr Detention (L/s)	**58**	**42**			**42**
(Igpm)	760	560			560

The combined predicted pumping rates for the North Part of the quarry proposal are summarized below.

Table 5
Summary of Dewatering Schedule – North Part

	Phase 1					Phase 2 & 3				
	Lift 1				Lift 2	Lift 1				Lift 2
Years Open	**5**	**10**	**15**	**20**	**40**	**45**	**50**	**60**	**70**	**110-115**
Minimum Pumping Rate (frozen conditions or drought)										
Sump A (L/s)	0.4	0.8	1.2	1.7	2.0	2.0	1.5	1.5	1.5	1.5
Sump B (L/s)						0.4	1.3	2.1	2.8	3.8
Total (L/s)	**0.4**	**0.8**	**1.2**	**1.7**	**2.0**	**2.4**	**2.8**	**3.6**	**4.3**	**5.3**
Dry Season Pumping Rate (average day)										
Sump A (L/s)	4	8	12	17	17	17	11	11	11	11
Sump B (L/s)						4	12	21	28	29
Total (L/s)	**4**	**8**	**12**	**17**	**17**	**21**	**23**	**32**	**39**	**40**
Wet Season Pumping Rate (average day)										
Sump A (L/s)	5	10	15	19	20	20	13	13	13	13
Sump B (L/s)						5	15	24	33	33
Total (L/s)	**5**	**10**	**15**	**19**	**20**	**25**	**28**	**37**	**46**	**46**
Peak Pumping Rates – 25 mm Runoff Event										
24 hr Detention										
Sump A (L/s)	43	87	130	174	174	174	127	127	127	127
Sump B (L/s)						43	133	220	298	298
Total (L/s)	**43**	**87**	**130**	**174**	**174**	**217**	**360**	**347**	**555**	**555**
72 Hour Detention										
Sump A (L/s)	14.5	29	43	58	58	59	42	42	42	42
Sump B (L/s)						14.5	44	73	99	99
Total (L/s)	**14.5**	**29**	**43**	**58**	**58**	**72.5**	**86**	**115**	**141**	**141**

Sumps C and D – South Part

If it can be assumed that the South Part of the quarry proposal will advance in the same manner as the North Part (ie. a 10 to 15 metre initial lift followed by a 20 metre second lift), then the predicted dewatering schedule would be as shown on Table 6:

Table 6
Phases 4 and 5 – South Part
Dewatering Schedule

	Phase 4 – Sump C			Phase 5 – Sump D		
	Lift 1		Lift 2	Lift 1		Lift 2
Years Open	**5**	**10**	**25**	**5**	**10**	**25**
Phase 4 – Sump C						
Area Open (ha)	15	26	26	15	32	32
Maximum Depth (masl)	255	255	232-235	225	255	232-235
Groundwater Seepage (m^3/d)	35(1)	60(1)	390	35(1)	75(1)	475
Minimum Pumping Rate (L/s)	**0.4(1)**	**0.7(1)**	**4.5**	**0.4(1)**	**0.9(1)**	**5.5**
(Igpm)			59			73
Dry Season						
July Precip. - Ave. Day (m^3/d)	327	566	566	327	698	698
July Evap. - Ave. Day						
(Sump C = 50 x 45 m)	11	11	11			
(Sump D = 60 x 45 m)				13	13	13
July Ave. Daily Discharge (m^3/d)	350	615	945	350	745	1,160
Ave. Day Pumping Rate - Dry Season (L/s)	**4**	**7**	**11**	**4**	**9**	**13**
(Igpm)	50	90	140	50	110	180
Wet Season						
November Precip. Ave Day (m^3/d)	376	652	652	376	802	802
November Ave. Daily Discharge (m^3/d)	410	710	1,040	410	860	1,280
Ave. Day Pumping Rate - Wet Season (L/s)	**5**	**8**	**12**	**5**	**10**	**15**
(Igpm)	60	110	160	60	130	195
Peak Pumping Rate						
25 mm Rain Vol.	3,750	6,500	6,500	3,750	8,000	8,000
24 hr Detention (L/s)	**43**	**75**	**75**	**43**	**93**	**93**
(Igpm)	570	990	990	530	1,220	1,220
72 hr Detention (L/s)	**14.5**	**25**	**25**	**14.5**	**31**	**31**
(Igpm)	190	330	330	190	410	410
Area Flooded(2) Ave. (ha)	1.5	2.3	2.3	1.5	2.6	2.6
Maximum Depth Above Sump rim (m)	0.5	0.6	0.6	0.5	0.65	0.65

(1) Not modelled for South Part – North Part values assumed, use full extraction values for measuring impact.

(2) Assumes semi circular flooding from sump and quarry floor at 0.5% slope to sump.

Table 7
Summary – Dewatering Schedule – South Part

	Phase 4			Phase 5		
	Lift 1		Lift 2	Lift 1		Lift 2
Years Open	**5**	**10**	**25**	**5**	**10**	**25**
Minimum Pumping Rate (frozen or drought conditions)						
Sump C (L/s)	0.4(1)	0.7(1)	4.5	4.5	4.5	4.5
Sump D (L/s)				0.4(1)	0.9(1)	5.5
Total (L/s)	**0.4**	**0.7**	**4.5**	**4.9**	**5.4**	**10.0**
Dry Season Pumping Rate (average day)						
Sump C (L/s)	4	7	11	11	11	11
Sump D (L/s)				4	9	13
Total (L/s)	**4**	**7**	**11**	**15**	**20**	**24**
Wet Season Pumping Rate (average day)						
Sump C (L/s)	5	8	12	12	12	12
Sump D (L/s)				5	10	15
Total (L/s)	**5**	**8**	**12**	**17**	**22**	**27**
Peak Pumping Rates – 25 mm Runoff Event						
24 hr Detention						
Sump C (L/s)	43	75	75	75	75	75
Sump D (L/s)				43	93	93
Total (L/s)	**43**	**75**	**75**	**118**	**168**	**168**
72 Hour Detention						
Sump C (L/s)	14.5	25	25	25	25	25
Sump D (L/s)				14.5	31	31
Total (L/s)	**14.5**	**25**	**25**	**39.5**	**56**	**56**

(1) Not modelled for South Part – North Part values assumed and are likely underestimated.

7.4 Dewatering Impacts on Stream Flow

7.4.1 Talbot River Tributary

Table 8 summarizes the impact of dewatering on Talbot River tributary stream flow:

Table 8
Dewatering Impacts on Stream Flow
Talbot River Tributary – Main Branch

		Upstream	Downstream		
		Horncastle Rd	Shrike Rd.		
			With Outlet	No Outlet	Total
Existing Conditions					
Area (ha)		223	621	17	638
Dry Season Flow (L/s)		7			23
2 hr – 25 mm rainfall Peak Flow[1] (m^3/s)		1.95			5.4
Phase 1					
Open Quarry (ha)		60			60
Table Lands (ha)		345	561	17	578
Total Upstream Area (ha)		405			638
Dry Season Flow (average day)	Quarry (L/s)	17			17
	Table Lands (L/s)	12			23 - (0.039)(60) = 21
	Total (L/s)	29			38
2 hr – 25 mm Rainfall Peak Flow	Quarry (m^3/s) 72 hr Detention	0.058			0.058
	Table Lands[1] (m^3/s)	3.0			4.9
	Total (m^3/s)	3.1			5.0
Phases 2 & 3					
Open Quarry (ha)		44			147[2]
Table Lands (ha)		345	496	22	518
Total Upstream Area (ha)		389			665
Dry Season Flow (average day)	Quarry (L/s)	13			29
	Table Lands (L/s)	12			23 - (0.039)(120)=18.3
	Total (L/s)	25			47.3
2 hr – 25 mm Rainfall Peak Flow	Quarry (m^3/s) 72 hr Detention	0.042			0.099
	Table Lands[1] (m^3/s)	3.02			4.34
	Total (m^3/s)	3.06			4.44
Phases 4 & 5					
Open Quarry (ha)		26			58[3]
Lake Lands (ha)					147
Table Lands (ha)		198	460	14	474
Total Upstream Area (ha)		224			679
Dry Season Flow (average day)	Quarry (L/s)	11			24
	Table Lands (L/s)	7-(0.031 L/s/ha)(25) = 6			23 - (0.039)(26) - (0.031)(25)=21
	Total (L/s)	17			45
2 hr – 25 mm Rainfall Peak Flow	Quarry (m^3/s) 72 hrs Detention	0.025			0.056
	Table Lands[1] (m^3/s)	1.73			4.02
	Lake				0.0
	Total (m^3/s)	1.8			4.1

(1) Peak flow = 0.0028 CIA, where: C= 0.25 (runoff coef); I= 22 mm/2 hr (rainfall intensity); A= table land area (ha)
(2) 27 ha from Canal Lake tributary watershed added
(3) 14 ha from Talbot River watershed added

The two hour 25 mm rainfall was used in Table 8 to determine the impacts of changes in drainage area and quarry surface water runoff storage on flows in the tributary stream. The rational method was selected because of its simplicity. This method establishes peak flow using the runoff coefficient, rainfall intensity and drainage area. A runoff coefficient of 0.25 was selected. The results provided a relative comparison of impact on surface drainage. (More detailed hydraulic modelling would be required for the design of water flow control structures.)

Table 9
Impact Summary of Dewatering
on Talbot River Tributary Flow

	Stream Flow			
	Existing Cond.	**Phase 1**	**Phases 2 & 3**	**Phases 4 & 5**
Dry Season Flow (L/s) – average day flows				
Horncastle Rd.	7	29	25	17
Shrike Rd.	23	38	47	45
2 hr - 25 mm Rainfall Flow (m^3/s) – typical storm				
Horncastle Rd.	2.0	3.1	3.1	1.8
Shrike Rd.	5.4	5.0	4.4	4.1

Impact on Stream Flow at Horncastle Road
Table 9 shows that there will be two to four times the existing dry season, and similarly wet season, average day stream flow just downstream of Horncastle Road depending on the stage of quarry development. For regular rainfall events, peak stream flow will be one-half times existing when the North Part is developed and lower than existing when the South Part is developed. This increase is primarily due to the diversion of 122 hectares of drainage area from the north tributary branch to the main (south) branch at Horncastle Road.

Impact on Stream Flow at Shrike Road
The diversion ditch will discharge to the wetland at Horncastle Road resulting in an increase in water level which may be mitigated by discharging the diversion ditch downstream of the wetland outlet ±300 metres west of Horncastle Road.

The average day flow at Shrike Road will double over the long term while dewatering is occurring. The existing twin 2.2 x 1.35 metre CSPA culverts at Shrike Road would easily be able to handle the anticipated increases in flow.

Peak stream flows in response to regular rainfall or snowmelt events will be maintained or decreased. For significant runoff events, peak flows will decrease. The decrease in peak flows is a result of the increase in storage and detention period provided within the excavations.

Impact at Closure
When mining is terminated, the excavations are ultimately to be rehabilitated by allowing them to fill with water.

Pre-quarry development and post-quarry development hydrologic characteristics will change due to the increased amount of surface water runoff storage provided by the created lakes, and the replacement of evapotransporation losses by evaporation losses over those lands covered by water. Because evaporation losses are less than evapotransporation losses the net impact is beneficial in terms of stream baseflow augmentation/maintenance.

When comparing active quarry development to post-development, the increase experienced in dry season flow, and decrease in peak flows, will be moderated.

Impact on Stream Geomorphic Characteristics
The Environmental Impact Assessment (Niblett, 1995) provided a reach by reach assessment of stream conditions, which are summarized in the following Table 10. Surveys for each reach are found in Appendix "E".

Table 10
Talbot River Tributary Characteristics

Reach	Characteristics
1. Downstream of Shrike Rd. to McNamee Rd.	- open pasture lands - flow – 1.5 m wide by 0.1 m deep – sand substrate with gravel and muck - flat gradient with two riffles and one pool, active erosion occurring due to cattle access - low to moderately stable banks
2. Shrike Rd. to ±250 m upstream	- open pasture/meadow lands - flow 1.0 m wide by 0.1 m deep - flat gradient - sand substrate with gravel - active erosion occurring due to cattle access - low to moderately stable banks
3. ±250 m upstream of Shrike Rd. to confluence of north branch	- grass meadow - flow – 0.75 m wide by 0.25 m deep - flat gradient - sand substrate with gravel and silt - cattle access - moderate to high bank stability - some undercutting of banks from confluence with north branch
4. From confluence with north branch ±400 metres upstream	- mud flats/old beaver pond - flow – 1.0 m wide by 0.1 m deep - flat gradient - sand and muck substrate - moderately stable banks - sections of stream overgrown with coontail
5. ±400 m upstream of confluence to ±500 m downstream of Horncastle Rd.	- beaver pond complex - ponds flood fields - ponded water 10 m wide by 0.25 m deep - muck substrate - high bank stability
6. ±500 m downstream of Hornscastle Rd. to ±300 m downstream	- water flow on bedrock - flow – 0.5 m wide by 0.1 m deep - moderate gradient - bank stability provided by bedrock - cattle access
7. Horncastle Rd. to ±300 m downstream	- no defined channel - sand and muck substrate
8. Upstream of Horncastle Rd.	- large beaver pond - muck substrate

The anticipated adjustments in stream flow within Reaches 1, 2 and 3 will occur over decades. For example, during Phase 1, or periods of first lift excavation, the rate of increase in dry season average day flow will be approximately 0.8 L/s per year for the first twenty years and will not resume increasing in significant amounts until the first lift of subsequent phases are initiated. The slow rate of increase in average day flow will permit the active portion of the channel to adjust gradually in response, minimizing potential impacts on stream morphology.

Further, since cattle are already causing stream bank instability and are impacting sediment loadings within Reaches 1 and 2, the existing condition will not be made worse than it is already.

The highest magnitude of increase in Talbot River tributary stream flow will occur upstream of the tributary confluence and downstream of Horncastle Road due to the diversion of the north branch tributary to the main branch. The segments of stream exposed to the anticipated increase include Reaches 4, 5, 6, and possibly 7.

Reach 7 will not be impacted provided the Phase 1 diversion is discharged downstream to Reach 6.

Reach 6 flows on bedrock, therefore, erosion will be minimal.

Reach 5 consists of several beaver ponds which reduce erosion and sediment load potentials due to low stream channel velocities.

Similarly, the mud flats of Reach 6 have low flow velocity and therefore low erosion and sediment load potential.

7.0 Impact on Livestock Watering and Adjacent Surface Water Supplies

It is evident from the Permit to Take Water that it applies to water supply in general, whether it be for human consumption, livestock watering or riparian use.

Figure 3 identifies those sources used for watering cattle and the potential number of cattle grazed obtained from interviews with local farmers.

Table 11 summarizes an assessment of potential impact on livestock watering sources for surrounding properties.

Table 11
Summary of Potential Impacts of Dewatering on Livestock Water Supply

Location	Approximate Number of Cattle	Water Source	Potential for Impact (Contingency)
Conc. 8 Lot 6/7 (M.V. McNamee)	20	Dug well and Talbot River Tributary	None due to maintenance of stream flow through dewatering discharge.
Conc. 8 Lot 8/9 (M. McNamee)	70	Spring and well on west side of Concession 8	None due to water source distance from excavation.
Conc. 8 Lot 9/10 (C. Wylie)	85-95	Dugout and well	Low due to low hydraulic conductivity of bedrock between Phase 2/3 of N.Part and source. 17 ha of tributary drainage area removed during Phase 3 or potentially approx. 34,340 m^3/yr* or 1.1 L/s (14.4 Igpm) loss to surface runoff/baseflow. (Divert dewatering of Part of Phase 3 to dugout.)
Conc. 9 Lot 5 (various)	15-20 (potential)	Unknown	Low due to distance, poor pasture land and no existing source of water.
Conc. 9 Lots 6 to 10 (Ferma grazed by C. Wylie)	100	Talbot River Tributary	Low due to maintenance of stream flow through dewatering discharge.
Conc. 9 Lot 11	Unknown	Surface water to north of site	Low due to intervening low hydraulic conductivity of bedrock between Phase 1/2/3 of N. Part and surface water source. 10 ha of drainage area removed during Phase 3 or approximately 29,800 m^3/yr* or 0.6 L/s (8 Igpm) loss to surface flow/baseflow. (Divert portion of dewatering of Phase 3 to road side ditch and 5 ha from E ½ Lot 10 Conc. 9 to wetland to compensate.)
Conc. 10 Lots 6 to 10 (Fitzgerald)	130	Ponds, wind pump, and well on Victoria Rd	Low, due to low intervening hydraulic conductivity of bedrock, distance and dewatering discharge locations on east boundary will maintain presence of surface water sources.

*Based on an annual surface water contribution of 80 mm/yr and groundwater discharge of 122 mm/yr, or 202 mm/yr total which is equivalent to 2,020 m^3/yr/ha or 0.06 L/s/ha (see Section 6.0).

Hydraulic modelling completed in 1995 indicated that groundwater table drawdown resulting from quarry dewatering would not decrease flow in the Talbot River tributary or adjacent wetlands.

The discharge of water accumulated in the excavation from groundwater seepage and precipitation will increase surface water flow along the east boundary of the site and within the tributary stream of Talbot River. This will maintain surface water sources at livestock watering at these locations.

The wetland to the northeast of the site will lose 10 hectares of watershed when Phase 3 of the North Part is developed. Similarly, there is a 17 hectare area draining towards the west and the dugout north of the C. Wylie farmhouse and Canal Lake that would be diverted to the Talbot River tributary and the Talbot River which also flows to Canal Lake. The impact of drainage area loss to both these receiving water bodies is not felt to be significant. However, if necessary, it remains possible to proportion dewatering discharge on a predevelopment drainage area basis when Phase 3 of the North Part is to be extracted. Similar contingency measures may be employed when the South Part of the quarry proposal is developed.

8.0 Conclusions and Recommendations

Permit to Take Water
A Permit to Take Water in the amount of 120 L/min, or 172,000 L/d, dated May 15, 1998, has been granted to Ferma Crushed Stone Inc. (now Ferma Aggregates Inc.) by the Ministry of Environment. The Permit applies to the taking and pumping of groundwater from Sump A within the first lift of Phase 1 of the proposed quarry (E½ of Lots 8 and 9, Concession 9, Carden Township). The permit expires on May 15, 2008.

As a result of the granting of the PTTW, there are several relevant Conditions that are to be placed on the Site Plans. These Conditions relate to: the provision of potable water for domestic and livestock supply should existing sources be impacted by dewatering activities; the establishment of a groundwater monitoring network; the limits of extraction; annual reporting requirements; contingency measures; and, triggering mechanisms.

Surrounding Land Use
There has been no significant change in nearby surrounding land use since the 1995 Hydrotechnical Report was prepared.

Static Water Levels
Annual groundwater monitoring since 1994 shows that static water levels in the bedrock aquifers fluctuate between two and four metres depending on location.

Static water levels in the shallow overburden aquifer fluctuate between two and three metres depending on location.

Talbot River Tributary Stream Flow
Measurements of stream flow within the Talbot River tributary just upstream of Shrike Road range between 19 and 25 L/s.

Stream flow within the same tributary at Horncastle Road was not measurable regularly due to ponded conditions. One measurement of 7 L/s was taken ±300 metres further downstream of Horncastle Road. The corresponding flow at Shrike Road on the same day was 23 L/s. It was reported that no significant precipitation had fallen during the previous five days.

These flow rates were used as a baseline for predicting the impact of quarry dewatering and drainage area diversions on stream flow.

Dewatering Design Considerations
A double pumping system should be employed at each sump. A low rate pumping system would provide discharge for groundwater seepage and minor rainfall/snowmelt events. A high rate pumping system would provide discharge for more significant rainfall/snowmelt events and ensure that 72 hours of detention is provided for 25 mm of runoff. This detention period exceeds MOE guidelines for urban and industrial subdivision drainage water quality criteria.

The low rate pump intake should be located in a sub-sump to draw cooler water from the bottom of the dewatering sump.

Since there is no coldwater fishery, the impact of warming/cooling precipitation detained on the quarry floor is not as critical.

A large portable pump will be needed in the case of emergencies.

Dewatering
Minimum pumping rates for Phase 1 are predicted to be between 0.4 L/s (5 Igpm) after five years of operation to 2.0 L/s (26 Igpm) at full excavation. These rates would be expected to occur during frozen ground and prolonged dry weather conditions. Typical dry/wet season pumping rates will range from 4 L/s (50 Igpm)/5 L/s (65 Igpm) after five years operation to 17 L/s (220 Igpm)/19 L/s (260 Igpm) at full excavation.

Pumping rates following a 25 mm runoff occurrence are predicted to range from 14.5 L/s (190 Igpm) to 58 L/s (760 Igpm) for a 72 hour detention period. Pumping rates for 24 hour detention are proportionately higher. Providing the space is available, pumping costs and discharge shock impacts downstream would be reduced, while discharge water quality would increase if a 72 hour detention period is adopted. Water in excess of sump capacity would be permitted to flood the quarry floor in the vicinity of the sumps.

Impact on Stream Flow
The greatest impact on tributary stream flow will occur within the main (south) branch of the Talbot River tributary between the confluence with the north branch and the wetland at Horncastle Road. Throughout the life of the quarry this section of stream will experience a predicted increase in average day flow ranging from four times the existing normal flow rate peaking at the completion of Phase 1, then dropping to just over two times the existing flow rate just prior to completion of South Part Phases 4 and 5.

To minimize the increase in flow on the south tributary stream wetland at Horncastle Road, the outlet for the diversion ditch should be located below the outlet of the wetland which is approximately 300 metres downstream of Horncastle Road. If an increase in wetland water levels are not a concern, then this would be unncessary.

At Shrike Road the normal average day flow in the tributary stream is predicted to be approximately 1.5 times existing at completion of Phase 1, 2.0 times existing just prior to completion of Phases 2 and 3, and 2.0 times existing just prior to completion of Phases 4 and 5. Upon the quarry extractions filling with water at closure, stream flow will be augmented slightly over existing conditions.

There will be an increase in peak stream flow by approximately 1 m^3/s during a 25 mm storm within that section of stream between Horncastle Road and the confluence of the tributary branches due to the diversion of the north tributary to the main branch at Horncastle Road. There will be a decrease in peak flow discharging off-site at Shrike Road. Overall, the quarry excavation and subsequent lakes will have a benefit in terms of increasing the amount of surface water runoff storage that is available, thereby reducing peak flows within the tributary stream.

The magnitude of the decrease in peak flow and increase in normal flows are not expected to have a detrimental impact on Talbot River flow.

There will be a 27 hectare total catchment area loss to the tributary stream of Canal Lake that flows from northeast to southwest located approximately 750 metres northwest of the site. The wetland located to the northeast of the site is part of this tributary. This loss will occur during Phase 3 of the quarry development. In terms of water balance, the diversion of 10 hectares translates to approximately 0.6 L/s (8 Igpm) loss in flow to the wetland; and the diversion of 17 hectares translates to a 1.1 L/s (14.5 Igpm) loss in flow towards the west at the extreme northwest corner of the site.

The recent purchase of 42.5 hectares located on the E½ of Lot 10, Concession 9, by Ferma would allow approximately 5 hectares of Talbot River tributary watershed to be blocked and diverted to the Canal Lake tributary/wetland lying northeast of the site to partially compensate for the 10 hectare loss during Phase 3.

Impact on Stream Geomorphology
The increase in average day stream flow and reduced peak flows are not expected to impact channel erosion or sediment loads for the following reasons:

- The increase in flow rate is very gradual until the first lift of any phase is established then the increase is minimal (ie 0.8 L/s/yr over 20 years for Phase 1).

- Those stream reaches experiencing the greatest impact in increase in flow are the most tolerant sections to erosion due to bedrock stratigraphy and beaver activity which slows channel velocities.

- Those stream reaches that are most susceptible to erosion are already impacted and are already in unstable condition due to cattle activity. The anticipated increase in average day flows would not cause a condition that is worse than existing.

- The magnitude of increase on stream flow will not exceed the active channel flow regime and therefore will not significantly impact stream morphology.

Reduced peak stream flows resulting from the detention of 25 mm of rainfall or snowmelt for 72 hours will reduce the potential for stream bank erosion for those events that approach bank full condition (ie. 1:1.5 to 1:2 year flow).

Livestock Water Supplies

The above loss of 17 hectares of Canal Lake tributary watershed draining towards the west and the C. Wylie farm from Phase 3 of the quarry excavation could possibly impact the livestock water supply at the dugout on the west side of Shrike Road. If impacted, this water supply may be replaced by constructing a small sump and dewatering a portion of Phase 3 to the dugout. The loss of watershed catchment area to the Canal Lake tributary, or elsewhere, may be compensated in a similar manor should an impact occur.

The impact of dewatering on livestock water supplies will be minimal due to the low hydraulic conductivity of the bedrock between the quarry and the supply source, and the maintenance of surface water sources (Talbot River tributary) through dewatering discharge.

The Permit to Take Water establishes Ferma's obligations to monitor and replace/reinstate groundwater supplies for domestic or livestock consumption.

The proposed monitoring program will obtain data during actual dewatering operations. This will allow for calibration of the groundwater model and the fine-tuning of predicted impacts prior to further advancement of the quarry beyond the first lift of Phase 1.

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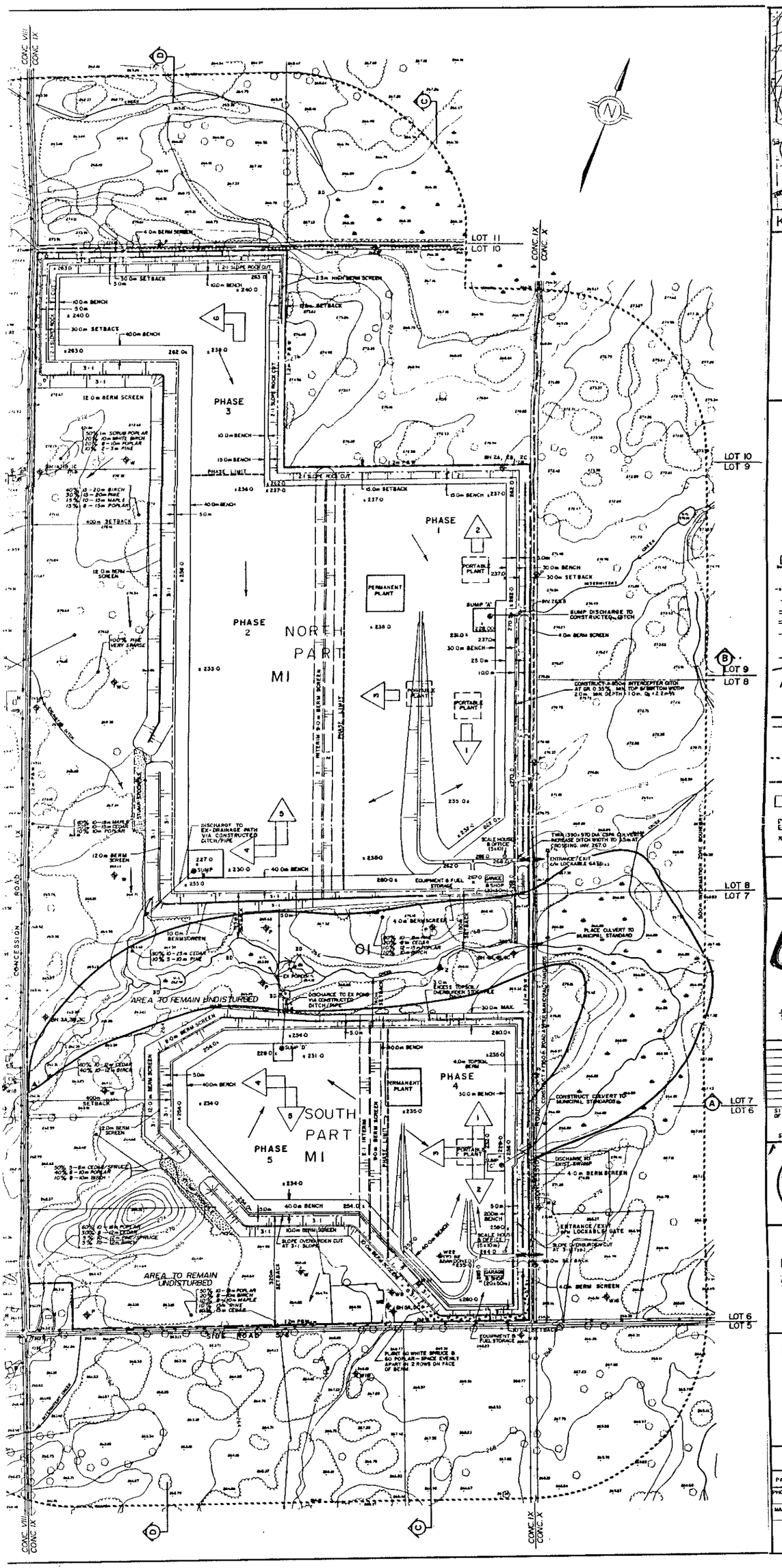
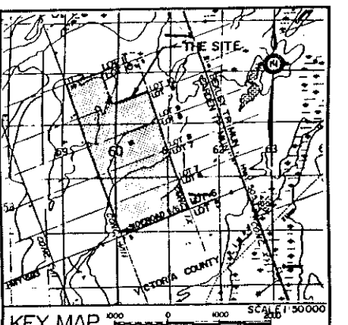
Appendix A:

Figures





NOTES

1. LICENSED AREA – 384.5 ha
2. AREA OF EXTRACTION — SOUTH PART – 68.3 ha; NORTH PART – 135.0 ha; TOTAL 203.3 ha
3. AREA TO BE REHABILITATED — SOUTH PART – 71.2 ha; NORTH PART – 132.7 ha; TOTAL 203.9 ha
4. THE WATER TABLE ELEVATION VARIES BETWEEN 260 AND 272, AND BETWEEN 0 m AND 5 m BELOW THE GROUND SURFACE AS RECORDED BY FIELD SURVEY.
5. THIS PLAN WAS PREPARED USING PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS.
6. LOT, CONCESSION AND BOUNDARY LINES ON THIS PLAN ARE APPROXIMATE.
7. THIS IS NOT A LEGAL SURVEY DRAWING IN ACCORDANCE WITH THE PROVINCE OF ONTARIO SURVEYORS ACT 1987.

- STREAM FLOW MONITORING POINT
- TOP OF SLOPE / ANGLE OF SLOPE (HORIZ. TO VERT.) / BOTTOM OF SLOPE
- EXISTING ELEVATION
- 2.0m CONTOUR INTERVAL
- TREES / BUSH
- DRAINAGE COURSE & FLOW DIRECTIONS
- GENERAL SURFACE DRAINAGE DIRECTION
- BEAVER DAM
- SWAMP
- POND AND WATER LEVEL
- HYDRO / TELEPHONE POLES
- BUILDINGS (HOUSE-BARN-SHED-GARAGE-COTTAGE) DIMENSIONS
- MONITORING WELL / PIEZOMETER LOCATION & NUMBER
- FENCE TYPE & HEIGHT (P & W - POST & WIRE; S R - SPLIT RAIL)
- GATE
- ASSUMED ROAD / INTERNAL ROAD
- UNASSUMED ROAD
- TRAIL
- ENTRANCE / EXIT
- LOT / CONCESSION LINE
- ZONE BOUNDARY FOR OI
- AI OI MI — ZONING (AI - RURAL GENERAL; OI - OPEN SPACE; MI - INDUSTRIAL EXTRACTIVE)
- PUMP(S) LOCATION
- BOUNDARY OF LICENSED AREA
- EXTRACTION LIMIT & SETBACK DISTANCE
- 237.0 FINAL ELEVATION
- 500m INFORMATION AREA LIMIT LINE
- CROSS SECTION/PROFILE NUMBER & LOCATION
- PHASE LIMIT
- DIRECTION OF EXTRACTION & SEQUENCE
- STUMP STOCK PILE AREA
- 70% 10-15m POPLAR — AVERAGE TREE SPECIES % COVERAGE & HEIGHT
- 50 DIA. WELL (M) / 50 DIA. BI-LEVEL PIEZOMETERS (P)

THIS SITE PLAN IS PREPARED FOR SUBMISSION TO THE MINISTRY OF NATURAL RESOURCES IN CONJUNCTION WITH AN APPLICATION FOR A CLASS A LICENCE UNDER THE AGGREGATE RESOURCES ACT AND REGULATIONS.

FERMA CRUSHED STONE INC.
2666 RENA ROAD
MISSISSAUGA, ONTARIO
L4T 3C8
Telephone (905) 677-9241 Fax (905) 677-9817

SIGNATURE OF LICENSEE — DATE

AMENDMENTS	DATE APPROVED

SITE PLANS APPROVED BY MINISTRY OF NATURAL RESOURCES

SIGNATURE — DATE

J.S. COURLEY — PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

THESE PLANS WERE DESIGNED TO ENSURE COMPLETE PRACTICALITY DURING THE OPERATIONS, PROGRESSIVE REHABILITATION AND FINAL REHABILITATION OF THE LICENSED PROPERTY

OLIVER MANGIONE McCALLA & ASSOCIATES LIMITED
Consulting Engineers
89 Colborne Street East, Orillia, Ontario L3V 1T6
Telephone (705) 327-0272 Fax (705) 327-1063

92-8977

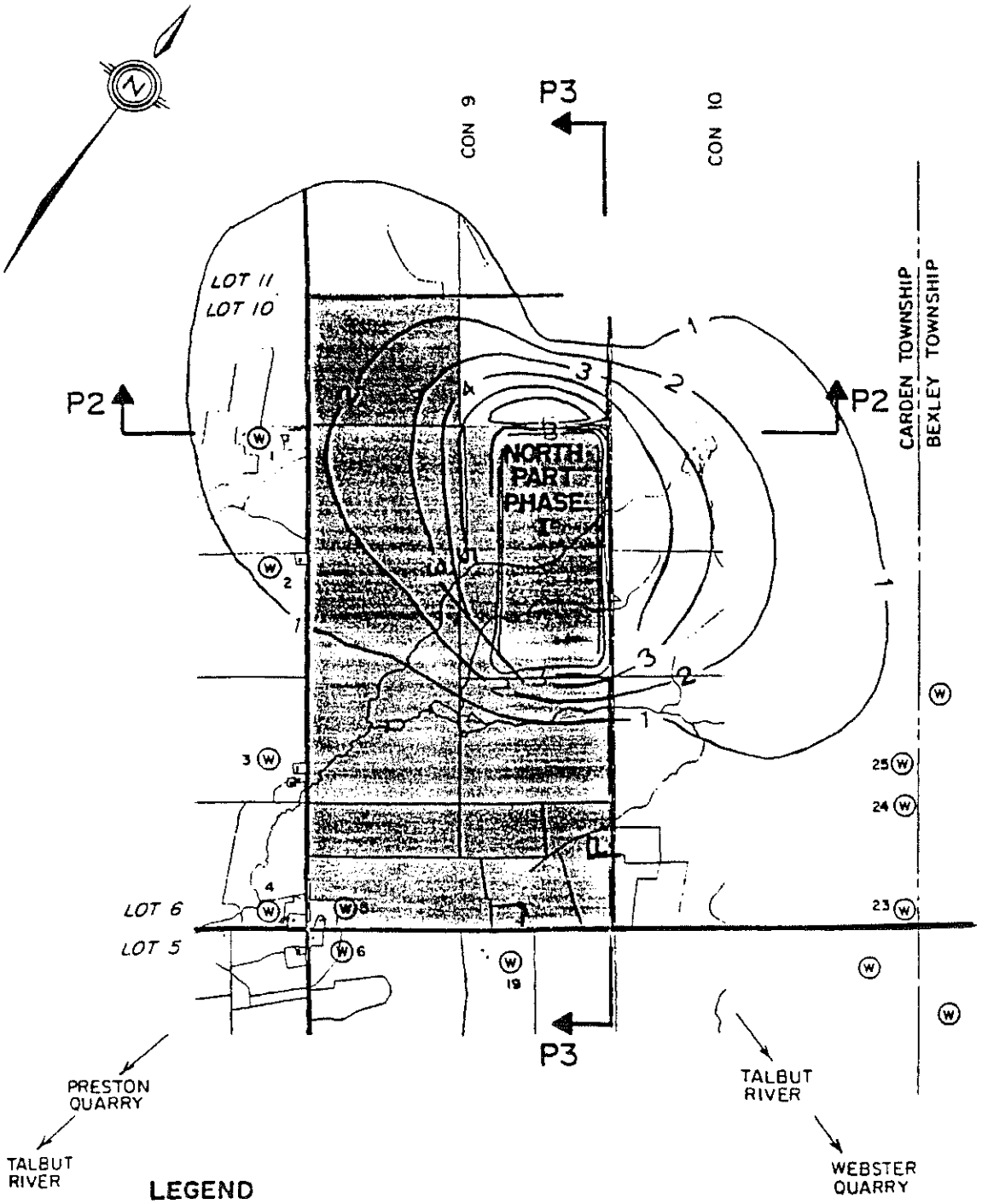
FERMA-CARDEN QUARRY

LOTS 6, 7, 8, 9, & WEST HALF OF LOT 10
CONCESSION IX
TOWNSHIP OF CARDEN
COUNTY OF VICTORIA

OPERATIONAL PLAN

PAGE 2 OF 5				
PHOTO SCALE 1:16000	ROLL No. 87-4426	PHOTO Nos. 188 – 190	LINE No. 3	PHOTO DATE MAY 1987
MAP SCALE AS SHOWN	CONTOUR INTERVAL 2.0 m		DATE OF SITE PLAN APRIL 1993	

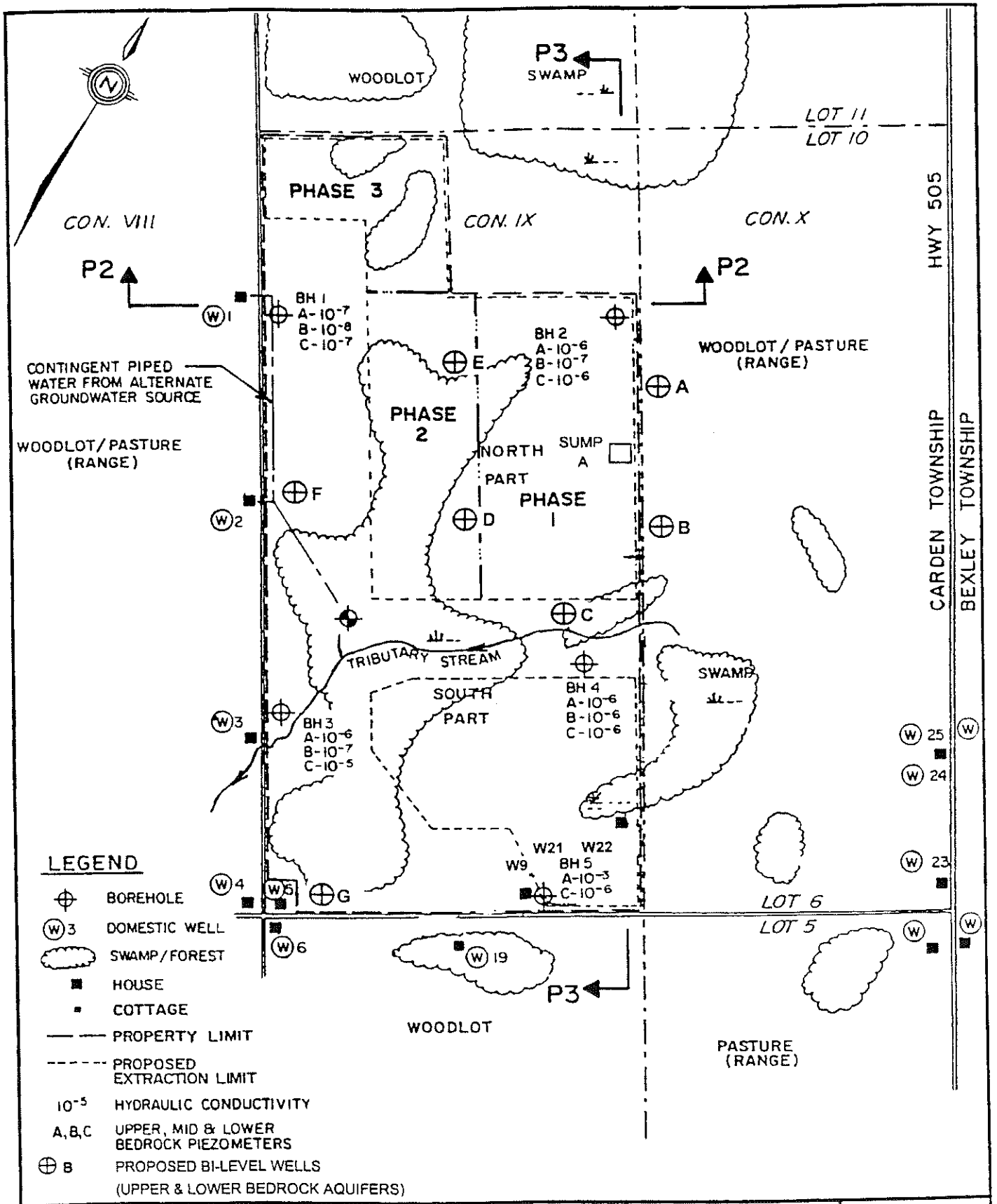
100 0 100 200 300 400m



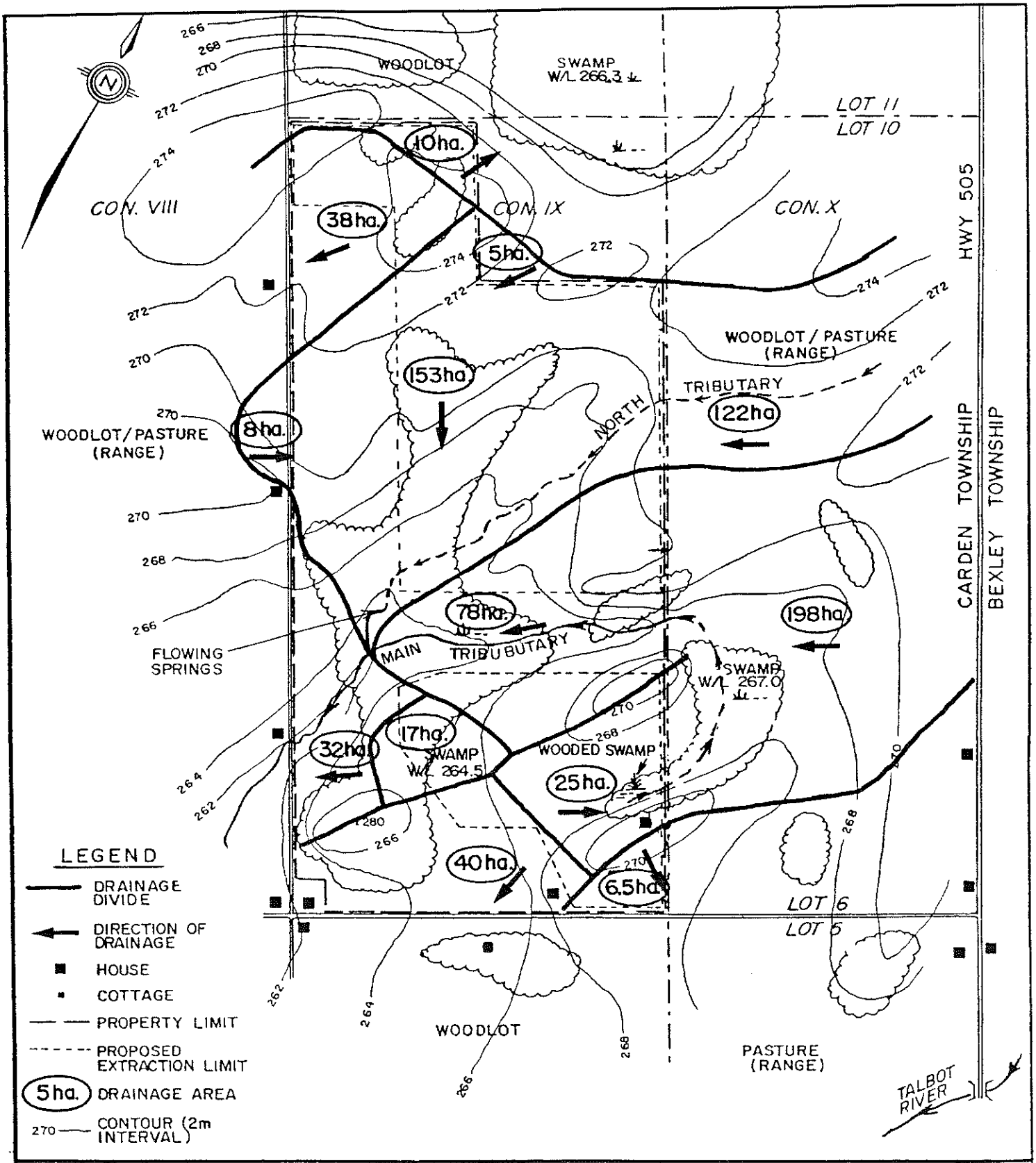
LEGEND

- (W) SURROUNDING DOMESTIC SUPPLY WELLS WITHIN UPPER BEDROCK AQUIFER
- —— 2 —— DRAWDOWN (m) NORTH PART PHASE I
- P3 ← SECTION LINE

DATE *February 1998*	OMM A TROW COMPANY CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS — Trow — OLIVER, MANGIONE, McCALLA & ASSOCIATES a Division of Trow Consulting Engineers Ltd.	Job:92-8977
SCALE *1:30,000 approx.*	*STEADY STATE DRAWDOWN - UPPER AQUIFER*	*Figure: 1*



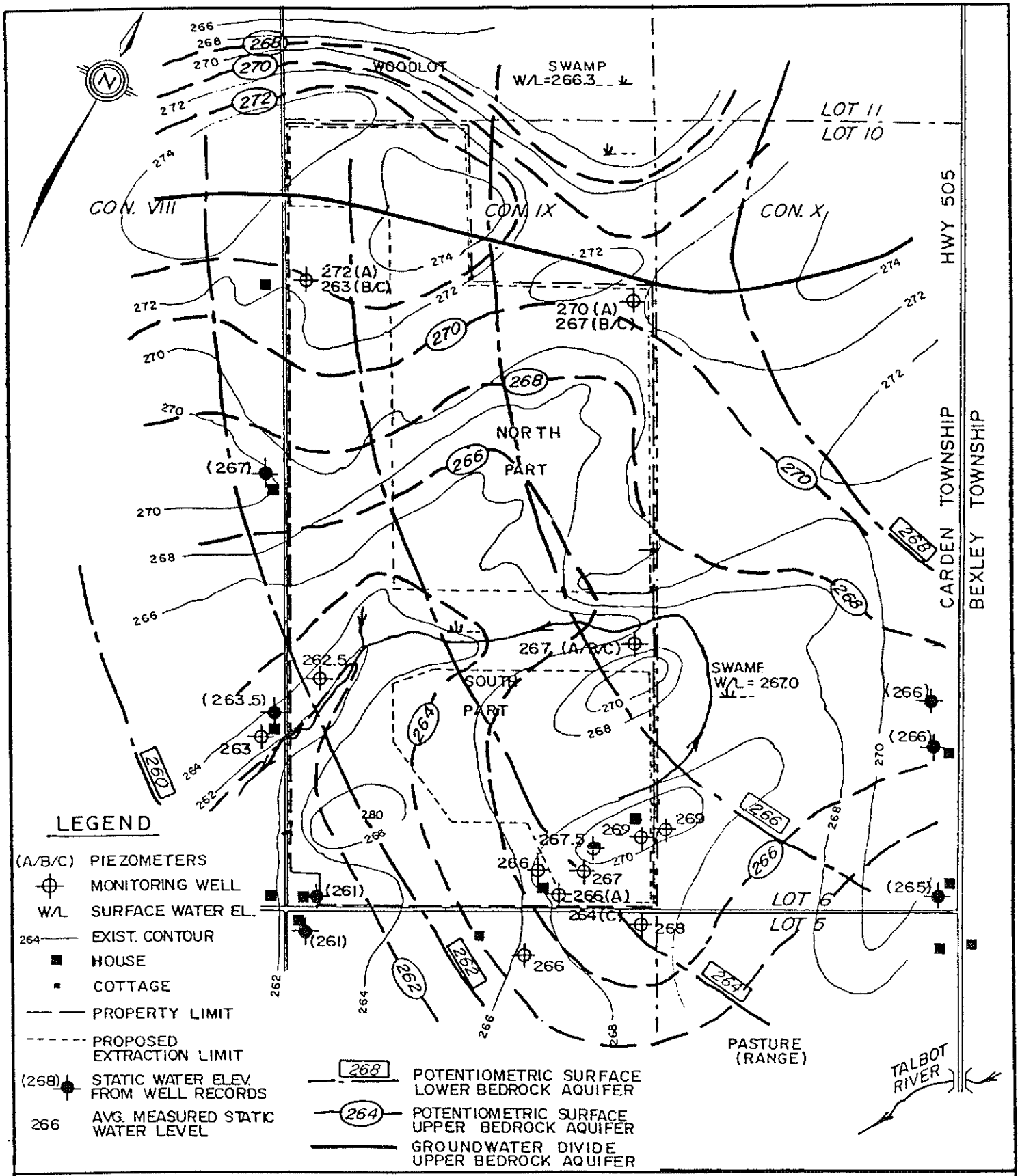
DATE *February 1998*	OMM A TROW COMPANY CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS — Trow	OLIVER, MANGIONE, McCALLA & ASSOCIATES a Division of Trow Consulting Engineers Ltd.	Job: 92-8977
SCALE *1:20,000*	*PROPOSED MONITORING WELLS & HYDRAULIC CONDUCTIVITIES*		*Figure:* 2



OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS

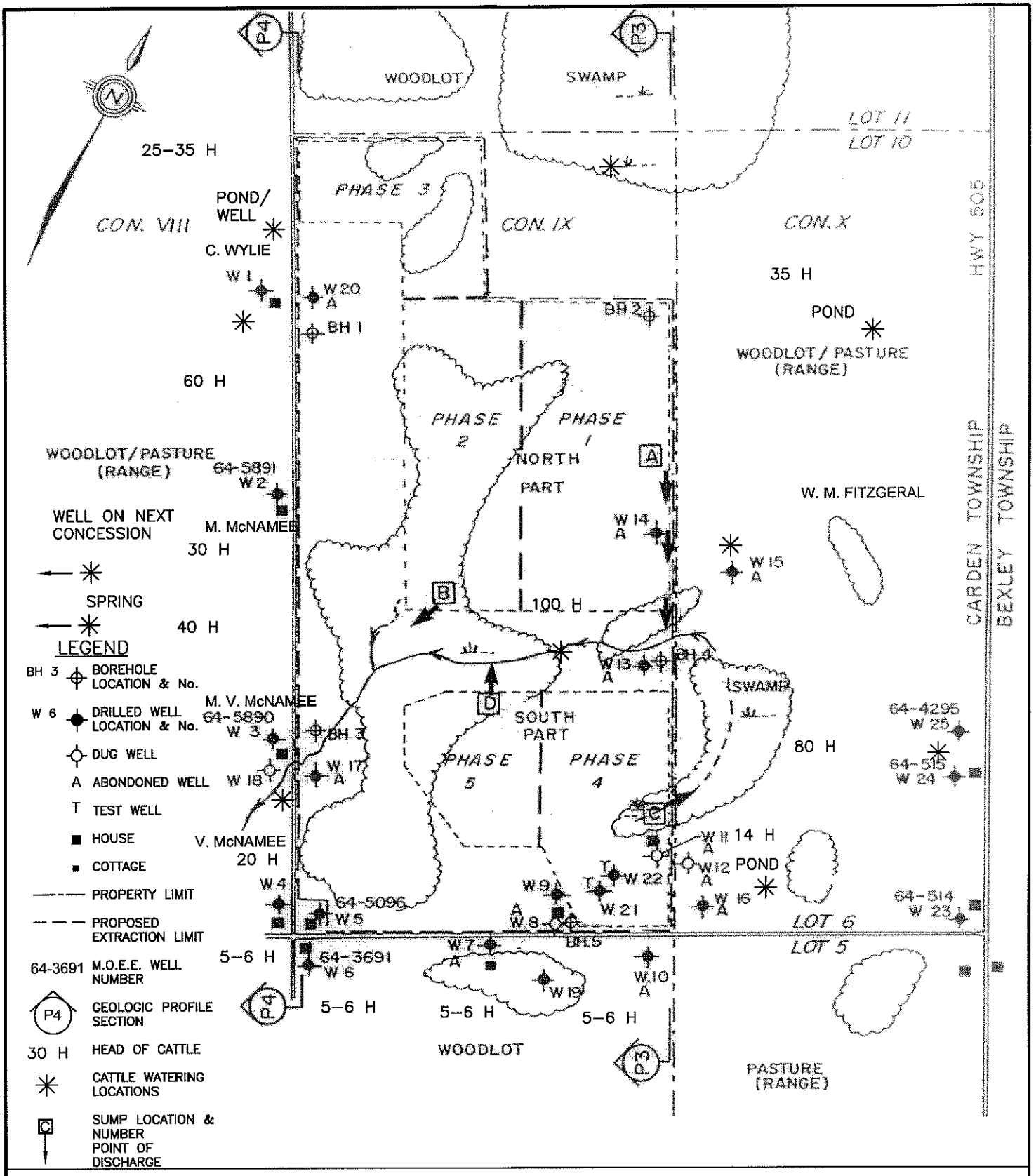
DATE AUG., 1994	CLIENT FERMA - CARDEN QUARRY	DWG. No. 92 - 8977-HR
SCALE 1:20000	TITLE SITE DRAINAGE	FIG. 3



OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

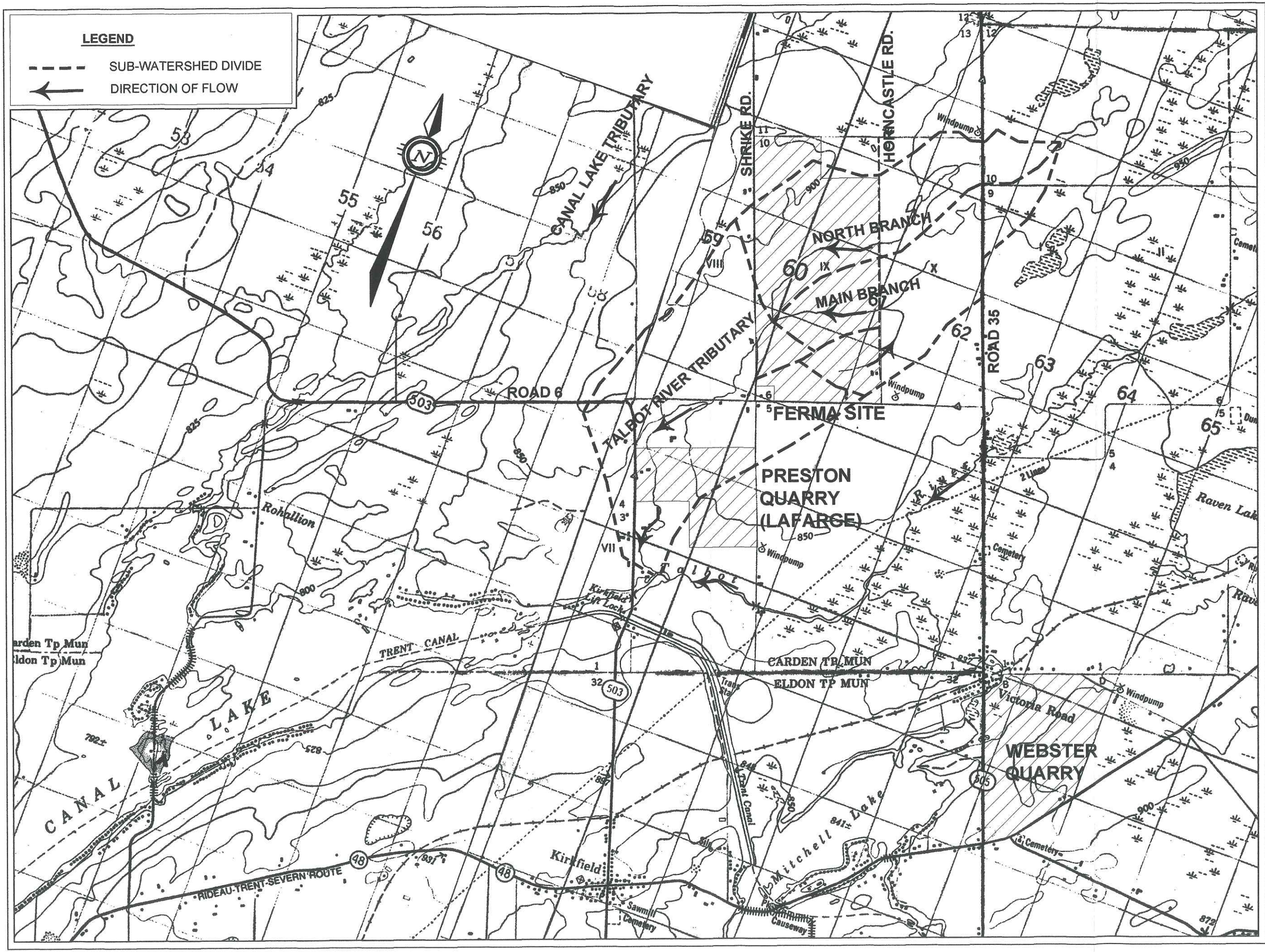
CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS

DATE AUG., 1994	CLIENT FERMA - CARDEN QUARRY	DWG. No. 92 - 8977-S9
SCALE 1:20000	TITLE MEASURED POTENTIOMETRIC SURFACE	FIG. 4



Trow Consulting Engineers Ltd.
Parent Company of Oliver, Mangione, McCalla & Associates
561 BRYNE DRIVE UNIT D
BARRIE, ONTARIO L4N 9Y3
Tel: (705) 734-6222
Fax: (705) 734-6224

SCALE 1:20,000	CLIENT: **FERMA**	JOB NO. BRBA0008977A
DATE: MAY 2002	TITLE: **CARDEN QUARRY WELL & CATTLE WATERING LOCATIONS**	FIGURE 5
DRAWN: LLC		



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561 BRYNE DRIVE UNIT D
BARRIE, ONTARIO L4N 9Y3
Tel: (705) 734-6222
Fax: (705) 734-6224
Trow

FERMA

CARDEN QUARRY
REGIONAL DRAINAGE

CLIENT:

TITLE:

SCALE:	1:4000
DATE:	MAY 2002
DRAWN:	LLC
JOB:	BRBA0008977
	SK–1

Appendix B:

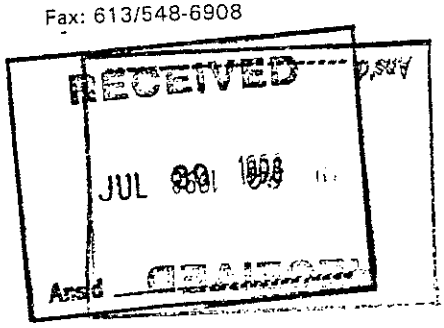
Relevant MOE Correspondence

92-377

Ontario

Ministry of the Environment
P.O. Box 820
Kingston, Ontario
K7L 4X6
613/549-4000 or 1-800/267-0974
Fax: 613/548-6908

Ministère de l'Environnement
C.P. 820
Kingston (Ontario)
K7L 4X6
613/549-4000 ou 1-800/267-0974
Fax: 613/548-6908



July 24, 1998

Ministry of Natural Resources
Minden, Ontario
K0M 2K0

Attention: Mr. Dennis Simmons

Dear Mr. Simmons:

Re: Ferma Crushed Stone Inc. Quarry
Carden Township, Lots 6-10, Concession 9

Further to my letter to you dated May 25, 1998, we have reviewed the letter from Oliver, Mangione, McCalla & Associates dated June 23, 1998. A carbon copy of this letter was also sent to you.

Vic Schroter in the Noise Assessment Unit has reviewed the letter and has no concerns. The consultants have proposed three noise conditions, and the four blasting conditions we had requested previously. *We have no further concerns with respect to noise and blasting issues provided the noise and blasting conditions proposed in the June 23, 1998 letter from Oliver, Mangione, McCalla & Associates are added to the site plan.*

As discussed in my May 25 letter, we are prepared to recommend in favour of approval of phase I of the quarry only. Excavation in subsequent phases should not be approved without further hydrogeological assessment of groundwater issues. MOE must be involved in review of hydrogeological studies which would support expansion/excavation into subsequent lifts and phases, as part of both the quarry licensing process and MOE's Permit To Take Water process. Groundwater Unit staff have no concerns with excavation in phase I of the Quarry, subject to the conditions outlined in the letter from Oliver, Mangione, McCalla & Associates (OMMA) dated February 18, 1998. The consultants have indicated that the conditions outlined in the letter will be placed on the Quarry licence. *We recommend that these conditions also be placed on the site plan.*

If you have questions or concerns about the above comments, please contact me.

Yours truly,

Vicki Mitchell
Approvals Evaluator
Air, Pesticides and Environmental Planning
Technical Support Section
Eastern Region
VM/gl
Attachment
cc: Ferma Crushed Stone Inc., 2666 Rena Road, Suite 202, Mississauga, Ontario, L4T 3C8,
Attn: Mr. David Kennedy
– Oliver, Mangione, McCalla & Associates, 89 Colborne St. E., Orillia, Ontario, L3V 1T8,
Attn: Mr. Jamieson S. Gourley

Ontario

Ministry of the Environment
P.O. Box 820
Kingston, Ontario
K7L 4X6
613/549-4000 or 1-800/267-0974
Fax: 613/548-6908

Ministère de l'Environnement
C.P. 820
Kingston (Ontario)
K7L 4X6
613/549-4000 ou 1-800/267-0974
Fax: 613/548-6908

May 25, 1998

Ministry of Natural Resources
MINDEN, Ontario
K0M 2K0

Attention: Mr. Dennis Simmons

Dear Mr. Simmons:

Re: Ferma Crushed Stone Inc. Quarry
Carden Township, Lots 6-10, Concession 9

Further to my letter to you dated October 31, 1995, this office's Groundwater Unit has reviewed additional information in support of the quarry licence application and the Permit To Take Water application. Comments from Groundwater Unit staff are attached and should be considered part of this Ministry's formal response.

Groundwater Issues

In general, Groundwater Unit staff have no concerns with excavation in phase I of the Quarry, subject to the conditions outlined in the letter from Oliver, Mangione, McCalla & Associates (OMMA) dated February 18, 1998. The consultants have indicated that the conditions outlined in the letter will be placed on the Quarry licence. *We recommend that these conditions also be placed on the site plan.*

A Permit To Take Water has been issued for dewatering in the first lift of phase I only (98-P-4050). Subsequent lifts and phases will require a new Permit To Take Water.

In terms of groundwater issues, we are prepared to recommend in favour of approval of phase I of the quarry only. Excavation in subsequent phases should not be approved without further hydrogeological assessment of groundwater issues. MOE must be involved in review of hydrogeological studies which would support expansion/excavation into subsequent lifts and phases, as part of both the quarry licensing process and MOE's Permit To Take Water process.

Noise Issues

In my October 1995 letter, I indicated that additional information was required before the Noise Assessment Unit could complete their review of the quarry proposal. This issue remains outstanding. Vic Schroter of the Noise Assessment Unit has notes of telephone conversations

involving issues such as the rock drill and the building design in the permanent plant area, however, neither of us can find a record of the subsequent information that OMMA indicates that they have provided (refer to OMMA letter to MNR dated May 14, 1997), nor any written comments from the Noise Assessment Unit on these issues.

We request that the information be resubmitted, so that this Ministry can provide final comments on the noise issues for the entire site plan area. I apologize for any inconvenience this may cause.

The applicant must adhere to this Ministry's Guidelines for Blasting as outlined in Publication NPC-119 from the Model Municipal Noise Control By-law dated August, 1978. We recommend that the following conditions be placed on the licence concerning blasting:

1) All residents within 500 metres of the boundaries of the licenced area must be given adequate notice prior to blasting.

2) All blasting must be monitored.

3) Blasts shall not exceed the peak pressure level limit for concussion of 128 dB and the peak particle velocity limit for vibration of 1.25 cm/s.

4) The information outlined in the above conditions must be kept by the applicant and made available to the Ministry of the Environment upon request.

General Comments

As indicated in my earlier letter, our Abatement Section has raised concerns regarding possible noise and dust affecting nearby residents as a result of increased truck traffic associated with this quarry. The municipality should be contacted in this regard.

Any excess (waste) material generated by the quarry operation such as stumps, branches, brush, roots, etc. must be transported and disposed of in accordance with this Ministry's waste management legislation or preferably reused as a product.

The site plan indicates that both permanent and portable processing plants will be used on the site. These plants require Certificates of Approval (Air) in accordance with the *Environmental Protection Act*. In addition, the proponent should be advised to contact our District Office in Peterborough prior to operating this equipment on the site. The owner is responsible for ensuring that Certificate of Approval conditions regarding separation distance, and any other noise or dust mitigation measures, are adhered to.

The site plan mentions the use of quarry sumps and a possible wash plant and settling basin. The settling basin will require approval under Section 53 of the *Ontario Water Resources Act*. The discharge from the sump may also require an Approval. Application forms and guides are available from this office. Any questions regarding Approvals for discharge of wastewater should be directed to the Industrial Approvals section of Approvals Branch.

If a petroleum hydrocarbon spill or leak occurs on the site, petroleum hydrocarbons will move with the groundwater flow. We recommend that the applicant prepare a contingency plan to prevent possible groundwater contamination as a result of a spill. Any necessary spill containment materials should be maintained on site. Site personnel should receive training in spill response procedures.

In summary, we do not have objections to excavation in phase 1 of the quarry with respect to groundwater issues. Conditions should be placed on the site plan and the licence stating that no extraction shall occur in subsequent phases until a hydrogeological assessment has been prepared in support of the expansion and has been accepted by the Ministry of the Environment.

However, we are unable to recommend in favour of the proposal at this time because the noise issues have not been completely resolved. We recommend that the noise issues for the entire site plan area be addressed to the satisfaction of MOE staff prior to the licence being issued by MNR. When Noise Assessment Unit staff have had the opportunity to review the requested noise information, we will provide final comments and recommendations to MNR on the quarry proposal. If you have questions or concerns about the above comments, please contact me.

Yours truly,

Vicki Mitchell
Approvals Evaluator
Air, Pesticides and Environmental Planning
Technical Support Section
Eastern Region
VLM/sh
Attachment
cc: Ferma Crushed Stone Inc., 2666 Rena Road, Suite 202, Mississauga, Ontario, L4T 3C8.
Attn: Mr. David Kennedy
– Oliver, Mangione, McCalla & Associates, 89 Colborne St. E., Orillia, Ontario, L3V 1T8,
Attn: Mr. Jamieson S. Gourley

Ontario

Ministry of the Environment
P.O. Box 820
Kingston, Ontario
K7L 4X6
613/549-4000 or 1-800/267-0974
Fax: 613/548-6908

Ministère de l'Environnement
C.P. 820
Kingston (Ontario)
K7L 4X6
613/549-4000 ou 1-800/267-0974
Fax: 613/548-6908

May 15, 1998

Ferma Crushed Stone Inc.
2666 Rena Road, Suite 202
MISSISSAUGA, Ontario
L4T 3C8

Attention: Tony Ferragine, President

Dear Mr. Ferragine:

Re: Permit to Take Water Number 98-P-4050

Enclosed please find Permit to Take Water Number 98-P-4050 which authorizes the taking of water from a quarry located on Lots 8, 9, and 10, Concession IX, Township of Carden, County of Victoria.

The Permit has been issued in accordance with the procedures and amounts stated on the application for the Permit To Take Water. The Permit is subject to the General Conditions and Special Conditions that may be stated on the Permit. The Conditions have been designed to allow for the development of water resources for beneficial purposes, while providing reasonable protection to existing water uses and users.

The Permit is valid until May 15, 2008, or until such time as there are changes in the rate, amount or method of water taking. If changes occur, an application must be submitted to and approved by this Ministry prior to the commencement of the changes. The attached application form must be used to request an amendment to the Permit.

The Permit should be reviewed carefully prior to water taking. Compliance with the Conditions of the Permit is the responsibility of the Permit Holder. Any person taking water under the authority of this Permit must be familiar with the Conditions.

If you have any questions regarding your Permit please contact Gail McFall at this office.

Yours truly,

Clyde Hammond

Clyde Hammond, Director
Section 34, R.S.O. 1990
Ontario Water Resources Act
Ministry of the Environment
GM/sh
Enclosure
cc: Jamieson Gourley, Oliver Mangione, McCalla & Associates Limited, 89 Colborne Street East, Orillia, Ontario, L3V 1T8

Ontario Ministry of the Environment / Ministère de l'Environnement

PERMIT TO TAKE WATER
Number 98-P-4050

Notice of Terms and Conditions
Section 100, Ontario Water Resources Act, R.S.O. 1990

Pursuant to Section 34 of the Ontario Water Resources Act, R.S.O. 1990 permission is hereby granted

TO: Ferma Crushed Stone Inc.
2666 Rena Road, Suite 202
Mississauga, Ontario
L4T 3C8

for the taking of water from a quarry located on Lots 8, 9, and 10, Concession IX, Township of Carden, County of Victoria for quarry dewatering. The rate of taking shall not exceed 120 litres per minute, or 172,000 litres per day for quarry sump "A".

Except where modified by this Permit the water taking shall be in accordance with the application dated September 13, 1995, and signed by Jamieson S. Gourley, of Oliver Mangione, McCalla & Associates, on behalf of the Ferma Crushed Stone Inc..

You are hereby notified that this Permit is issued to you subject to the following Definitions, General Conditions and Special Conditions.

DEFINITIONS

1. (a) "Director" means a Director, Section 34, Ontario Water Resources Act, R.S.O. 1990.

(b) "Ministry" means Ontario Ministry of the Environment.

(c) "Permit" means this entire Permit to Take Water including its schedules, if any, issued in accordance with Section 34 of the Ontario Water Resources Act, R.S.O. 1990.

(d) "Permit Holder" means Ferma Crushed Stone Inc.

GENERAL CONDITIONS

2. This Permit shall be kept available at the offices of Ferma Crushed Stone Inc., 2666 Rena Road, Mississauga, Ontario, with a copy of the Permit to be kept on-site at the quarry for inspection by Ministry staff at all times.

3. The Director may, from time to time, where a situation of interference or anticipated interference with water supplies exists, or in a situation requiring information on water takings for purposes of water resource inventory and planning, give written notice to the Permit Holder to undertake any of the following actions. The Permit Holder shall comply with any such notice:

   (a) To establish and maintain a system for the measurement of the quantities of water taken;
   (b) To operate such a system and to record measurements of the quantities of water taken on forms provided by the Director, with such frequency or for such time periods as the Director may specify;
   (c) To return to the Director records made pursuant to clause 3(b) at such times or with such frequency as the Director may specify; and
   (d) To keep records made pursuant to clause 3(b) available for inspection until such time as they are returned to the Director pursuant to clause 3(c).

4. The Permit Holder shall immediately notify the Director of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint.

5. For Surface-Water Takings, the taking of water (including the taking of water into storage and the subsequent or simultaneous withdrawal from storage) shall be carried out in such a manner that streamflow is not stopped and is not reduced to a rate that will cause interference with downstream uses of water or with the natural functions of the stream.

6. For Ground-Water Takings, if the taking of water is forecast to cause any negative impact, or is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent the forecast negative impact or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of so doing.

7. Prior to the taking of water under the authority of this Permit to Take Water, the Permit Holder shall ensure that the works complies with Section 52 of the Ontario Water Resources Act, R.S.O. 1990.

8. Prior to the taking of water under the authority of this Permit to Take Water, the Permit Holder shall ensure that the discharge complies with Section 53 of the Ontario Water Resources Act, R.S.O. 1993.

9. The Permit Holder shall report to the Director any changes of address or telephone number, or change of ownership of the property for which this Permit is issued and shall report to the Director any changes in the general conditions of water taking from those described in the Permit application within thirty days of any such change. The Permit Holder shall not assign his rights under this Permit to another person without the written consent of the Director.

10. No water may be taken under authority of this permit after the expiry date of this Permit, unless the Permit is renewed, or after the expiry date shown on any subsequent renewal of this permit, unless it is likewise renewed.

11. This Permit does not release the Permit Holder from any legal liability or obligation and remains in force subject to all limitations, requirements, and liabilities imposed by law. This Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

12. The Permit Holder must forthwith, upon presentation of credentials, permit Ministry personnel, or a Ministry authorized representative(s) to carry out any and all inspections authorized by Section 15, 16 or 17 of the Ontario Water Resources Act, R.S.O. 1990, Section 156, 157 or 158 of the Environmental Protection Act, R.S.O. 1990 of Section 19 or 20 of the Pesticides Act, R.S.O. 1990.

SPECIAL CONDITIONS

13. Records with respect to the measurement and reporting criteria defined under General Condition 3(d) listed above shall be kept daily when pumping by the Permit Holder at the offices of Ferma Crushed Stone Inc., 2666 Rena Road, Mississauga, Ontario, until this Ministry requests them to be submitted or states otherwise.

14. The Permit is valid only during that part of the proposed quarry operations designated as Phase 1 on the site plan and as illustrated in the attachment to the letter, dated February 18, 1998, from Jamieson Gourley (attached).

15. The locations of monitoring wells and the monitoring of static water levels in the wells shall be conducted as per the program outlined in the letter, dated February 18, 1998, from Jamieson Gourley (attached).

16. One (1) year after the commencement of dewatering activities, the Permit holder shall prepare, or have prepared on his/her behalf, a report summarizing and analyzing the previous year's observations. The report shall be completed within 90 days after the anniversary of the commencement of the water taking and shall be kept by the Permit holder at the offices of Ferma Crushed Stone Inc., 2666 Rena Road, Mississauga, Ontario, until this Ministry requests it be submitted or states otherwise. The report shall contain the information outlined in the Monitoring and Reporting section of the letter, dated February 18, 1998, from Jamieson Gourley (attached). If the results of the monitoring measurements, or the results and conclusions of the report, indicate the occurrence of an impact, the attainment of the contingency plan triggering condition or forecasts the potential for an impact on area wells, the Permit holder shall notify the Director immediately.

17. The contingency for the provision of alternative water supplies for affected wells shall be as outlined in the letter, dated February 18, 1998, from Jamieson Gourley (attached). Implementation of the contingency plan shall be initiated as outlined in the letter, dated February 18, 1998, from Jamieson Gourley (attached).

18. The permit holder shall be responsible for the investigation of water supply interference complaints as outlined in the letter, dated February 18, 1998, from Jamieson Gourley (attached). Upon receipt of a complaint, the Permit holder shall notify the Director and the Ministry of Natural Resources District Office of the complaint.

19. No water shall be taken under authority of this Permit after May 15, 2008.

The reason for the imposition of Special Condition 13 is to establish a record of water taking.

The reason for the imposition of Special Condition 14 is to limit the extent of the water taking until such time as additional information regrading the possible impacts to the groundwater resource and established users can be gathered and analyzed.

The reason for the imposition of Special Conditions 15 and 16 is to ensure that the impact of the water taking on the area aquifer is monitored and that the results of the monitoring evaluated is on an annual basis in order to determine the potential for interference with established users of the groundwater resource.

The reason for the imposition of Special Conditions 17 and 18 is to ensure that complaints with respect to well water shortages that may have been caused by this water taking are investigated and resolved and that established users which are affected or impacted by this water taking have a continuing supply of water sufficient for their normal usage.

The reason for the imposition of Special Condition 19 is to ensure that this Ministry has an opportunity to review the continued availability of water to be taken under authorization by this Permit as it relates to interference with other established uses.

You may, by written notice served upon me and the Environmental Appeal Board within 15 days after receipt of this Notice, require a hearing by the Board. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, Chapter 0.40, provides that the Notice requiring the hearing shall state:

1. The portions of the Permit or each Term or Condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Permit number;
6. The date of the Permit;
7. The name of the Director;
8. The municipality within which the taking is located;

And the Notice should be signed and dated by the appellant.

This notice must be served upon:

The Secretary
Environmental Appeal Board
P.O. Box 2382
2300 Yonge Street, 12th Floor
TORONTO, Ontario
M4P 1E4

AND The Director
Section 34, Ontario Water Resources Act
Ministry of the Environment
133 Dalton Avenue, Box 820
KINGSTON, Ontario
K7L 4X6

Dated at Kingston this 15th day of May, 1998.

Director
Section 34, Ontario Water Resources Act
Ministry of the Environment.

Ontario

Ministry of the Environment
133 Dalton Avenue
P.O. Box 820
Kingston, ON K7L 4X6

Ministère de l'Environnement
133 avenue Dalton
C.P. 820
Kingston, ON K7L 4X6

6 May, 1998

MEMORANDUM

To: Vicki Mitchell
Environmental Approvals
Technical Support Section
Southeastern Region

From: Gail McFall
Sr. Environmental Officer (Groundwater)
Technical Support Section
Southeastern Region

RE: Application for Class A Licence - Aggregate Resources Act; and Permit to Take Water; Applicant: Ferma Crushed Stone Inc., Carden Quarry, Lots 6, 7, 8, 9 + 10, Concession IX, Township of Carden, County of Victoria.

I have reviewed the above-noted application and the accompanying hydrogeological report, dated April 1995, and additional information provided in letters dated May 14, 1997, and February 18, 1998, by Oliver Mangione McCalla and Associates Limited (OMMA) on behalf of the applicant. The OMMA report was prepared in support of applications for various licences and permits including the Class "A" Licence under the Aggregate Resources Act and the Permit to Take Water (PTTW) under the Ontario Water Resources Act. With respect to the groundwater concerns relevant to the licence and the permit applications for the Carden Quarry, I offer the following comments.

OMMA has provided the necessary information requested in a telephone conversation and documented in a letter dated October 23, 1997, from OMMA to MOEE. The proponent has agreed to limit the excavation to the area outlined on the site plan as Phase 1, and the PTTW shall be issued for the first lift of Phase 1 only. Prior to the commencement of the second lift, the results of the groundwater monitoring shall be reviewed and assessed with respect to the potential for interference with established users in the area. OMMA has provided clarification of the location, construction of monitoring wells and outlined the monitoring program. Contingency plans and trigger water levels have also been provided..

Investigations of alleged water quantity interference by the Kirkfield Aggregates - Preston Quarry operations (pumping and blasting), which is located on the next concession south of the proposed Ferma quarry site, and an assessment of the results of groundwater level monitoring associated with the Preston Quarry operations by Kirkfield Aggregates' retained hydrogeologist, has indicated that there is a seasonal fluctuation in the amount of water available in the upper

bedrock aquifer which supplies many of the domestic water wells in the area. The volume of water in the aquifer is dependent on the amount of precipitation in the area and the results of the groundwater level monitoring indicate that quarry operations at the Preston Quarry have minimal effect on the groundwater immediately adjacent tot he quarry. Excavation of the first lift of Phase 1 of the proposed Ferma Quarry will enter this upper bedrock aquifer and therefore provide additional information on the potential for impacts on area wells.

OMMA indicates that the conditions outlined in their letter of February 18, 1998, shall be included on the quarry licence.

Provided the area of extraction is limited to Phase 1 only, and the conditions outlined by OMMA are included on the site plan, then I have no further concerns with respect to the groundwater aspect of these applications at this time. I recommend issuing the PTTW with the conditions outlined in the OMMA letter dated February 18, 1998.

Gail McFall

cc: Frank Crossley, Team Leader - Groundwater Unit
GW 07-13 Carden Township
STAR #2294- ARA application
STAR #3202- PTTW application

OMM A TROW COMPANY
Trow
CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS

Oliver, Mangione, McCalla & Associates
a Division of Trow Consulting Engineers Ltd.

89 Colborne Street East
Orillia, Ontario
L3V 1T8

Telephone: (705) 327-0272
Facsimile: (705) 327-1063
E-mail: orillia@trow.com

Reference: 92-8977

VIA COURIER

February 18, 1998

Ms. Gail McFall
Sr. Environmental Officer (Groundwater)
Technical Support Section
Eastern Region Ministry of Environment and Energy
133 Dalton Avenue
P.O. Box 820
Kingston, ON K7L 4X6

Re: Ferma - Carden Quarry, Lots 6 to 10, Concession IX, Township of Carden
Permit to Take Water (first 15 metre lift, Phase 1, North Part, east half of Lots 8 & 9, Concession IX).

Dear Ms. McFall:

Further to our submission of May 14, 1997, and our telephone conversation in late October, 1997, we wish to limit our application for Water Taking to the first lift of Phase 1 of the North Part of the proposed Ferma Quarry.

The Permit to Take Water (PTTW) would be granted based on the Conditions outlined below. The same Conditions would be placed on the Quarry Licence (minor revisions would be required to our Operational Plan in order that they correspond accordingly).

PTTW Condition 1 - Water Taking

The Permit to Take Water applies to dewatering the first lift of Phase 1, North Part, Ferma-Carden Quarry which is defined as a limestone excavation limited to a minimum floor elevation of 255.0 masl over the east half of Lots 8 and 9, Concession IX, Carden Township. Subsequent lifts or Phases will require a new Permit to Take Water.

.../2

The base of the upper bedrock aquifer within and surrounding Phase 1 is approximately 251.0 masl. Computer simulation of dewatering (steady state) to this elevation results in an estimated drawdown of one to two metres at closest domestic wells W1 and W2 as shown on Figure 1. If upper aquifer dewatering is reduced to elevation 255.0 masl, the simulated drawdown (transient solution, 20 years) is between 0.75 and 1.9 metres at wells W1 and W2, respectfully.

The depth of excavation would be controlled by constructing the top of Sump "A" to elevation 255.0 masl and sloping the quarry floor towards the sump at 0.5% grade. This would result in first lift floor elevations at the north and west limits of Phase 1 of 257.0 masl, and 258.0 masl at the south limit of Phase 1. The corresponding depth of excavation is between 11.0 and 15.0 metres. The amount of limestone reserve is approximately 15 million tonnes.

There would remain approximately 15 metres of formation between the base of excavation and the top of the lower bedrock aquifer.

The estimated maximum groundwater taking will be approximately 144 m^3/day, or 100 L/min. To accommodate both groundwater and surface water collected when Phase 1 is fully excavated, pumping facilities should be capable of pumping 910 L/min (200 IGPM).

PTTW Condition 2 - Monitoring Wells

Monitoring wells containing bi-level piezometers at locations WA (mid north part of east limit of Phase 1), WB (mid south part of east limit of Phase 1), WC (mid south limit of Phase 1), WD (mid south part of west limit of Phase 1), WE (mid north part of west limit of Phase 1), WF (opposite side of road from domestic well W2), and WG (southwest corner of site) are to be constructed six months prior to commencing dewatering. Upper and lower bedrock aquifer piezometers are to have base elevations at approximately 250 masl and 230 masl, respectively. Each bi-level monitoring well will have two 50 mm diameter piezometers each having a 1.0 metre long slotted screen section located within the water bearing zone of respective aquifers. The annulus surrounding the screens and casings are to be backfilled with silica sand with upper and lower aquifers isolated by a 3.0 metre thick bentonite seal placed using a tremie pipe or by pumping. Surface protection is also required per Regulation 901. On a quarterly basis commencing six months prior to dewatering, static water levels are to be record within the above monitors, and at existing piezometers which include: BH 1A, 1B, 1C; BH 2A, 2B, 2C; BH 3A, 3B, 3C; BH 4A, 4B, 4C; BH 5A, 5C; W9; and W22. All piezometers destroyed by quarry operations are to be replaced.

Well locations are shown on Figure 2 and will be added to the Operational Plan and Staging Diagrams.

.../3

The purpose of recording static level observations at wells WA through WF are as follows:

- to measuring compliance with PTTW Condition 1;
- to measure drawdown at distance due to dewatering in both upper and lower aquifers;
- to permit calibration of any future computer simulations;
- to validate complaints of adverse impacts by surrounding landowners; and
- provide more data relating to aquifer characteristics and groundwater flow.

The purpose of recording static level observations at existing multilevel piezometers, proposed well WG, and existing wells W9 and W22 are:

- to determine if there is any impact at distance due to dewatering Phase 1;
- to determine if there is any impact as a result of other nearby quarry dewatering operations;
- to determine if there is any impact on the lower bedrock aquifer as a result of dewatering the upper aquifer; and
- to validate complaints of adverse impacts by surrounding landowners.

PTTW Condition 3 - Monitoring and Reporting

Within 90 days following the first anniversary of commencing dewatering activities, the Operator will submit a report to the Ministries of Environment and Natural Resources summarizing for the previous year: static water level observations; pumping rates; water budget calculations; the extent of drawdown; anticipated pumping rates and corresponding drawdown within the next operating year; well logs of constructed wells; a sketch showing well locations, extent of excavation and equipotential contours of the upper and lower aquifer; water supply complaints received and steps taken to resolve same; contingency measures implemented; and any out of the ordinary observations made.

PTTW Condition 4 - Contingency Measures

The Operator will maintain a potable water supply source to surrounding wells adversely affected by dewatering operations. Contingency measures include, but are not limited to, the construction of a new well(s) within the upper bedrock aquifer at a location(s) unaffected by quarry dewatering and the delivery of water from the new well(s) by pressurized piped system to each affected residence. Dewatering mechanisms will be shut down failing the resolution of water supply problems caused by quarry dewatering.

.../4

PTTW Condition 5 - Trigger Mechanism

A drop in minimum static level at BH1A by 2.0 metres (to approximately 270 masl), and a corresponding drop of greater than 2.0 metres in static water level at proposed observation wells WD and/or WE, shall initiate contingency measures for water supply at domestic well W1 upon confirmation that W1 supply is inadequate. Similarly, a drop in minimum static water level at proposed monitoring well WF of 2.0 metres (to approximately 265 masl), and a corresponding drop in static level at proposed monitoring well WD and/or WE of greater than 2.0 metres, shall initiate contingency measures for water supply at domestic well W2 upon confirmation that W2 supply is inadequate.

The static water level at W1 is estimated to be between 271 and 272 masl, and at W2 it is 267 masl.

The above invokes contingency measures upon confirmation that a 2.0 metre decline in static water levels at observation wells corresponds with an adversely affected water supply at respective adjacent domestic wells. (It is not known if a two metre drop in static levels would effect either wells W1 or W2 without obtaining further well information pertaining to pump settings, well capabilities etc.)

PTTW Condition 6 - Complaint Resolution

Should a complaint by an affected landowner remain unresolved by the Operator, the complaint will be settled by arbitration at the cost of the Operator. (Ultimately, an unresolved complaint could result in Licence suspension.)

Please give me a call to discuss the above Conditions and their adequacy.

Yours very truly,

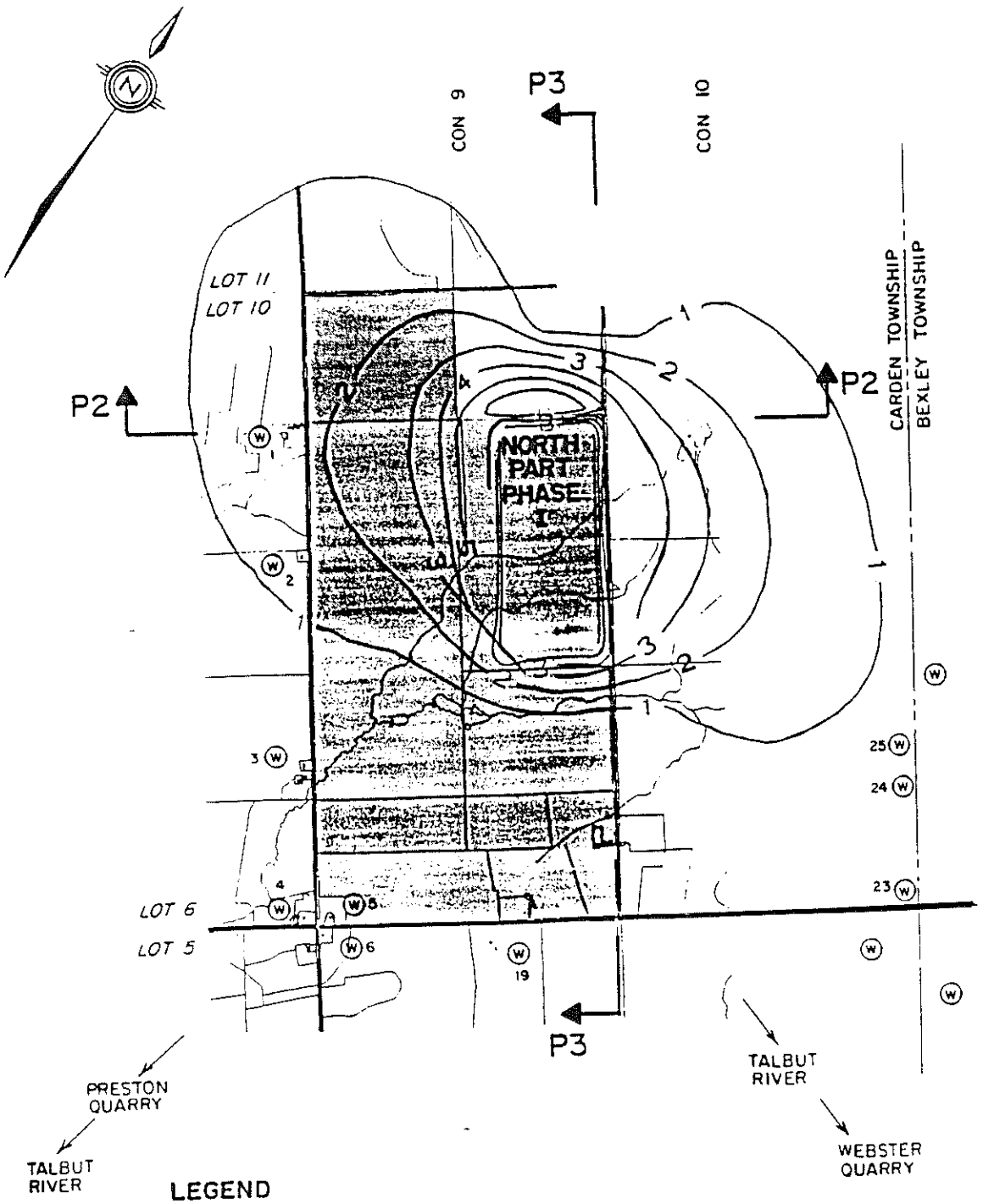
Jamieson S. Gourley, P.Eng.
Project Engineer
Manager, Orillia Branch

John A. McKee, M.SC., CGWP, P.Eng.
Director GeoEnvironmental Division
Assistant Manager, Ottawa Branch

OLIVER, MANGIONE, McCALLA & ASSOCIATES
a Division of Trow Consulting Engineers Ltd.

CC. Dennis Simmons - MNR Minden
Dave Kennedy and Tony Ferragine - Ferma Crushed Stone Inc.

Attach.



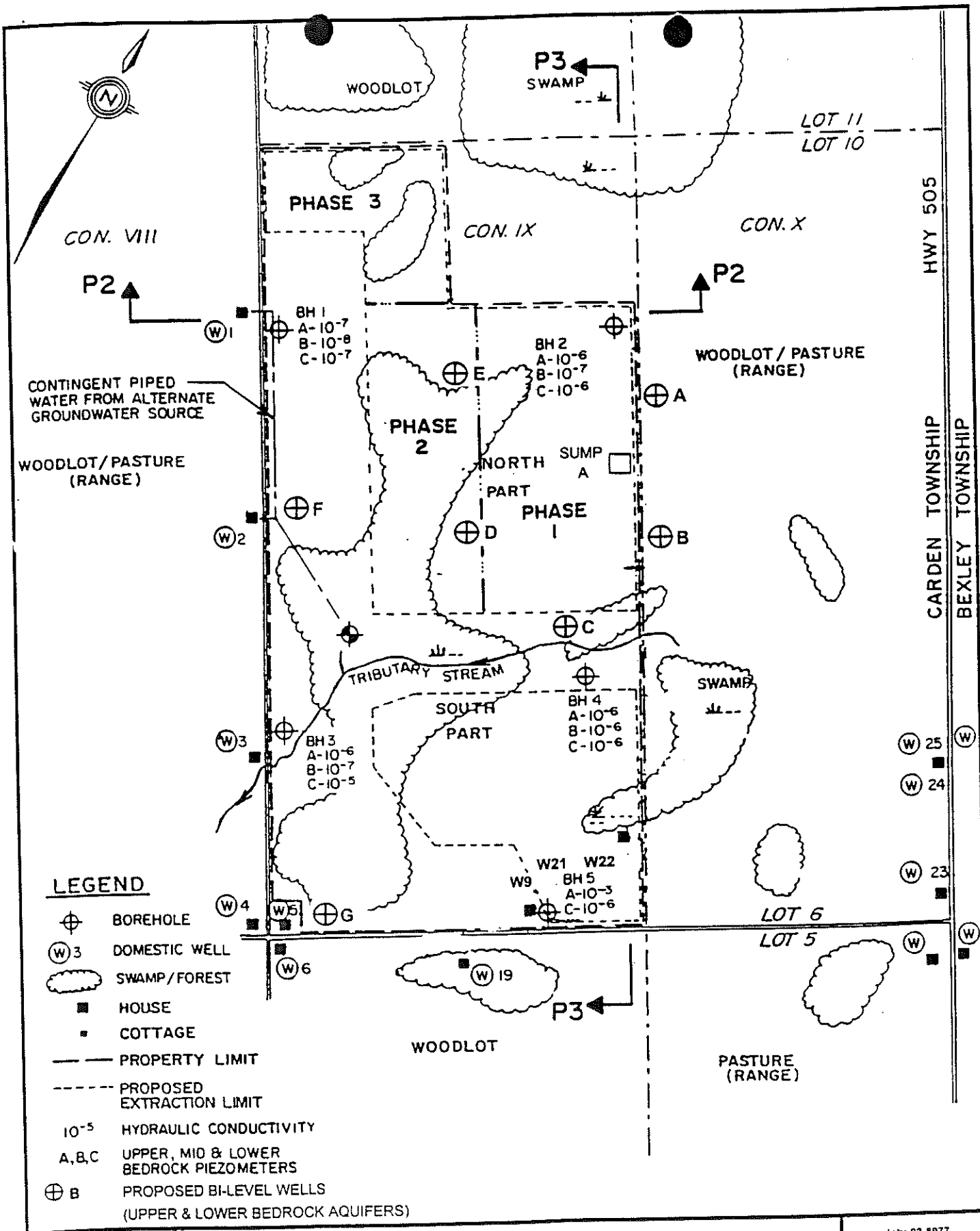
LEGEND

(W) SURROUNDING DOMESTIC SUPPLY WELLS WITHIN UPPER BEDROCK AQUIFER

—— 2 —— DRAWDOWN (m) NORTH PART PHASE I

P3 ← SECTION LINE

DATE *February 1998*	OMM A TROW COMPANY CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS — OLIVER, MANGIONE, McCALLA & ASSOCIATES a Division of Trow Consulting Engineers Ltd.	Job:92-8977
SCALE *1:30,000 approx.*	*STEADY STATE DRAWDOWN - UPPER AQUIFER*	*Figure: 1*



DATE *February 1998*	OMM A TROW COMPANY CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS — Trow ENGINEERS — **OLIVER, MANGIONE, McCALLA & ASSOCIATES** a Division of Trow Consulting Engineers Ltd.	Job: 92-8977
SCALE *1:20,000*	*PROPOSED MONITORING WELLS & HYDRAULIC CONDUCTIVITIES*	*Figure:* 2

Trow
CONSULTING ENGINEERS,
HYDROGEOLOGISTS & PLANNERS

Memorandum

February 18, 1998

Reference: 8977

To: J.S.G.

cc:

From: S.R.W.

Subject: **Modelling Results**

Jamie:

Transient Solution, 20 years

Elevation of Quarry Floor	Well 1 Drawdown	Well 2 Drawdown
254	0.80	2.09
255	0.75	1.96
260	0.50	1.40]

Steve

OMM A TROW COMPANY Trow
CONSULTING ENGINEERS,
HYDROGEOLOGISTS & PLANNERS

Oliver, Mangione, McCalla & Associates Limited

89 Colborne Street East
Orillia, Ontario
L3V 1T8

Telephone: (705) 327-0272
Facsimile: (705) 327-1063

Memorandum

VIA FACSIMILE

Reference: 92-8977

October 23, 1997

To: Gail McFail, MOEE, Kingston @ 613-548-6908

Copy: Tony Ferragine @ 905-677-9817
Dave Kennedy
John McKee - OMM/Trow (Ottawa)

Re: Ferma - Carden Quarry
Permit to Take Water

Further to our telephone conversation, the following additional information is to be provided:

1) Clarification/definition of monitoring well locations for Phase 1 - North Part.

2) Confirmation that monitoring wells to be constructed will be completed in both the upper and lower aquifers.

3) The level of drawdown impact observed at monitoring locations which will trigger contingency plans considering the sensitivity of the upper aquifer observed at the Preston Quarry site.

4) A review of contingency options considering that lower aquifer water quality found at the Preston site is very salty. (The lower aquifer water sample for the Ferma site was good, but was a mixture of up and lower aquifer water.)

5) A review of monitoring requirements considering the observed incomplete recovery (0.5 metres) of the upper aquifer over the long term (5 years) for dry weather data (i.e. monitoring program to include water budget considerations).

6) As to whether or not it would be appropriate/acceptable to limit the Permit to Take Water to the first 10 metre lift within Phase 1 - North Part. A technical review and reapplication for a Permit to Take Water, for the 2nd lift of Phase 1 - North Part would be necessary.

.../2

7) Method of complaint resolution by operator (Future complaints by the public must be handled by the operator, not MNR or MOEE, staff and could result in Licence suspension if unresolved.)

Please give me a call if the above is not completely accurate.

per

Jamieson S. Gourley, P.Eng.
OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

JSG/fh

Job: 92-8977 O/M

May 14, 1997

Mr. Dennis Simmins
Minden Area Office
Ministry of Natural Resources
Minden, Ontario K0M 2K0

Re: Ferma Crushed Stone Inc.
Class "A" Quarry Licence Application
Lots 6 - 10, Concession IX, Carden Township

Dear Mr. Simmins:

The following letter is provided to resolve technical issues identified by the Ministry of Environment and Energy's (MOEE) correspondence in Mrs. V. Mitchell's letter of October 31, 1995 prepared in response to your Ministry's circulation of site plans and related technical documents prepared by us for the above quarry licence application, and our client's application for a Permit to Take Water.

By copy of this letter to Mrs. Mitchell, we address those items identified by MOEE as follows:

Noise and Blasting Impact Analysis

It is our understanding that Dr. Vic Schroter of the MOEE Noise Assessment and Systems Support Unit had no serious concerns, although the following additional information was requested and subsequently provided as noted.

- A copy of the operational drawings and information regarding quarry staging. (This information is detailed on the site plans which were subsequently forwarded to Dr. Schroter from this office on September 22, 1995.)

- Clarification regarding the proposed construction of the building housing noisy pieces of equipment within the permanent plant area.

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According to a memorandum dated February 12, 1996 from our noise sub-consultant, Mr. John Emeljanow, P.Eng. of Valcoustics Canada Ltd., Dr. Schroter requested the following changes/additions be made to the Operational Plan notes.

- *The rock drill should be an Ingersoll Rand DM 30 or acoustical equivalent having a maximum sound emission level not exceeding 85.3 dBA at 15 m.*
- *Building design for housing noisy pieces of equipment within the permanent processing plant to be reviewed and approved by a qualified acoustical engineer to ensure compliance with applicable noise guidelines prior to construction.*
- *Prior to the commencement of quarrying, all noise control measures must be fully implemented for the particular quarrying location.*

The operational notes will be revised to conform with the above once input from all technical review is finalized.

Air Quality Impact Assessment

The conclusions concerning dust suppression, as outlined in the Air Quality Impact Assessment (OMM, December 1994), are incorporated into the Operational Plan and, as such, will be a condition on the Licence.

Truck Traffic

The local municipalities have been contacted concerning impacts due to truck traffic.

GROUNDWATER

1) **Aquifers**

On-Site

There are three aquifers identified in the "Hydrotechnical Report" (OMM, April 1995).

a) Where there is sufficient overburden there is a thin unconfined aquifer found above the bedrock surface. This aquifer is present in the southeasterly quadrant of the site only.

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b) The second aquifer extends from the bedrock surface to a depth of 10 to 20 metres. It coincides with the upper, middle, and lower (upper) Bobcaygeon limestone formations as shown on attached Figures 2 and 3.

c) A deep limestone bedrock aquifer is found above the Precambrian basement. It is 10 to 15 metres thick and located within the lower Gull River and Shadow Lake limestone formations.

The overburden and upper bedrock aquifer are hydraulically connected where the overburden aquifer exists. Surrounding domestic wells rely primarily upon the upper bedrock aquifer for potable water supply. The probability of the lower aquifer being capable of providing an alternate source of domestic water supply varies from good in southerly and mid sections of the site, to unlikely in northerly sections.

Between the upper and lower bedrock aquifers there is a 10 metre thick confining unit corresponding with the lower (lower) Bobcaygeon and upper Gull River limestone formations. The hydraulic conductivity of this unit was found to be one order of magnitude lower than that of the upper and lower bedrock aquifers, as shown on the attached Figures 1, 2 and 3. An exception was found at BH4 where the hydraulic conductivity of all geological units were found to be uniform. BH4 is located adjacent to the easterly site boundary and the tributary stream which bi-sects the site. A connection between the upper and lower bedrock aquifers is suspected at this location only.

Seasonal reversals in vertical hydraulic gradient were consistently observed at multilevel piezometers BH3 and BH4 located adjacent to the tributary stream. Therefore, the stream area is an area of groundwater discharge and recharge to the bedrock aquifers in response to seasonal conditions.

Consistent downward hydraulic gradients were observed at BH1, 2 and 5. This confirms a potential groundwater recharge to both bedrock aquifers in upland areas removed from the stream.

Potable water quality was found in groundwater samples collected from the upper bedrock aquifer and in a mixed sample of upper and lower bedrock aquifer groundwater.

Surrounding

a) Webster Quarry

Similar geologic and hydrogeological conditions were documented by Golder Associates Ltd. in their report entitled, "Geological and Hydrogeological Conditions - Proposed Quarry Development - Victoria Road" (1994) prepared for Mr. James Webster. The Webster site is located four kilometres southeast of the Ferma site, southeast of the Hamlet of Victoria Road within Lots 7, 8, and Block B, North Portage Road Concession of Bexley Township.

Local wells in the area of the Webster site also rely on the upper bedrock aquifer for water supply. Golder also identified a deeper bedrock aquifer in the lower Gull River limestone formation confined beneath a six metre thick horizon in the upper Gull River limestone formation. Golder concluded this lower aquifer to be a suitable alternate source of water supply in terms of water quantity and quality.

b) Preston Quarry

Those hydrogeological reports reviewed, and which pertain to the Preston Quarry located 1.8 kilometres southwest of the Ferma site, included the "Preston Carden Township Quarry, Phase II Hydrogeologic Study, Part of Lot 4, Concession 8, Township of Carden" (Gartner Lee, 1991), and "Carden Township Quarry 1993 Monitoring Report" (Gartner Lee, 1993). The 1993 monitoring report was obtained through the Freedom of Information Act, while the 1991 hydrogeological study was reviewed by OMM staff in the Ministry of Natural Resources (MNR) Minden Area office. We had not requested, or reviewed, the Terraspec report for the Preston quarry, as we have assumed the Terraspec report to be superseded by the 1991 Gartner Lee report.

Gartner Lee Ltd. reported the local groundwater supply aquifer at the Preston Quarry to be within the first four metres of weathered limestone. A lower bedrock aquifer was not identified by Gartner Lee Ltd. The 1993 Monitoring Report provided no specific information with respect to site dewatering.

2) **Recharge**

The Ministry is concerned that dewatering during mining may affect recharge to the upper aquifer, specifically, to the northwest of the local groundwater divide found in the northwestern part of proposed mining (North Part, Phase 3).

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Changes to recharge area that would result from quarry development were considered in the development of the groundwater model created to help predict the effects of quarrying on the local groundwater system - Appendix "J" of the "Hydrotechnical Report" (OMM, April 1995). The modelling exercise demonstrated that under existing conditions recharge to the upper aquifer is required to produce the groundwater calibrated head distribution map presented as Figure 8 on Page 45 of the report which corresponds well with the measured heads presented in Figure 7 on Page 29. The model therefore is considered to provide a reasonable representation of existing hydraulic conditions on site.

The computer simulation of quarrying in the northern part of the site accounted for the change in recharge conditions in this area as mining proceeds. The predicted head distributions during quarry dewatering consider the reduction in recharge to the shallow aquifer system in all scenarios examined.

The second MOEE comment on recharge concerns possible drawdown effects on local wells as a result of a hydraulic connection between the upper and lower bedrock aquifers. This is in reference to Section 7.1 in the 1995 report, which discusses groundwater dewatering impacts. The Ministry is concerned that the presence of a hydraulic connection between the upper and lower aquifer will increase the amount of drawdown in the upper aquifer as dewatering proceeds and the lower aquifer is recharged as a result of leakage from the upper.

We had acknowledged this may occur in our 1995 report and provided simulated cones of depressions within the upper and lower bedrock aquifers (Hydrotechnical Report, Figures J6 and J7, respectively), assuming total draining of the entire North Part to elevation 232 masl.

It must be emphasized that there is no evidence of a hydraulic connection between the two aquifers where mining is proposed. Elsewhere, the degree and distribution of hydraulic connection between the shallow and deep bedrock aquifers, especially off-site, is not known. This information could be obtained by conducting a massive and expensive off-site drilling and testing program, or by recording the water levels in proposed monitoring wells as dewatering operations progress. While a significant connection between the two aquifers will result in greater drawdown in wells completed in the upper aquifer when mining proceeds into the deep aquifer, the opposite would occur while dewatering the shallow aquifer only, due to upward pressure gradients.

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3) **Potential Stress Relief Effects**

MOEE expressed concern that the removal of the confining load on subsurface rocks may result in the formation of a pop-up on the quarry floor, and a resultant breach of the lower aquifer.

A review of published literature concerning the quarry pop-up phenomenon indicates that these stress relief features only affect bedrock to a depth of a few metres. Roorda (The Mechanics of a Pop-Up: A Stress Relief Phenomenon in Can. Geotech J. Vol. 32, 1995) calculated the depth of the disrupted area in a medium bedded limestone to be in the order of 0.3 to 1.2 metres, depending upon the degree of compressive stress and the thickness of the individual beds. Franklin and Hungr (Rock Stresses in Canada Their Relevance to Engineering Projects in Rock Mechanics, Supp. 6, 25-46, 1978) excavated a pop-up in a quarry floor and determined that the depth of the impacted zone was 3 to 4 metres. This corresponds to calculated estimates presented by Golder Associates Ltd. (1994) for the Webster Quarry site. Since the thickness of the lower permeability aquitard which is present between the upper and lower bedrock aquifer is 10 to 13 metres thick, the occurrence of a pop-up while mining the first lift to elevation 250 m.a.s.l. should not occur. However, as mining is proposed to proceed below 250 masl and through the confining layer into the lower aquifer unit, pop-up can be expected at some point in time.

The MODFLOW groundwater flow model, described in the OMM (April 1995) report, was modified to simulate the effects of a pop-up, assuming a breach between the upper and lower aquifers. A three layer model was used, with the top and bottom layers corresponding to the upper and lower bedrock aquifers respectively, and the middle layer represented by the lower permeability material. The hydraulic conductivity of two cells located in the area of proposed quarry floor (4 x 8 metre area) was increased to simulate the stress relief feature. Vertical hydraulic conductivity values of both 10^{-2} m/sec and 10^{-1} m/s were used in separate simulations. The model, which was run under both steady state and transient conditions, predicts a maximum drawdown in the lower aquifer as a result of pop-up in the intermediate confining layer in the order of two to three metres at a distance of 200 metres from the quarry. This predicted drawdown within the lower aquifer, as a result of pop-up, is less than that predicted for proposed final mining depths.

4) **Combined Drawdown - Preston and Ferma Quarries**

The cumulative affects of mutual interference between the two quarry sites was not addressed in the OMM (April 1995) Hydrotechnical Report. The reasons this was not addressed are two fold and discussed as follows:

. . ./7

- The Gartner Lee Report for Preston Quarry (1991) estimated the extent of dewatering influence to extend 300 metres upgradient of the Preston site. The Ferma site is approximately 1.5 kilometres upgradient of the Preston site.

- The volume of limestone reserves at the Preston Site are estimated at approximately 9,400,000 m^3 assuming an area of extraction measuring 500 metres by 400 metres to a depth of 45 metres. (The aerial dimensions were scaled, while the proposed depth of extraction is referenced from the Gartner Lee report). The equivalent volume of limestone is 24.4 million tonnes which is approximately 54 years of reserves assuming 100% production at the Preston Quarry licensed annual extraction rate of 450,000 tonnes.

  By comparison, Phase I of the North Part of the Ferma site has an estimated reserve volume of 44 million tonnes. At a 100% annual maximum extraction rate of 1.0 million tonnes, this reserve would last 44 years.

  Since the Preston site has been operating continuously over the last few years, while the Ferma site must still overcome planning hurdles, it is likely that the most optimistic time frame of maximum mutual interference will occur when Phase 1 of the North Part of the Ferma site is nearing completion.

The maximum drawdown from mining the Ferma-North Part Phase 1 to 232 masl is shown on Figures 2, 3, 4 and 5 for the upper and lower bedrock aquifers. Drawdown of the upper aquifer is limited in the southerly direction as a result of the constant hydraulic boundary presented by the tributary stream immediately to the south of Phase 1.

Drawdown in the lower aquifer extends towards Preston Quarry and has a depth of approximately five metres at Side Road 5/6. However, this aquifer was not reported to exist at Preston Quarry. To document groundwater drawdown during dewatering, a number of piezometers and monitoring wells are to be constructed as described by the Operational Plan. Perimeter monitors surrounding the North Part are to be constructed at the outset of developing same. To provide further documentation of water levels between the Ferma - North Part and Preston Quarry, the Operational Plan notes will be revised. The revision will include the Site Plan condition that groundwater monitors located along the westerly site limits, between the North Part and the southerly licensed boundary, be constructed prior commencing Phase 1 - North Part dewatering (i.e. all proposed South Part monitoring wells located within the west half of Lots 6 and 7, Concession IX).

5) **Combined Drawdown - Webster and Ferma Quarries**

The Webster site has not yet received approval for quarry development, although a licence is in place for gravel extraction. Mutual dewatering interference between the Ferma and Webster quarries is not considered likely due to intervening constant head boundaries provided by Mitchell Lake and Talbot River.

6) **Quarry Staging and Permit to Take Water**

The application for a Permit to Take Water for quarry dewatering was submitted to MOEE. The Permit to Take Water application submitted was for the North Part of the quarry only, the MOEE comments appear to reflect full site development.

Section 9.0 of the Hydrotechnical Report - page 59 (OMM, April 1995) states, "Drawdowns in bedrock aquifer groundwater levels, as a result of quarry development, were simulated using numerical techniques (see Appendix J, Hydrotechnical Report, OMM 1995 for full description). The results presented within are considered a worse case scenario estimate. Actual groundwater drawdown during quarry development will vary from predicted values due to the heterogeneous and anisotropic nature of the fractured limestone bedrock aquifers." To address this, a comprehensive ground and surface water monitoring program is proposed. The predicted aquifer response would be subject to re-evaluation through further groundwater flow model calibration using data obtained from field observations. Quarry operations could subsequently be modified if warranted.

When full site dewatering is examined, our findings show surrounding domestic wells to be impacted. However, with the development of Phase 1 - North Part only, the predicted extent of impact is limited to two adjacent domestic wells. This is demonstrated on the attached Figures 4 and 5. It is noted that the aerial extent of drawdown in the lower bedrock aquifer is extensive, however, surrounding wells do not rely on this aquifer for water supply.

The predicted two to three metre drawdown on the upper bedrock aquifer at domestic Wells 1 and 2 are considered manageable and acceptable. This level of drawdown should not affect the use of these wells for domestic water supply. If not, then alternate sources of water supply would have to be arranged. This can be accomplished by either of the following:

- Further development of existing wells within the upper bedrock aquifer, i.e. deepening.

. . ./9

- Providing a piped groundwater supply to replace affected domestic wells from an upper aquifer groundwater source located within the Ferma site.

It is therefore put forth to both MOEE and MNR that the following conditions of approval be imposed, in addition to those already suggested.

- The Permit to Take Water be revised to reflect the dewatering requirements of Phase 1 - North Part only. The estimated volume of water taking at full Phase 1 - North Part development is 1,565 m^3/day (239 IGPM), which includes 465 m^3/day (71 IGPM) groundwater, and 1,100 m^3/day (168 IGPM) surface water (average day for months of April/November).

- That conditions be placed on the Permit to Take Water by MOEE that limit the water taking by Ferma Crushed Stone Inc. to the east one-half of Lots 8 and 9 of Concession IX, Carden Township in Victoria County.

- That the Operational Plan conditions reflect the above and, in addition, stipulate that stages or sub-stages (i.e. lifts) of development Phases subsequent to Phase 1 not proceed until a Permit to Take Water has been put in place for that Phase to be developed.

- That should water shortages be experienced at existing neighbouring wells as a result of site dewatering, new sources of water supply shall be provided either by further developing the supply aquifer at the affected well site, or providing a piped water supply from a suitable groundwater source located within the Ferma site (see Figure 1). Pumping tests have already confirmed adequate water supply and quality exist within the Ferma site.

We are available to discuss the above issues directly with representatives of the Ministry of Environment and Energy in order to ensure all necessary and reasonable mitigating, contingency, and monitoring measures are in place as required for approval under the applicable legislation.

Respectfully Submitted,
OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

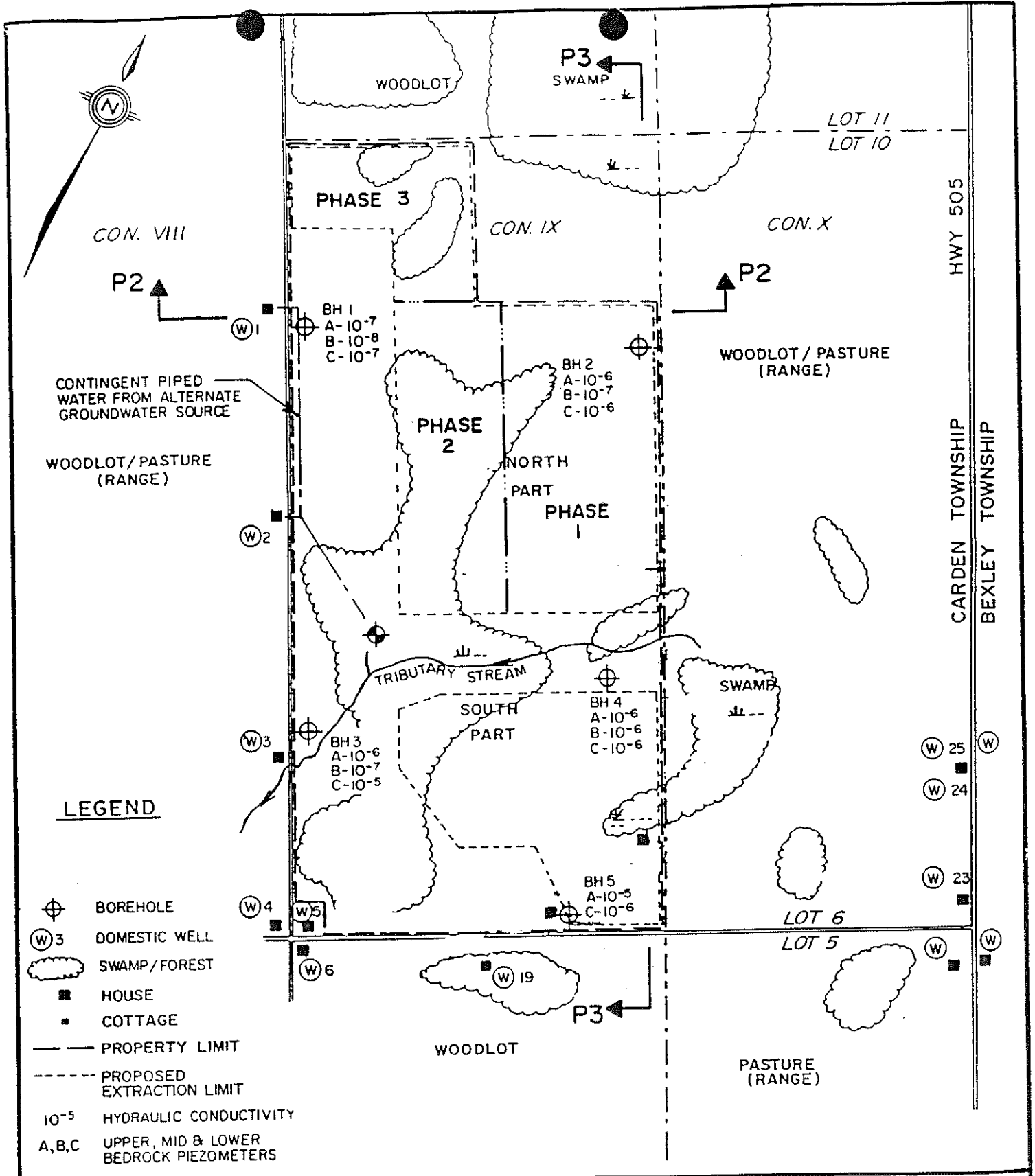
Jamieson S. Gourley, P.Eng.

John A. McKee, M.Sc., P.Eng.

cc: Mrs. V. Mitchell, Ministry of Environment and Energy (Eastern Region)
Mr. D. Kennedy - Ferma Crushed Stone Inc.
Mr. A. Ferragine - Ferma Crushed Stone Inc.

Attch.

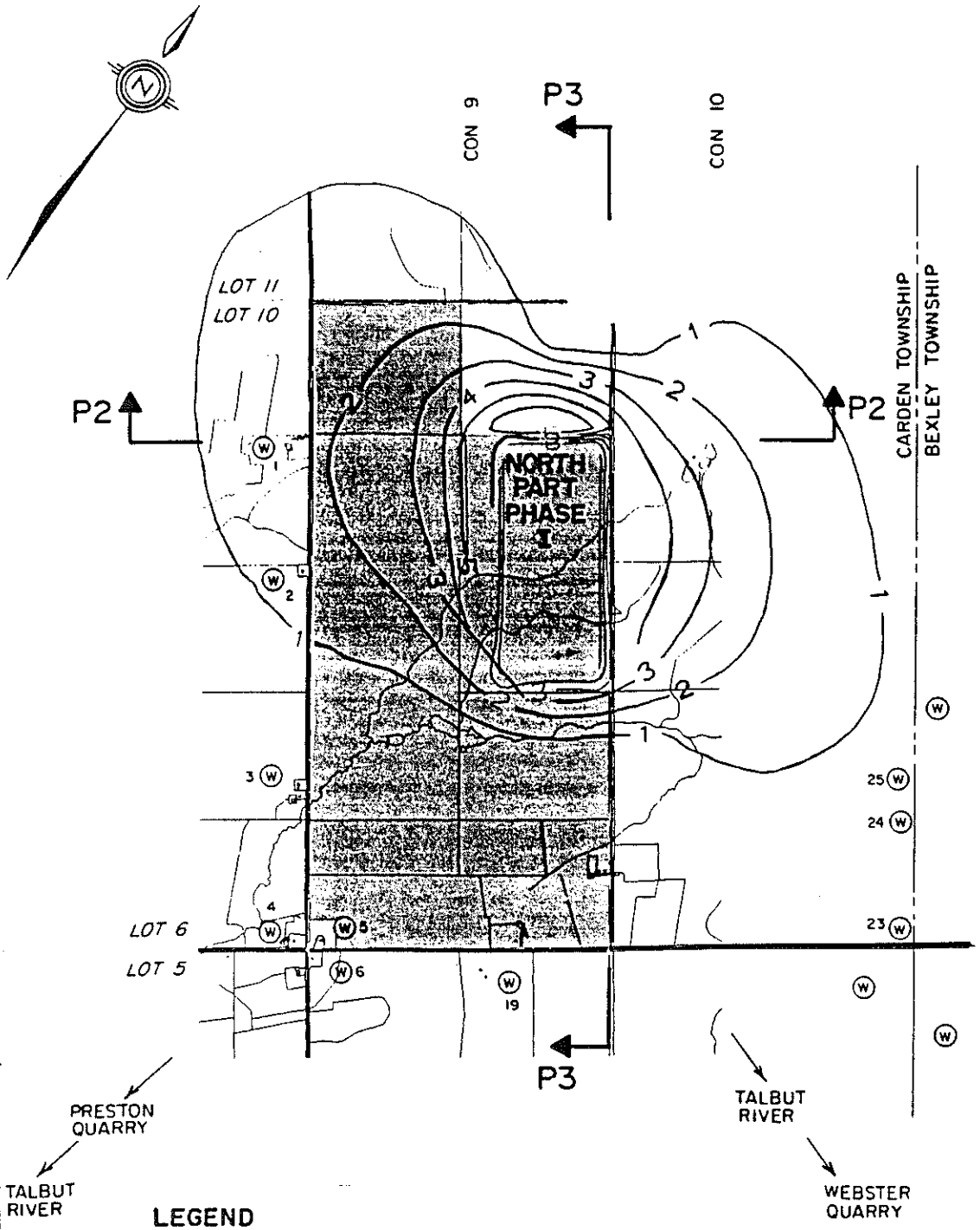
JSG:rb



OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS

DATE MARCH 1997	CLIENT FERMA - CARDEN QUARRY	DWG. No. 92 - 8977
SCALE 1 : 20000	TITLE HYDRAULIC CONDUCTIVITIES	FIG. 1



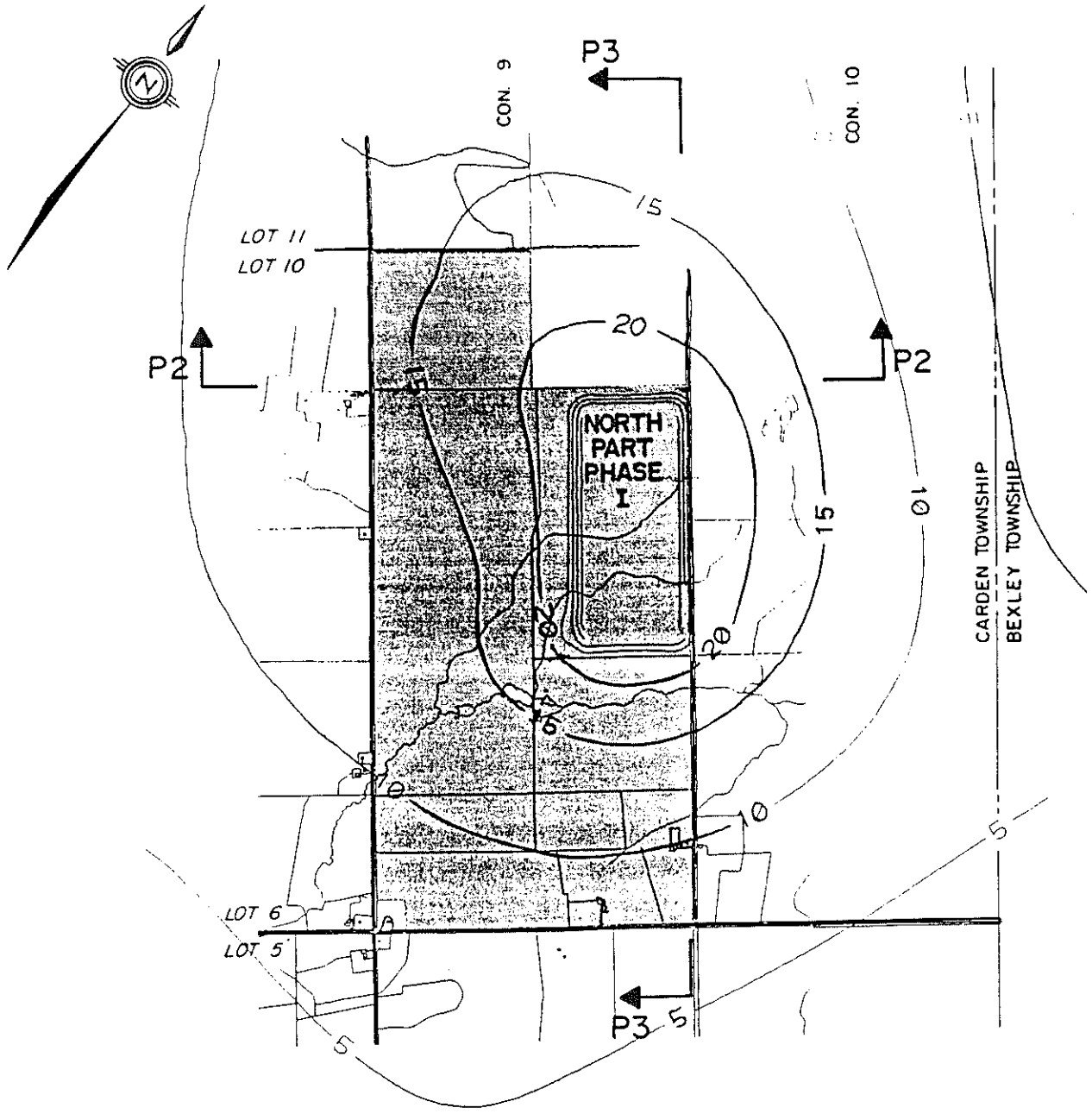
LEGEND

- (W) SURROUNDING DOMESTIC SUPPLY WELLS WITHIN UPPER BEDROCK AQUIFER
- —— 2 —— DRAWDOWN (m) NORTH PART PHASE I
- P3 ← SECTION LINE

OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS

DATE MARCH 1997	CLIENT FERMA - CARDEN QUARRY	DWG. No. 92 - 8977
SCALE 1:30 000 APPROX	TITLE STEADY STATE DRAWDOWN - UPPER AQUIFER	FIG. 4



LEGEND

- (W) SURROUNDING DOMESTIC SUPPLY WELLS WITHIN LOWER BEDROCK AQUIFER (NONE)
- — 2 — DRAWDOWN (m) NORTH PART PHASE I
- P2 ← SECTION LINE

OLIVER, MANGIONE, McCALLA & ASSOCIATES LIMITED

CONSULTING ENGINEERS, HYDROGEOLOGISTS & PLANNERS

DATE MARCH 1997	CLIENT FERMA - CARDEN QUARRY	DWG. No. 92 - 8977
SCALE 1:30 000 APPROX.	TITLE STEADY STATE DRAWDOWN - LOWER AQUIFER	FIG. 5

22.02(a)

Ontario

1-613/549-4000 1-800/267-0974 Fax: 613/548-6908

Ministry of Environment and Energy

Ministère de l'Environnement et de l'Énergie

133 Dalton Avenue
P O Box 820
Kingston ON K7L 4X6

133 avenue Dalton
C P 820
Kingston ON K7L 4X6

31 October 1995

Ministry of Natural Resources
MINDEN, Ontario
K0M 2K0

Attention: Mr. Dennis Simmons

Dear Mr. Simmons:

Re: Ferma Crushed Stone Inc. Class "A" Quarry Licence Application
Carden Township, Lots 6-10, Concession IX

This office and the Peterborough District Office have reviewed the licence application, site plans, and accompanying reports prepared by Oliver, Mangione, McCalla and Associates Limited (OMMA). We offer the following preliminary comments.

The Noise Impact Analysis and Blasting Impact Analysis were forwarded to our Noise Assessment section for review. Mr. Vic Schroter of the Noise Assessment Unit has advised me that he has been in contact with the consultant and has requested additional information.

Peterborough District staff comment that the municipality should be contacted concerning impacts due to truck traffic.

Staff recommend that the conclusions concerning dust suppression, as outlined in the December 1994 "Air Quality Impact Assessment" prepared by OMMA, be incorporated into the Operational Plan or that they be made a condition on the Licence.

Groundwater Unit Staff have reviewed the April 1995 "Hydrotechnical Report, Ferma - Carden Quarry", prepared by OMMA. Detailed Groundwater Unit comments are attached, and should be considered in their entirety as part of the MOEE response. Some of the issues identified include:

> The quarry will penetrate the main water bearing zone and dewatering will be required. There will be adverse affects to the yields of nearby wells. OMMA has indicated that quarry dewatering operations could impact water wells up to 1 km away from the site.

OMMA does not discuss the possible effects of quarry operations and dewatering on recharge of the groundwater aquifers. A groundwater divide/recharge zone for the upper bedrock aquifer is located in the northern part of the site and crosses part of the north quarry excavation.

If a connection between the upper and lower bedrock aquifers exists, then the lower bedrock aquifer would be recharged at the expense of the upper bedrock aquifer, resulting in a greater draw down of the upper bedrock aquifer. This additional draw down or "draining" could result in a larger cone of influence and therefore a greater and/or more widespread effect on water well yields in the area.

The consultants have not addressed the possibility and results of stress relief on the quarry floor. Alteration and/or decrease of the stresses, either due to the formation of a pop-up or from removal of the overlying load, may result in the passage of water under a hydrostatic head through fracture openings caused by the relaxation of the stresses acting upon them. Given that the hydrostatic head for the lower bedrock aquifer is higher than the quarry floor, further breaching of the aquifer may cause an increased flow of groundwater into the quarry.

Kirkfield Aggregates operates the Preston Quarry which is located approximately 750 m southwest of the site. The two zones of influence of the Preston and Carden quarries will overlap and possibly extend onto one another's sites. The impact on well yields could be even greater due to the combined effects of the quarry operations. It is uncertain whether the cones of influence for the Preston and Carden quarries will overlap with respect to time.

The proposed monitoring program does not address the manner in which interference with wells on the southwest side of the site will be deemed to be caused by dewatering of the Carden Quarry rather than dewatering of the Preston Quarry.

There is insufficient detail to determine the effectiveness of the proposed contingency plan. It appears that the contingency plan involves deepening wells into the lower bedrock aquifer. This lower bedrock aquifer will also be impacted by dewatering activities. This is not an acceptable solution unless it can be clearly demonstrated that there will be no further interference with the wells.

In summary, the Groundwater Unit concerns must be addressed and additional information must be provided to the Noise Assessment Unit before this office can provide final comments on the proposed quarry. Groundwater Unit concerns with respect to recharge areas, additional draw down or "draining" due to recharge of the lower bedrock aquifer from the upper bedrock aquifer, the possibility of a pop-up occurring, and the combined interference of the Preston and Carden quarries, should be addressed before we can recommend in favour of the quarry licence.

If you have questions or concerns about the above comments, please contact this office. Questions about the Groundwater Unit concerns should be directed to Gail McFall in this office.

Yours truly,

V. Mitchell (Mrs.)
Environmental Assessment Evaluator
Environmental Approvals
Technical Support Section
Eastern Region
VLM/km
Enclosure
cc: Ferma Crushed Stone Inc., 2666 Rena Road, Suite 202, Mississauga, Ontario, L4T 3C8, Attn: Mr. David Kennedy

Ontario

1-613/549-4000 1-800/267-0974 Fax: 613/548-6908

Ministry of Environment and Energy

Ministère de l'Environnement et de l'Énergie

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MEMORANDUM

4 October, 1995

TO: V. Mitchell
Environmental Assessment Evaluator
Environmental Approvals
Technical Support Section
Eastern Region

FROM: Gail McFall
Sr. Environmental Officer (Groundwater)
Technical Support Section
Eastern Region

RE: Application for Class A Licence - Aggregate Resources Act and Permit to Take Water
Applicant: Ferma Crushed Stone Inc., Carden Quarry
Lots 6, 7, 8, 9 & 10, Concession IX
Township of Carden, County of Victoria

I have reviewed the above-noted application and the accompanying hydrogeological report, dated April 1995, by Oliver Mangione McCalla and Associates Limited (OMMA) on behalf of the applicant. The OMMA report was prepared in support of applications for various licences and permits including the Class "A" Licence under the Aggregate Resources Act and the Permit to Take Water under the Ontario Water Resources Act. With respect to the groundwater concerns relevant to the licence and the permit applications for the Carden Quarry, I offer the following comments.

INFORMATION PROVIDED BY APPLICATION DOCUMENTS - GROUNDWATER

Background

The application is for a Class "A" Licence under the Aggregate Resources Act (ARA). This is a new quarry to be located on a site of approximately 348.5 ha but the extraction area is limited to two segments totalling 205 ha. The quarry will have an average depth of 32 m (elevation of 235 m asl.).

The site is approximately 5.7 km north of the Town of Kirkfield. The site is located approximately 1 km north of the Preston Quarry which is owned and operated by Kirkfield Aggregates Limited. Two residences located on-site are abandoned. Seven residences are adjacent to the site and an additional seven residences occur within

1.5 km of the site. The proposed quarry site lies between a tributary of Canal Lake, which is approximately 375 m to the northeast of the site, and the Talbot River, which is approximately 500 m to the southeast of the site. The Talbot River also empties in to Canal Lake. The site is surrounded by, and consists of, open pasture and woodlot/swamp.

The site is transected by two intermittent streams that flow westward and join to become a tributary of the Talbot River. The larger of the two streams splits the site into northerly and southerly sections. The land surface is variable characterized by gently rolling topography to the east and poorly drained wooded swamp, a wooded rocky knoll and open range to the west. The topography varies from 274 m asl. in the northwest corner to 270 m asl. in the southeast corner with an intervening diagonal depression (down to 262 m asl.) that corresponds with the location of the two intermittent streams.

Site plans are included in the OMMA report. The site plans illustrate the following: the extent of the site and a 500 m wide perimeter zone; the location of surface waters and the direction of surface drainage; the location of the two proposed excavations and the final quarry floor elevations with the quarry discharge and sump areas denoted; several cross-sections of the proposed quarry showing the top of bedrock, the elevations of the aquifers and the potentiometric levels of the underlying aquifers, and the final lake elevation; the location of water wells within 500 m of the site; and relevant well and groundwater information.

With respect to groundwater, the accompanying report illustrates and/or discusses the following: the location and characteristics of the groundwater aquifers; the location of water wells in the area; the results of pumping tests and the potential for interference with existing domestic water supplies; the results of water quality tests; and monitoring and contingency plans for groundwater interference when it occurs.

Geology

The proposed quarry site is underlain by rocks of, in descending order, the Middle Ordovician Black River and Trenton groups, which includes limestones of the Bobcaygeon and Gull River formations, the sandstones and shales of the Shadow Lake Formation and the Precambrian granites. The unconsolidated cover materials are till.

The surficial materials are generally thin (< 0.3 m) over much of the site. Only in the southeastern corner of the property does the overburden reach a thickness of between 2 and 5 m. The cover materials consist of gravels, sand, silt, and clay tills.

The upper part of the bedrock is formed by the Bobcaygeon Formation which consists of an upper 3 m thick medium to fine grained limestone with shale interbeds, a 6 to 7 m thick middle member of medium to fine grained limestone with minor calcareous limestone zones and rare shaley limestone beds, and a lower member consisting of 9 m of grey limestone overlying 3 m of light grey to brownish limestone. The contact between the Bobcaygeon Formation and the underlying Gull River Formation is

approximately 20 to 25 m below ground surface. The Gull River Formation consists of an upper 4 to 6 m thick limestone with shale/mudstone interbeds, a rare 1 m thick middle member of fine grained limestone, and a 8 to 10 m thick lower member of dolostone. The Gull River Formation is underlain by 2 to 4 m of quartz sandstones and dolomitic limestones of the Shadow Lake Formation. The Shadow Lake Formation, in turn, unconformably overlies the Precambrian basement.

Quarry Proposal

The proposed quarry will excavate into the lower member of the Gull River Formation. The quarry will consist of a larger northern segment (147 ha), to be developed in three phases, and a smaller southern segment (58 ha), to be developed in 2 phases. The northern part will be developed first and the excavation allowed to begin filling with water prior to the commencement of extraction activities in the southern part. Extraction of the resource would proceed by two sequential lifts to a total depth of between 30 and 36 m (average elevation 232 m asl.). The intent is to extract below the local water-bearing zones occurring between 15 to 20 m below ground surface (250-260 m asl.). The final water level in the abandoned quarry will be approximately 264 m asl. The projected life of the quarry is 110 years for the north part and 40 years for the south part, therefore a total of 150 years of operation.

HYDROGEOLOGY

Groundwater Conditions

Information on wells and the groundwater conditions was obtained by a house-to-house survey or from MOEE Water Well Records for the area. The OMMA report indicates that there are 22 wells within the 500 m radius of the site Four of these wells are dug wells; three dug wells are on-site and are no longer used for water supplies but will be maintained by the quarry as monitoring wells, and one well is approximately 100 m west of the southwestern part of the site and is used for watering livestock. Of the remaining 18 wells, 6 are domestic well supplies, 2 are unused domestic supply wells, 2 are unused livestock supply wells, 2 are test wells that were constructed for hydraulic testing, and 6 wells have been plugged and abandoned. All of the bedrock wells terminate within 15 m from ground surface or obtain water from fractures within 8 to 20 m from surface. Well yields range from 4.5 to 137 l/min. Five boreholes were drilled for the site investigation and three standpipe piezometers were installed in each borehole. These boreholes bring the number of wells within 500 m of the site to 27.

OMMA indicates that aquifers occur within the overburden, within the upper and middle members of the Bobcaygeon Formation at a depth of about 15 m from surface (250-260 m asl.) and in the lower parts of the limestone sequence at about 30-47 metres from surface (237-223 m asl.). The overburden has an unconfined aquifer that is limited to the 8% of the site where the overburden is > 2-3 m thick. The overburden aquifer

generally occupies a zone from 1 metre below surface to 1 to 2 m below the fractured bedrock surface. The direction of flow in the overburden aquifer is primarily controlled by the topography.

Figure 7 of the OMMA report illustrated the potentiometric surfaces for the two bedrock aquifer in the area of the quarry. The potentiometric surface for the upper bedrock aquifer varies from 262 m asl. in the southwestern part of the site near the tributary to the Talbot River to 272 m asl. in the northern part of the site. The potentiometric surface for the lower bedrock aquifer varies from 260 m asl. in the southwestern part of the site to 268 m asl. in the northeastern part of the site. The potentiometric surfaces of both bedrock aquifers converge at the Talbot River tributary stream which crosses the site. OMMA indicates that the stream is a groundwater discharge or groundwater recharge area for both the upper and lower groundwater aquifers depending on the season. OMMA suggests that the higher elevation areas to the north of the site where the vertical hydraulic gradients are between 0.005 and 0.008 m/m are groundwater recharge areas. Horizontal gradients of 0.004 to 0.008 m/m in the upper bedrock aquifer correspond with local surface drainage which is controlled by the topography. Horizontal gradient in the lower bedrock aquifer is 0.003 with flow toward the Talbot River/Trent-Severn Canal in the southwest. This flow direction corresponds with the regional direction of surface drainage.

OMMA considers the loss of 30 ha of watershed drainage area to the Canal Lake tributary and a corresponding increase to the water shed area due to quarry dewatering discharge to the Talbot River tributaries, which flow into Canal Lake, insignificant.

Pumping Test

Three multi-level piezometers were installed in the five exploratory boreholes drilled on-site. The piezometers were positioned to independently test the upper and lower bedrock aquifers (2-20 m depth and 30-44 m depth respectively) and the intervening rock sequence (20-30 m depth).

Two new wells that were drilled on-site and one existing well were used for pumping tests. One well (W21) was drilled to a depth of 15.2 m in order to isolate just the upper bedrock aquifer but no water was encountered during drilling. The second well (W22) was terminated at 43 m from surface in an attempt to intersect both the upper and lower bedrock aquifers, however water was only encountered at 20 m depth. OMMA indicated that they were unsuccessful at isolating the upper and lower bedrock aquifers due to the upper bedrock water bearing zone being deeper than anticipated. The existing well (W9) is 12.2 m deep and water was found at 7.2 and 10.8 m depth. This well encounters the upper bedrock aquifer only.

Slug and/or bail tests were conducted on each of the piezometers installed in the 5 bore holes and a bailing test was also conducted on test well W21 after static water levels had stabilized about 3 months after drilling. Hydraulic conductivity in the upper bedrock aquifer varies from 2×10^{-5} m/s in the southeastern part of the site to 2×10^{-7} m/s in the northwestern part of the site. Hydraulic conductivity of the lower bedrock aquifer varies from 10^{-5} to 10^{-8} m/s. The intervening zone of bedrock has a hydraulic conductivity of about one magnitude lower in the upland area to the northwest (3×10^{-8} m/s) that decreases slightly to 10^{-7} m/s in the northeast part of the site and on the west side of the site in the area near the Talbot River tributary and decreases to 4×10^{-6} m/s on the east side of the site in the area of the Talbot River tributary.

Pumping tests were conducted for 6 hours on each of two wells (W22, W9) located at the southern end of the site. Three pumps were installed in test well W22 with two pumps located at the base of the well (43 m depth) in the zone ascribed to the lower bedrock aquifer and one pump was set at 20 m depth, which corresponds to the base of the upper bedrock aquifer, approximately at the level that water was found in the well (20 m). The combined discharge from the pumps was 164 l/min after 1 hour of pumping and remained constant for the remaining 6 hours of the pumping test. Draw down of the static water level in the pumping well was 10.7 m and 96% recovery of the initial static water level was reached within 2.9 hours after the termination of pumping. Monitoring of the effects of the pumping was conducted in the following wells: bedrock wells W9 and W19 which are located 220 m and 440 m, respectively, away from the pumping well; the piezometers installed in Borehole #5 which is 210 m away from the pumping well; and in overburden wells W8, W11, and W12 which are located 250 m, 280 m, and 300 m, respectively, away from the pumping well. Draw down was measured in W9 (0.02 m), W8 (0.06 m), W11 (0.03 m) and in piezometers in Borehole #5 located in the upper bedrock aquifer (0.07 m) and lower bedrock aquifer (0.15 m). Draw down was not observed in W12 or W19.

Pumping on W9, which terminates in the upper bedrock aquifer, was initiated 19 hours after the completion of the pumping test on W22. The well was pumped for 6 hours at a constant rate of 86 l/min. Draw down of the static water level in the pumping well was 4.8 m and 98% recovery of the initial static water level was reached within 1.1 hours after the termination of pumping. Monitoring of the effects of the pumping was also conducted in drilled wells W22 and Borehole #5 which are located 210 m and 50 m, respectively, from the pumping well and in overburden well W8 which is located 30 m from the pumping well. A draw down of 0.7 m was observed in the upper bedrock aquifer piezometer of Borehole #5. The lower bedrock aquifer piezometer in Borehole #5 and the other monitoring wells exhibited no measurable draw down. Based on the results of the pumping test, OMMA estimated transmissivities at 1×10^{-2} m^2/s for the overburden aquifer, from 1×10^{-2} to 2×10^{-6} m^2/s for the upper bedrock aquifer, from 1×10^{-3} to 2×10^{-7} m^2/s for the lower bedrock aquifer, and 10^{-5} to 10^{-7} m^2/s for the intervening rock layer. Storativity for the overburden aquifer was calculated at 1×10^{-3} to 4×10^{-4}, at 1×10^{-6} to 6×10^{-5} for the upper bedrock aquifer, and at 1×10^{-4} for the lower bedrock aquifer.

OMMA suggests that the results of the hydrogeological testing indicates the following: that there is a connection between the overburden and bedrock aquifers at some locations, the upper bedrock aquifer is both confined and unconfined, hydraulic connection between the upper and lower bedrock aquifers could not be confirmed but are connected in the area of the Talbot River tributary and less likely in areas removed from the stream, lack of water in W21 displays the variable nature of the bedrock aquifer.

Discharge Of Groundwater

Dewatering of the quarry will be required due to the extension of the quarry through the upper bedrock aquifer and into the upper sections of the lower bedrock aquifer and due to seasonal accumulation of surface water derived from precipitation. Dewatering of the quarry will proceed with the pumping of water collected in the sumps into ditches that discharge the water to the Talbot River tributary that is on-site. It is expected that a average of 3,040 l/min will be removed from the north part of the quarry and an average of 1610 l/min will be removed from the south part.

Water Quality

OMMA obtained samples of the groundwater from one domestic well and from the pumping well. Samples were taken at the beginning and end of each pump test and analyzed for routine inorganic and microbiological parameters. Water samples taken from the domestic well are indicative of water quality of the upper bedrock aquifer, and those taken from the test well are a mixture of upper and lower aquifer waters.

OMMA reports that the results of water quality testing of the ground water samples indicate that the groundwater quality within the upper bedrock aquifer, which is the main water supply aquifer in the area, meets Ontario Drinking Water Objectives (ODWO). The quality of the combined upper and lower groundwater aquifer water samples, with the exception of iron at 0.48 mg/l which is very slightly elevated above the 0.3 mg/l objective, is within the ODWO. OMMA indicates it is unlikely that the groundwater quality will be affected by quarry activities as quarry dewatering operations will establish hydraulic gradients that stimulate groundwater flow toward the quarry.

OMMA cites the model Spill Control Plan published by the Aggregate Producers of Ontario as a model for on-site fuel storage and handling. OMMA recommends that fuel storage and handling only be carried out in locations designated on the site plan and, when ever possible, that refuelling occur off-site. Any fuel storage areas shall be located on concrete pads with containment curbs.

MONITORING AND CONTINGENCY PLANS

The proposed final depth of the quarry will be below the main water bearing zone that is the source for domestic water supplies in the area. OMMA indicates that a comprehensive monitoring program will be required to provide factual data on the draw down of groundwater levels that will occur during site development. Monitoring and contingency plans have been outlined in the hydrogeological report for the proposed quarry. OMMA suggests that water level monitoring should be implemented prior to, and during quarry dewatering operations.

OMMA recommends the installation of additional groundwater monitoring wells around the perimeter of the north part of the quarry prior to the installation of the dewatering works. OMMA also suggests that the northern part of the quarry be completed, decommissioned and flooding commenced prior to proceeding with the extraction in the south part of the quarry. A similar plan for the installation of monitoring wells is suggested for the south part of the quarry. The bilevel piezometers will be positioned to monitor 5.0 m below the proposed depth of extraction, in the lower bedrock aquifer, and at 15 m below ground surface, in the upper bedrock aquifer. One hundred and fifty millimetre diameter wells will extend to 5.0 m below the proposed depth of extraction and be open from bottom to ground surface. Water levels in monitoring wells, pumping rates, sump water levels and streamflow measurements are to be recorded on a monthly basis and the impact of dewatering activities is to be assessed annually.

Should an adverse affect occur, contingency measures proposed include modification of proposed extraction limits, re-injection of groundwater, and replacing affected wells with deeper wells. OMMA does not indicate the depth of the water bearing zone that will be targeted for these deeper wells.

IMPACT OF QUARRY ACTIVITIES ON GROUNDWATER

Given that the quarry activities will be conducted below the potentiometric surfaces of the ground water aquifers and will intersect the main water supply aquifer (upper bedrock aquifer) for the area, it is expected that draw down effects caused by dewatering activities will impact on area well yields. OMMA used a model to simulate the susceptibility of the surrounding domestic wells to lowering of the potentiometric surface of the bedrock aquifers.

Assuming that there is no hydraulic connection between the upper and lower bedrock aquifer, OMMA anticipates that the cone of influence for the upper bedrock aquifer will vary from 3 to 16 m of draw down at the site boundary and 1 to 8 m of draw down one kilometre from the site depending on which phase of the quarry is being developed. For the lower bedrock aquifer, it is anticipated that the draw down related to dewatering in the north part of the quarry will vary from 10 to 20 m at the site boundary. Draw down of the lower aquifer would not be noticeable if there is no connection between the upper

and lower bedrock aquifers. Should a connection exist, then according to OMMA the draw down in the lower aquifer would be less than predicted and the draw down in the upper aquifer would be increased as the lower aquifer would be recharged at the expense of the upper aquifer. Using a predictive model accommodating a hydraulic connection between the aquifers, OMMA predicts that the draw down in the neighbouring wells will range from 0 to 15 m at various stages of site development.

OMMA predicts that two domestic wells will be affected by dewatering of the north part of the quarry and several domestic wells would be affected by dewatering of the south part of the quarry. Modelling of the draw down effects indicated that there should be no adverse impact on the Talbot River tributary base flow but a gradual enhancement of the base flow due to quarry water discharge.

The report does not address the potential buckling of the quarry floor and the possible impact on the lower water bearing zone and any wells that utilize this aquifer, or are deepened into this zone as a result of previous interference.

GROUNDWATER CONCERNS AND COMMENTS

Concerns and comments with respect to the ARA Licence application and groundwater issues are as follows:

a) The information with respect to groundwater required by Section 8 and Section 9 of the ARA were satisfied by information contained in the site plans that were contained in the hydrogeological report and the report.

b) Seven active water wells and 4 unused water wells are located within 500 m of the proposed site. These wells obtain water either from the overburden aquifer or the upper bedrock aquifer lying between 2 and 20 m below ground surface. The unused wells and or those wells drilled for the hydrogeological investigations are to be maintained as monitoring wells for quarry dewatering operations.

c) The projected quarry floor is at approximately 30 to 36 m below ground surface (232 m asl.). Given that the main water bearing zone for water wells in the area ranges from 2 to 20 m below ground surface, then the quarry will penetrate main water bearing zone and therefore dewatering of the quarry will be necessary. OMMA acknowledges that there will be adverse affects to the yields of nearby water wells.

d) OMMA calculated that the average amount of water to be discharged from the quarry will be 3040 l/min (4,377,600 l/day) for the north part of the quarry and 1610 l/min (2,314,800 l/day) will be removed from the south part of the quarry. Given that the volume of water to be removed from the quarry is in excess of 50,000 l/day, then the quarry will require a Permit to Take Water in order to conduct de-watering operations. Application has made for a Permit to Take Water.

Concerns and comments with respect to the application for a Permit to Take Water and groundwater issues are as follows:

a) OMMA does not discuss the possible affect on recharge of the groundwater aquifers resulting from the presence of, and the dewatering activities associated with, the quarry. According to the potentiometric surface map (Figure 7) a groundwater divide/recharge zone for the upper bedrock aquifer is located in the northern part of the site and crosses part of the north quarry excavation.

b) The recharge zone for the lower bedrock aquifer is some distance to the east of the site however OMMA indicate that should a connection between the upper and lower bedrock aquifers exist, then the lower bedrock aquifer would be recharged at the expense of the upper bedrock aquifer thereby resulting in a greater draw down of the upper bedrock aquifer. This additional draw down, or "draining", could result in a larger cone of influence and therefore have a greater and/or more widespread affect on water well yields in the area.

c) The quarry will also penetrate approximately 6 m into the upper part of the lower bedrock aquifer which occurs 30-47 m (237-223 m asl.) from ground surface. Therefore dewatering operations will remove groundwater from both the upper and lower bedrock aquifers regardless of whether or not they are connected.

d) OMMA has not addressed the possibility and results of stress relief on the quarry floor. Removal of the confining load on subsurface rock units by quarrying can increase the likelihood of the formation of a pop-up in the quarry floor. In this case, the actual zone of deformation may extend through the 10 m of lower bedrock aquifer, or alternatively, the alteration and/or the decrease of the stresses in the rock may extend through the lower bedrock aquifer. Alteration and/or decrease of the stresses, either due to the formation of a pop-up or from removal of the overlying load, may result in an increase in the size of fracture openings caused by the relaxation of the stresses acting upon them. An increase in the size of the fracture openings would permit the passage of water under a hydrostatic head through the fractures. Given that the hydrostatic head for the lower bedrock aquifer is higher than the quarry floor, further breaching of the aquifer may cause an increased flow of groundwater into the quarry.

e) OMMA has demonstrated an interconnection between the overburden aquifer and the upper bedrock and, in places, the upper and lower bedrock aquifers. Given that the hydrostatic levels of both the upper and lower bedrock aquifers is well above the proposed quarry floor, dewatering activities and/or breaching of the lower bedrock aquifer and the accompanying increased inflow of groundwater into the quarry may cause a further "draining effect" on the surrounding area and possibly result in an increased quantity and areal extent of the draw down of the static water levels in all three aquifers.

f) Kirkfield Aggregates operates the Preston Quarry which is located approximately 750 m southwest of the site. The Preston Quarry is also excavating materials from a zone which includes the upper bedrock aquifer and therefore is conducting quarry dewatering operations. The hydrogeological report for the Preston Quarry, prepared by Terraspec, indicates that the cone of influence from quarry dewatering activities in the Preston Quarry could extend as far as 870 m away from the site. Thus the areas of the two zones of influence from the Preston and Carden quarries will overlap and possibly extend onto one another's sites (see attached map). Since OMMA requested and received a copy of the Terraspec report, OMMA is aware of this overlap situation. Within and immediately adjacent to this overlap area are 6, possibly 7, water wells that have been identified as possibly being affected by individual dewatering operations. The impact on well yields could be even greater due to the combined effects of operations in the two quarries .

g) As discussed in f) above, the areal extent of the cones of influence for the Preston and Carden quarries overlap in space. It is uncertain whether the cones of influence will overlap with respect to time. Both the Carden and Preston quarries will be initiating extraction operations in those parts of their respective sites that are farthest away from the cone of influence overlap area. Nevertheless, depending on the rate of progress of each quarry, there may come a time when both quarries are sufficiently close enough together to create an overlap of their respective cones of influence. Since neither the Terraspec report for the ARA Licence application nor the Terraspec report supporting the PTTW indicate the projected rate of quarry operations, the timing of possible interference cannot be determined.

h) OMMA has indicated that quarry dewatering operations could impact water wells up to 1 km away from the site. Under the terms of the PTTW, the applicant is responsible for rectification of any well interference including those that occur beyond the 500 m perimeter zone. Fourteen residences lie within 1.5 km of the site however it is not known how many water supply wells lie within this area.

i) OMMA has suggested a monitoring program for the quarry operations. The outline of the monitoring program does not address how the Carden Quarry will determine their responsibility with respect to interference with wells on the southwest side of the site. Water wells located between the Carden and Preston quarries could be impacted upon by dewatering operations in either quarry. Without a methodology for determining who is responsible for impacts on local water wells, the Carden Quarry may be required to rectify well interferences caused by the Preston Quarry dewatering operations.

j) Although a contingency plan was proposed, there is insufficient detail to determine the effectiveness of the plan, particularly in the light of the potential additional interference from dewatering operations in the Preston Quarry. Given OMMA tested only the limestone bedrock and not the Precambrian rocks, one can only assume that the plan to remediate affected wells to a deeper aquifer means deepening wells into the lower bedrock aquifer. Dewatering activities affecting a wider area and drawing water from the lower bedrock aquifer, either directly, through the leaky aquatard or through relaxed fractures resulting from stress relief, may impact on the domestic wells that are extended into the lower water-bearing unit as rectification of impacts from dewatering of the upper water-bearing zones.

With respect to groundwater related issues, the site plans and report submitted with the application for the Class A licence have provided the information required under the Aggregate Resources Act.

There are concerns with respect to groundwater related to the application for the Permit to Take Water. Given the expected impact on nearby wells, and possibly wells located up to 1 km away, a detailed contingency plan describing the rectifications to be carried out, the monitoring threshold at which the contingency plan will be triggered, and short- and long-term replacement plans (note: MOEE does not consider trucking of water a long-term solution) must be submitted to MOEE for approval prior to the issuing of the permit.

The applicant should be advised that under the terms of the permit, the applicant will be responsible for rectification of all wells affected by quarry dewatering activities, not just those that fall within 500 m of the site. Rectifying affected wells by deepening them into another aquifer which is also being dewatered by quarry operations is **not** an acceptable solution unless it can be clearly demonstrated that there will be no further interference with the wells. If the lower bedrock aquifer is to be maintained as an alternative groundwater supply by isolating it from the quarry by an interval of unexcavated rock, then the ability of the remaining rock layer to maintain the isolation of the lower bedrock aquifer from the quarry must be demonstrated.

It should also be determined whether and when each of the two cones of influence will extend into the overlap area. Should interference from the Carden Quarry's post-date the initiation of interference from the Preston Quarry operations, then the contingency plan should take into consideration and accommodate any remedial work carried out by the Preston Quarry such that there will be no further interference with the local water supply wells that have already been remediated by the Preston Quarry. The applicant (Carden Quarry) may wish to enter into discussions with Kirkfield Aggregates (Preston Quarry) on this matter.

G. McFall
GM/km
cc: GW 07-13 Carden Township
- TMS #26545 - ARA application
- TMS #26868 - PTTW application

Ontario

1-613/549-4000 1-800/267-0974 Fax: 613/548-6908

Ministry of Environment and Energy

Ministère de l'Environnement et de l'Énergie

133 Dalton Avenue
P O Box 820
Kingston ON K7L 4X6

133 avenue Dalton
C P 820
Kingston ON K7L 4X6

August 30, 1995

Oliver, Mangione, McCalla & Associates Limited
89 Colborne Street East
ORILLIA, Ontario
L3V 1T8

Attention: Jamieson Gourley

Dear Mr. Gourley:

Re: Permit to Take Water Application
Ferma-Carden Quarry

This will acknowledge receipt of your application dated August 3, 1995 regarding the above project. Please find enclosed the updated Permit To Take Water application, since the application you submitted is now obsolete.

Our screening of your submission has concluded that the proposal is subject to the requirements of Part II of the Environmental Bill of Rights, R.S.O. 1993, Chapter 28, (EBR). The EBR was proclaimed in February of 1994 and it allows the residents of Ontario to participate in decisions that have a significant effect on the environment.

Regulation 681/94 entitled "Classification of Proposals for Instruments" lists the types of proposals that are "prescribed" or subject under the EBR. Proposals for prescribed instruments became subject to the EBR on November 15, 1994.

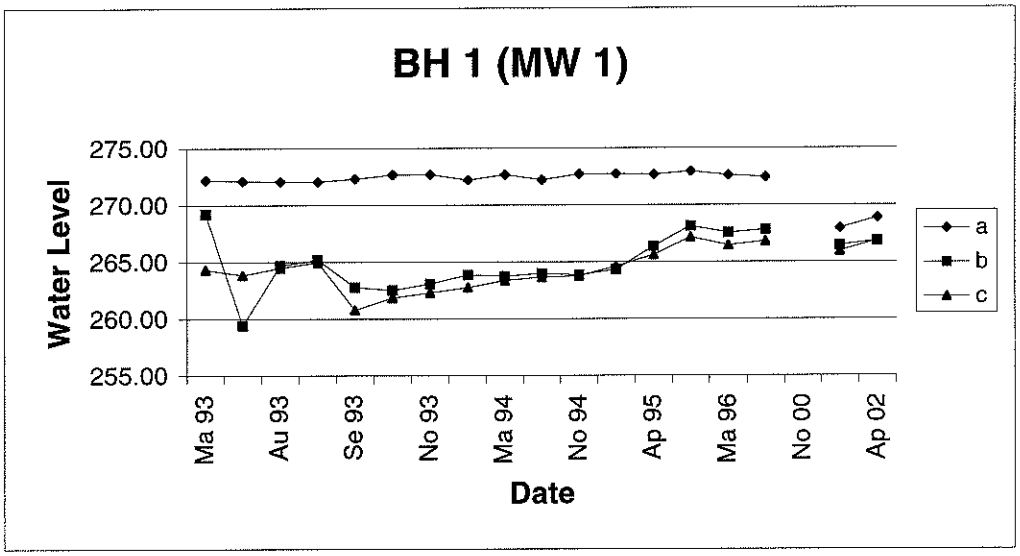
In order that the EBR requirements are met, we have attached copies of the new forms along with the guide on how to complete the forms. You are requested to complete the new form and to send it back to our office **along with a mandatory copy to the district office in the area of the proposal.** Please refer to the guides for explanatory notes on how to complete the new forms.

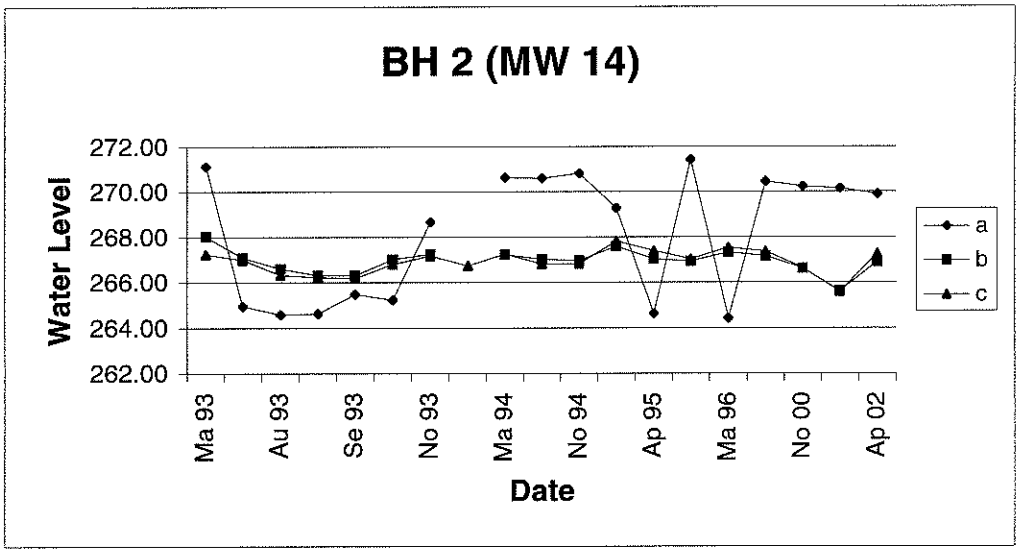
Completing the new form ensures that you are provided with an opportunity to indicate which of the supporting information is to be considered as proprietary and not subject to public viewing and to prepare a description of the proposal that will be put on the Registry. **We encourage you to clearly identify which of the information that you have submitted to us is considered as proprietary. If in doubt, you may request that we return your application for review and resubmission.**

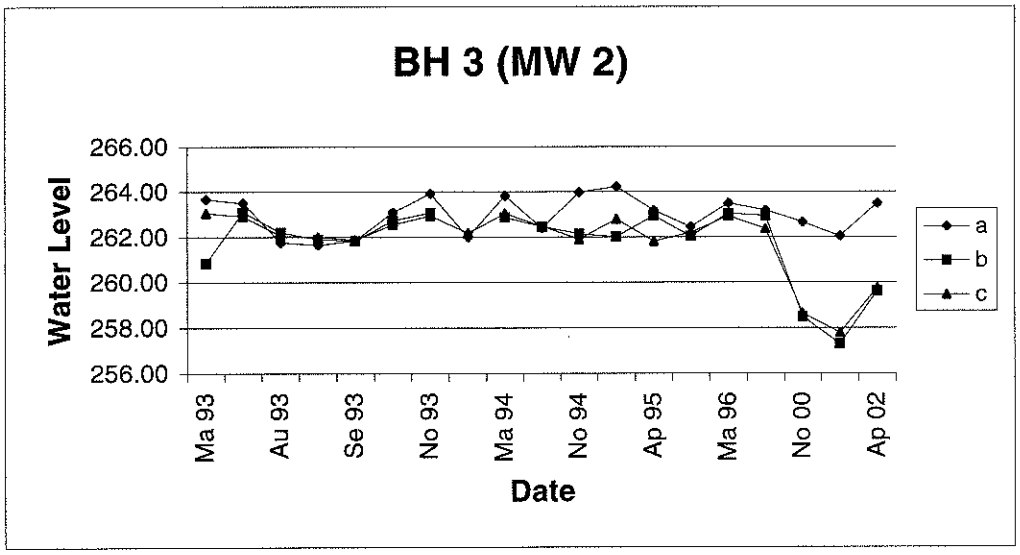
Appendix C:

Groundwater Monitoring Data

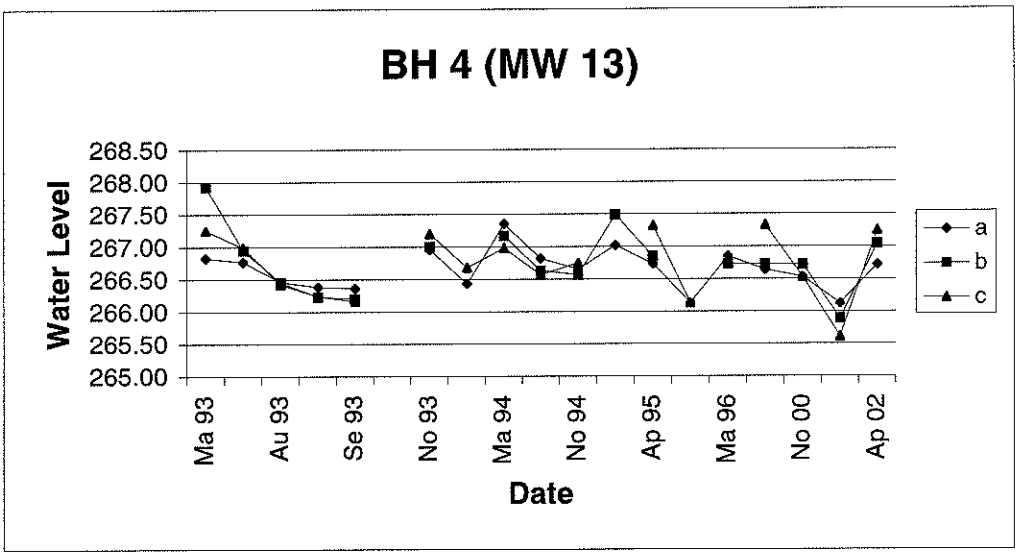
Monitoring Well Static Water Level Summary
Ferma Aggregates Inc. - Carden Quarry

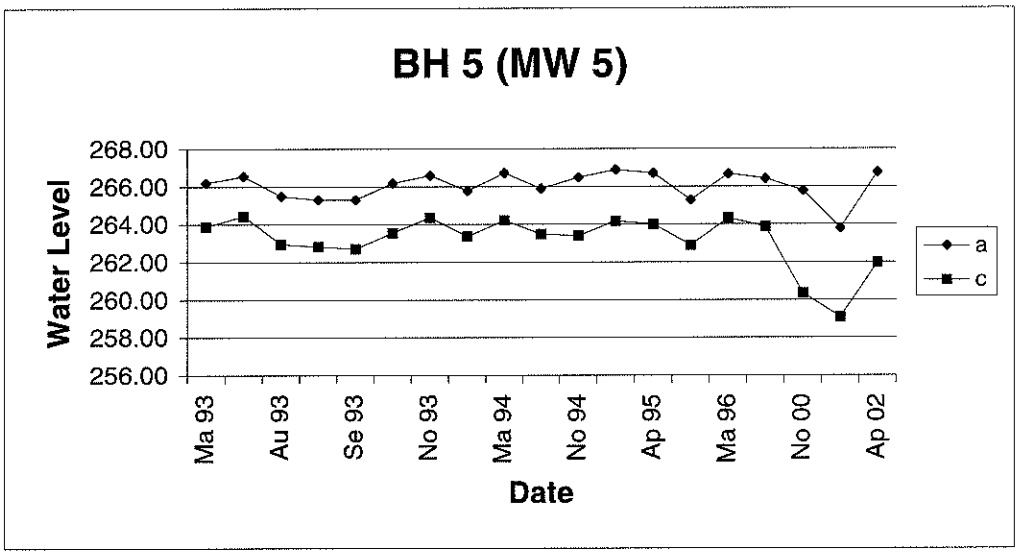






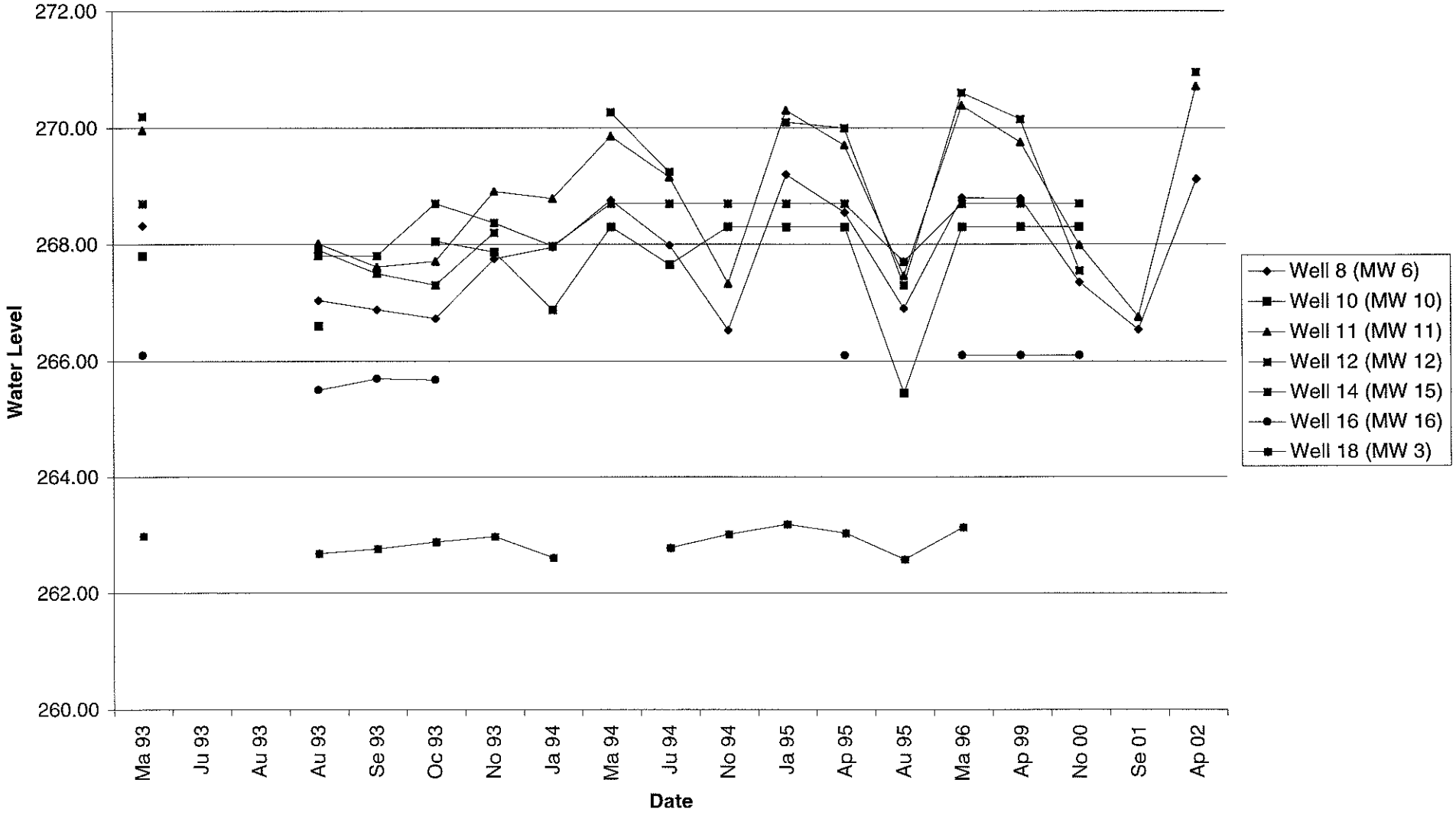
Monitoring Well Static Water Level Summary
Ferma Aggregates Inc. - Carden Quarry





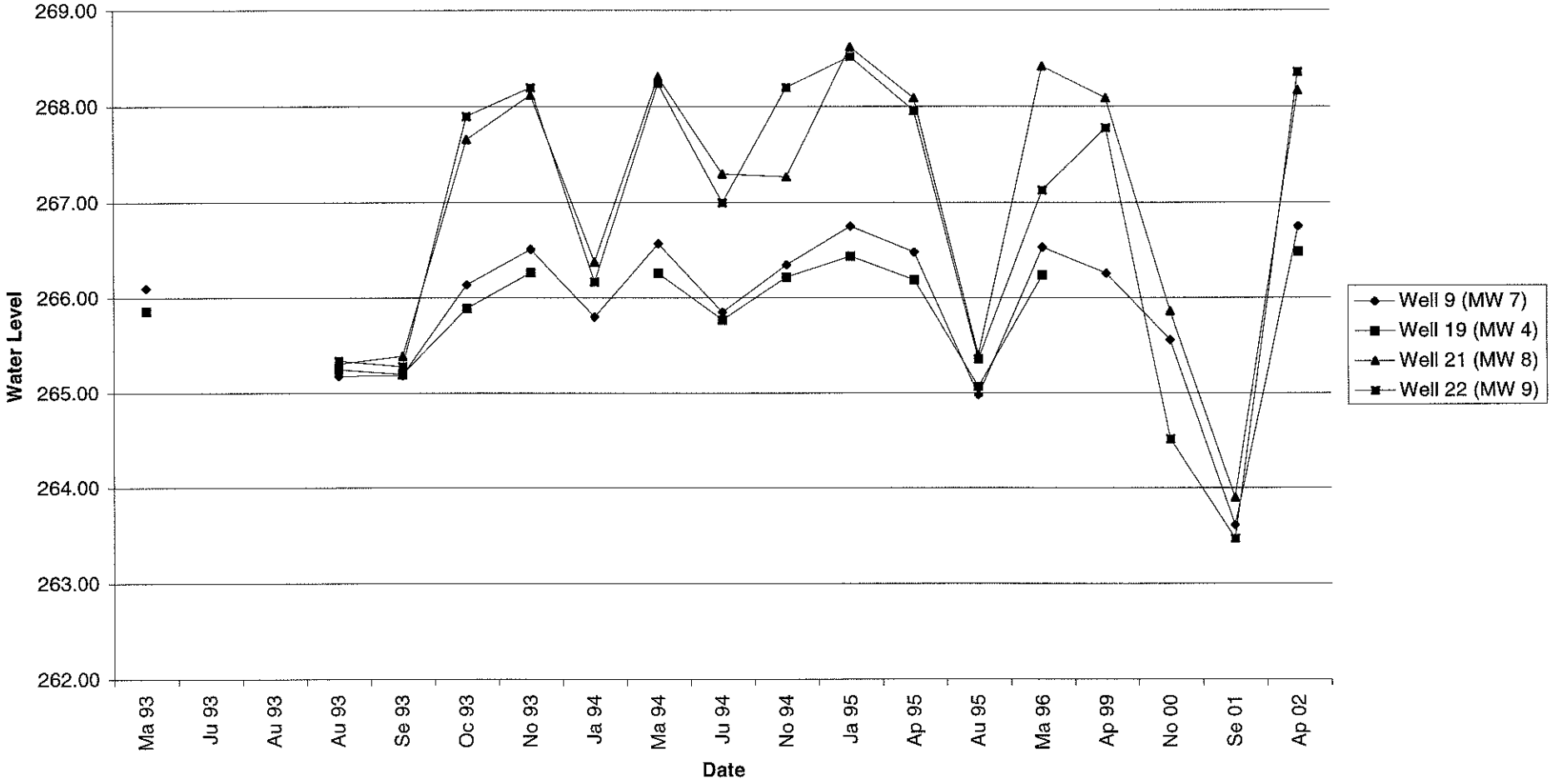
Hydrotechnical
Report Addendum
May 2002
92-8977

Monitoring Well Static Water Level Summary
Ferma Aggregates Inc. - Carden Quarry
Shallow/Dug Wells



Hydrotechnical
Report Addendum
May 2002
92-8977

Monitoring Well Static Water Level Summary
Ferma Aggregates Inc. - Carden Quarry
Drilled Wells



92-8977

Table B1
Monitoring Well Static Water Level Summary
Ferma Aggregates Inc. - Carden Quarry

Well No.	MW	Type	Description (Dia., material, tape, marks, etc.)	Recent Status (Sept. 2001)	Ground Elev. (m)	Well Depth (m)	Water Level Reference Point	Ref. Pt. Elevation (m)	Depth to Water Level from Reference Point Elevation (m)																				Depth to Water Level (m)			Elevation of Water Level (m)			Well No.
									1993							1994				1995			1996	1999	2000	2001	2002							
									May 11-18	June 8	Aug. 11	Aug. 27	Sept. 16	Oct. 13/14	Nov. 17/18	Jan. 20	May 4	June 21	Nov. 7	Jan. 24	April 3	Au./Se. 30/1	May 27	April 27	Nov. 10	Sept. 21	April 29	Avg.	Min.	Max.	Avg.	Min.	Max.	
BH 1a	1a	Drilled	25mm,PVC,tape	O.K.	273.2	12.3	T/Casing	274.15	1.95	2.03	2.07	2.09	1.85	1.47	1.44	1.95	1.48	1.94	1.43	1.43	1.49	1.20	1.55	1.71		6.21	5.26	1.96	1.20	6.21	272.19	272.95	267.94	BH 1a
1b	1b	Drilled	13mm,PE	O.K.	273.2	24.4	T/Casing	274.15	4.95	14.71	9.47	8.96	11.37	11.63	11.05	10.30	10.41	10.15	10.30	9.82	7.77	6.00	6.60	6.30		7.70	7.30	9.26	4.95	14.71	264.89	269.20	259.44	1b
1c	1c	Drilled	25mm,PVC	O.K.	273.2	44.4	T/Casing	274.15	9.83	10.31	9.66	9.17	13.36	12.30	11.85	11.40	10.78	10.51	10.39	9.55	8.54	7.00	7.69	7.33		8.19	7.26	9.87	7.00	13.36	264.28	267.15	260.79	1c
BH 2a	14a	Drilled	13mm,PE,tape	O.K.	271.3	9.1	T/Casing	272.23	1.10	7.28	7.64	7.61	6.74	7.00	3.57	ice	1.60	1.64	1.41	2.96	7.61	0.80	7.80	1.78	2.00	2.08	2.33	4.15	0.80	7.80	268.08	271.43	264.43	BH 2a
2b	14b	Drilled	13mm,PE	O.K.	271.3	24.4	T/Casing	272.23	4.20	5.14	5.62	5.92	5.92	5.21	4.98	ice	5.00	5.22	5.27	4.64	5.20	5.30	4.90	5.07	5.61	6.60	5.33	5.28	4.20	6.60	266.95	268.03	265.63	2b
2c	14c	Drilled	25mm,PVC	O.K.	271.3	41.5	T/Casing	272.23	4.99	5.25	5.91	6.00	6.05	5.42	5.06	5.50	4.98	5.42	5.41	4.41	4.84	5.20	4.70	4.86	5.59	6.64	4.97	5.35	4.41	6.64	266.88	267.82	265.59	2c
BH 3a	2a	Drilled	25mm,PVC,tape	O.K.	264.6	13.1	T/Casing	265.34	1.67	1.84	3.58	3.69	3.50	2.26	1.42	3.34	1.51	2.95	1.36	1.11	2.17	2.90	1.86	2.16	2.68	3.30	1.85	2.41	1.11	3.69	262.93	264.23	261.65	BH 3a
3b	2b	Drilled	13mm,PE	O.K.	264.6	29.0	T/Casing	265.34	4.50	2.25	3.13	3.44	3.51	2.61	2.27	ice	2.47	2.88	3.20	3.33	2.40	3.30	2.30	2.40	6.85	8.05	5.72	3.46	2.25	8.05	261.88	263.09	257.29	3b
3c	2c	Drilled	25mm,PVC	O.K.	264.6	41.5	T/Casing	265.34	2.29	2.43	3.28	3.34	3.47	2.79	2.40	3.16	2.30	2.87	3.44	2.54	3.52	3.15	2.41	2.98	6.70	7.55	5.59	3.37	2.29	7.55	261.97	263.05	257.79	3c
BH 4a	13a	Drilled	25mm,PVC,tape	O.K.	267.4	9.4	T/Casing	268.33	1.50	1.56	1.87	1.95	1.97		1.37	1.90	0.98	1.51	1.68	1.31	1.60	2.20	1.48	1.69	1.80	2.21	1.61	1.68	0.98	2.21	266.65	267.35	266.12	BH 4a
4b	13b	Drilled	13mm,PE	O.K.	267.4	24.4	T/Casing	268.33	0.40	1.38	1.88	2.10	2.13		1.33	ice	1.16	1.70	1.76	0.84	1.48		1.60	1.60	1.61	2.44	1.29	1.56	0.40	2.44	266.77	267.93	265.89	4b
4c	13c	Drilled	25mm,PVC	O.K.	267.4	41.5	T/Casing	268.33	1.08	1.34	1.91	2.09	2.17		1.13	1.65	1.35	1.76	1.58	ice	1.01	2.20		1.00	1.80	2.72	1.08	1.65	1.00	2.72	266.68	267.33	265.61	4c
BH 5a	5a	Drilled	25mm,PVC,tape,1 mark	O.K.	269.6	13.0	T/Casing	270.49	4.30	3.94	5.00	5.18	5.19	4.31	3.90	4.71	3.77	4.59	4.01	3.60	3.78	5.20	3.82	4.08	4.72	6.69	3.73	4.49	3.60	6.69	266.00	266.89	263.80	BH 5a
5b	5b	Drilled	13mm,PE	Blocked	269.6	27.4		270.49																										5b
5c	5c	Drilled	25mm,PVC,2 marks	O.K.	269.6	44.5	T/Casing	270.49	6.60	6.05	7.54	7.67	7.79	6.94	6.13	7.13	6.28	7.00	7.09	6.32	6.48	7.60	6.16	6.62	10.15	11.40	8.51	7.28	6.05	11.40	263.21	264.44	259.09	5c
7		Drilled	Hand Pump	Blocked/N.L.	265.5				0.00																		FL.							7
8	6	Dug	Hand Pump	O.K.	270.0	5.8	T/Wood Platform	270.00	1.68			2.96	3.12	3.27	2.25	2.05	1.24	2.02	3.47	0.80	1.45	3.10	1.20	1.21	2.65	3.46	0.88	2.25	0.80	3.47	267.75	269.20	266.53	8
9	7	Drilled	Open Casing	O.K.	269.8	12.8	T/Casing	270.23	4.13			5.05	5.04	4.09	3.72	4.43	3.66	4.38	3.88	3.48	3.75	5.25	3.70	3.97	4.67	6.62	3.48	4.36	3.48	6.62	265.87	266.75	263.61	9
10	10	Drilled	Hand Pump	O.K.	268.3	5.2	Ground Level	268.30	0.50			1.70		0.25	0.43	1.42	0.00	0.65	0.00	0.00	0.00	2.85	0.00	0.00	0.00		FL.	0.56	0.00	2.85	267.74	268.30	265.45	10
11	11	Dug	Hand Pump	O.K.	271.9	6.6	T/Wood Platform	271.86	1.90			3.85	4.25	4.15	2.95	3.07	2.00	2.70	4.53	1.56	2.15	4.40	1.48	2.10	3.87	5.10	1.15	3.13	1.48	5.10	268.73	270.38	266.76	11
12	12	Dug	Hand Pump	O.K.	272.0	5.0	Ground Level	272.00	1.80			4.10	4.50	4.70	3.80		1.73	2.75	dry	1.90	2.00	4.70	1.40	1.85	4.45	dry	1.05	3.05	1.40	4.70	268.95	270.60	267.30	12
13		Drilled	Wind Pump	Blocked																														13
14	15	Drilled	Wind Pump		268.7	1.6	Ground Level	268.70	0.00			0.90	0.90	0.00	0.33	0.73					0.00	1.00	0.00	0.00	0.00		FL.	0.35	0.00	1.00	268.35	268.70	267.70	14
15		Drilled	Wind Pump	Filled																														15
16	16	Drilled	Wind Pump	Filled	266.1		Ground Level	266.10	0.00			0.60	0.40	0.42		frozen					0.00		0.00	0.00	0.00		FL.	0.18	0.00	0.60	265.92	266.10	265.50	16
17		Drilled	150 mm Casing	Blocked/N.L.	261.8		T/Casing	262.71	1.68			1.90	1.80	1.74														1.78	1.68	1.90	260.93	261.03	260.81	17
18	3	Dug		Private	266.1	1.7	T/Casing	264.18	1.20			1.50	1.42	1.30	1.21	1.57		1.40	1.17	1.00	1.15	1.60	1.05					1.30	1.00	1.60	262.88	263.18	262.58	18
19	4	Drilled	150 mm Casing	O.K.		9.1	T/Casing	269.62	3.76			4.37	4.42	3.73	3.35		3.36	3.85	3.40	3.18	3.43	4.55	3.38				3.13	3.73	3.18	4.55	265.89	266.44	265.07	19
20		Drilled	150 mm Casing	Blocked																														20
21	8	Drilled	150 mm Casing	O.K.	270.9	15.2	T/Casing	271.80				6.49	6.41	4.14	3.68	5.42	3.49	4.50	4.53	3.18	3.71	6.40	3.38	3.71	5.94	7.90	3.63	4.86	3.18	7.90	266.94	268.62	263.90	21
22	9	Drilled	150 mm Casing	O.K.	271.1	42.7	T/Casing	272.11				6.77	6.83	4.21	3.91	5.94	3.87	5.11	3.91	3.59	4.15	6.75	4.98	4.33	7.60	8.64	3.75	5.37	3.59	8.64	266.74	268.52	263.47	22

N.L. - Not Located
FL. - Area around Well Flooded
BLK. - Blocked

Appendix D:

Climatic Data

ONTARIO/ONTARIO

ORILLIA
44° 37'N 79° 24'W 224 m

	JAN JAN	FEB FÉV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOÛT	SEP SEPT	OCT OCT	NOV NOV	DEC DÉC	YEAR ANNÉE	CODE CODE	
Daily Maximum Temperature	-4.5	-3.1	2.0	10.4	17.3	22.5	25.0	24.0	19.5	13.4	5.8	-1.2	10.9	8	Température Maximale Quotidienne
Daily Minimum Temperature	-15.0	-15.1	-8.9	-1.1	4.9	10.5	13.3	12.7	8.9	3.5	-2.1	-11.0	0.1	8	Température Minimale Quotidienne
Daily Temperature	**-9.7**	**-9.1**	**-3.5**	**4.7**	**11.1**	**16.5**	**19.2**	**18.4**	**14.2**	**8.5**	**1.9**	**-6.1**	**5.5**	**8**	**Température Quotidienne**
Standard Deviation, Daily Temperature	2.1	2.5	2.3	1.5	1.6	0.9	1.4	1.6	1.6	1.3	1.9	2.7	0.5	5	Écart Type de la Température Quotidienne
Extreme Maximum Temperature	15.6	10.6	25.6	29.4	33.3	36.7	40.0	37.8	34.4	28.9	25.0	20.0	40.0		Température Maximale Extrême
Years of Record	56	58	60	55	56	59	55	54	58	59	57	57			Années de Relèves
Extreme Minimum Temperature	-36.1	-35.6	-32.8	-21.1	-5.6	0.0	2.2	1.7	-4.4	-10.0	-22.8	-36.1	-36.1		Température Minimale Extrême
Years of Record	57	58	60	55	56	59	56	55	59	60	60	59			Années de Relèves
Rainfall	12.4	10.6	30.4	65.4	78.0	71.6	69.0	103.2	94.5	79.3	55.2	23.1	692.7	8	Chutes de Pluie
Snowfall	62.5	41.7	30.9	7.9	1.8	0.0	0.0	0.0	0.1	1.4	26.6	57.8	230.7	8	Chutes de Neige
Total Precipitation	**68.3**	**49.1**	**59.7**	**73.5**	**80.7**	**71.6**	**69.0**	**103.2**	**94.6**	**80.7**	**79.5**	**76.9**	**906.8**	**8**	**Précipitations Totales**
Standard Deviation, Total Precipitation	27.0	21.9	37.3	34.8	42.7	32.5	25.9	43.1	44.4	58.6	23.6	30.5	123.8	5	Écart Type des Précipitations Totales
Greatest Rainfall in 24 hours	29.2	25.9	45.7	36.6	41.9	86.1	95.8	147.3	66.5	61.0	53.6	34.0	147.3		Chute de Pluie Record en 24 heures
Years of Record	74	73	76	71	79	80	79	76	76	76	77	79			Années de Relèves
Greatest Snowfall in 24 hours	38.1	37.6	52.1	20.3	6.4	0.3	0.0	0.0	2.5	19.1	29.2	73.7	73.7		Chute de Neige Record en 24 heures
Years of Record	71	72	73	71	81	82	80	80	80	80	79	75			Années de Relèves
Greatest Precipitation in 24 hours	38.1	37.6	52.1	36.6	41.9	86.1	95.8	147.3	66.5	61.0	53.6	35.3	147.3		Précipitation Record en 24 heures
Years of Record	71	72	73	69	79	80	79	76	76	76	76	75			Années de Relèves
Days with Rain	2	2	5	10	11	11	10	11	12	12	10	4	100	8	Jours de Pluie
Days with Snow	12	9	7	2	0	0	0	0	0	0	5	11	46	8	Jours de Neige
Days with Precipitation	14	10	10	11	12	10	10	10	12	12	14	14	139	8	Jours de Précipitation

ORILLIA TS
44° 37'N 79° 25'W 219 m

Daily Maximum Temperature	-5.3	-6.7	2.5	9.1	18.4	21.7	25.5	23.8	19.1	11.3	5.7	-1.7	10.3	6	Température Maximale Quotidienne
Daily Minimum Temperature	-13.3	-16.6	-8.0	0.2	7.6	10.7	15.3	14.6	10.1	3.5	-1.2	-10.1	1.1	6	Température Minimale Quotidienne
Daily Temperature	**-9.3**	**-11.7**	**-2.8**	**4.6**	**13.0**	**16.2**	**20.4**	**19.2**	**14.6**	**7.4**	**2.3**	**-5.9**	**5.7**	**6**	**Température Quotidienne**
Standard Deviation, Daily Temperature	2.2	1.7	2.4	1.3	1.1	1.3	0.3	1.2	0.7	0.8	1.1	2.6	0.4	6	Écart Type de la Température Quotidienne
Extreme Maximum Temperature	9.0	4.5	16.0	21.0	32.5	33.2	34.0	32.0	30.0	24.0	18.0	11.0	34.0		Température Maximale Extrême
Years of Record	3	3	3	3	3	4	4	4	4	4	4	4			Années de Relèves
Extreme Minimum Temperature	-33.5	-37.0	-30.0	-10.0	-3.0	0.5	8.0	6.0	-1.5	-6.0	-19.0	-35.0	-37.0		Température Minimale Extrême
Years of Record	3	3	3	3	3	4	4	4	4	4	4	4			Années de Relèves
Rainfall	8.2	11.0	27.4	57.4	71.2	79.5	82.7	81.5	81.8	83.6	65.1	28.2	677.6	8	Chutes de Pluie
Snowfall	74.4	48.1	27.9	7.7	0.4	0.0	0.0	0.0	0.0	1.6	16.8	63.0	239.9	8	Chutes de Neige
Total Precipitation	**88.6**	**62.8**	**58.7**	**64.3**	**70.4**	**79.5**	**82.7**	**81.5**	**81.8**	**85.1**	**82.2**	**94.7**	**932.3**	**8**	**Précipitations Totales**
Standard Deviation, Total Precipitation	27.7	38.3	26.6	26.8	28.5	46.8	41.5	32.1	26.2	34.7	27.1	32.4	129.0	4	Écart Type des Précipitations Totales
Greatest Rainfall in 24 hours	15.7	31.8	34.0	32.1	38.9	57.7	104.0	57.9	51.4	43.8	35.0	26.9	104.0		Chute de Pluie Record en 24 heures
Years of Record	15	15	16	16	16	16	15	16	15	16	15	14			Années de Relèves
Greatest Snowfall in 24 hours	33.5	35.6	23.9	21.8	4.0	0.0	0.0	0.0	0.0	6.4	15.4	60.0	60.0		Chute de Neige Record en 24 heures
Years of Record	15	16	16	15	16	16	15	16	15	16	15	14			Années de Relèves
Greatest Precipitation in 24 hours	33.5	35.6	34.0	32.1	38.9	57.7	104.0	57.9	51.4	43.8	35.0	60.0	104.0		Précipitation Record en 24 heures
Years of Record	15	16	16	16	16	16	15	16	15	16	15	14			Années de Relèves
Days with Rain	2	2	5	10	11	11	10	10	12	12	11	4	100	8	Jours de Pluie
Days with Snow	15	10	7	2	0	0	0	0	0	0	4	13	51	8	Jours de Neige
Days with Precipitation	16	11	12	10	11	10	10	10	11	12	14	16	143	8	Jours de Précipitation

	JAN JAN	FEB FÉV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOÛT	SEP SEPT	OCT OCT	NOV NOV	DEC DÉC	YEAR ANNÉE	CODE CODE	
PETERBOROUGH															
44° 17'N 78° 19'W 194 m															
Daily Maximum Temperature	-3.9	-2.2	2.7	11.6	17.8	23.3	25.8	24.8	20.6	14.6	6.4	-1.4	11.7	3	Température Maximale Quotidienne
Daily Minimum Temperature	-13.2	-12.0	-6.7	0.7	6.1	11.7	14.2	12.8	9.3	3.5	-1.5	-9.6	1.3	3	Température Minimale Quotidienne
Daily Temperature	**-8.6**	**-7.1**	**-2.0**	**6.2**	**12.0**	**17.6**	**20.0**	**18.8**	**15.0**	**9.1**	**2.4**	**-5.5**	**6.5**	**3**	**Température Quotidienne**
Standard Deviation, Daily Temperature	2.6	2.4	2.0	1.4	1.8	1.2	1.4	1.3	1.5	1.4	1.7	2.7	0.6	3	Écart Type de la Température Quotidienne
Extreme Maximum Temperature	14.4	13.9	25.0	30.0	35.0	36.7	38.9	37.2	37.2	30.6	23.9	15.0	38.9		Température Maximale Extrême
Years of Record	83	86	85	85	85	84	84	86	84	86	86	83			Années de Relèves
Extreme Minimum Temperature	-37.8	-38.9	-31.1	-20.0	-7.2	-1.7	2.2	-2.8	-7.8	-14.4	-23.9	-39.4	-39.4		Température Minimale Extrême
Years of Record	82	82	84	86	84	85	84	83	83	84	85	82			Années de Relèves
Rainfall	18.5	10.6	27.4	55.7	76.9	75.3	66.1	70.5	71.1	62.6	55.2	26.7	616.6	8	Chutes de Pluie
Snowfall	45.2	42.4	23.4	7.3	0.2	0.0	0.0	0.0	0.0	1.1	13.9	37.9	171.4	8	Chutes de Neige
Total Precipitation	**63.6**	**52.1**	**51.2**	**63.5**	**78.3**	**75.3**	**66.1**	**70.5**	**71.8**	**64.3**	**70.9**	**65.4**	**793.0**	**8**	**Précipitations Totales**
Standard Deviation, Total Precipitation	14.3	22.6	18.2	27.3	29.9	37.0	31.5	24.7	36.6	44.9	20.4	20.2	110.6	4	Écart Type des Précipitations Totales
Greatest Rainfall in 24 hours	33.0	44.5	50.8	57.7	66.8	83.6	77.7	87.1	81.3	62.2	57.2	39.4	87.1		Chute de Pluie Record en 24 heures
Years of Record	93	95	93	95	97	97	96	97	96	97	98	91			Années de Relèves
Greatest Snowfall in 24 hours	66.0	40.6	55.9	23.4	15.2	0.0	0.0	0.0	2.5	15.2	27.9	30.5	66.0		Chute de Neige Record en 24 heures
Years of Record	93	95	97	97	98	98	97	99	99	98	97	93			Années de Relèves
Greatest Precipitation in 24 hours	66.0	44.5	57.9	65.3	66.8	83.6	77.7	87.1	81.3	62.2	61.5	43.2	87.1		Précipitation Record en 24 heures
Years of Record	93	95	94	96	97	97	96	97	96	97	96	92			Années de Relèves
Days with Rain	3	1	4	9	10	10	9	10	9	10	7	4	86	8	Jours de Pluie
Days with Snow	12	10	8	2	0	0	0	0	0	0	4	9	45	8	Jours de Neige
Days with Precipitation	14	11	12	10	10	10	9	10	9	10	12	13	130	8	Jours de Précipitation
PETERBOROUGH A															
44° 14'N 78° 21'W 191 m															
Daily Maximum Temperature	-3.5	-2.5	2.9	11.5	18.8	23.8	26.4	25.4	21.1	14.2	6.5	-1.0	12.0	8	Température Maximale Quotidienne
Daily Minimum Temperature	-15.0	-14.3	-7.8	0.3	5.3	9.7	12.0	10.8	6.8	1.6	-2.3	-10.9	-0.3	8	Température Minimale Quotidienne
Daily Temperature	**-9.3**	**-8.5**	**-2.5**	**6.0**	**12.1**	**16.8**	**19.2**	**18.1**	**14.0**	**7.9**	**2.1**	**-6.0**	**5.8**	**8**	**Température Quotidienne**
Standard Deviation, Daily Temperature	2.7	2.8	2.7	1.7	1.6	1.4	0.8	1.2	1.1	2.0	1.6	2.4	0.6	5	Écart Type de la Température Quotidienne
Extreme Maximum Temperature	11.1	9.5	22.1	27.8	31.7	31.7	35.2	33.9	33.3	28.9	22.8	13.3	35.2		Température Maximale Extrême
Years of Record	11	12	12	12	12	12	12	12	12	12	12	12			Années de Relèves
Extreme Minimum Temperature	-37.1	-37.8	-29.1	-15.0	-3.7	-0.7	4.4	0.0	-4.4	-9.4	-17.6	-33.9	-37.8		Température Minimale Extrême
Years of Record	11	12	12	12	12	12	12	12	12	12	12	12			Années de Relèves
Rainfall	14.2	21.2	35.9	64.0	56.6	60.4	77.9	74.2	73.7	59.0	52.8	40.5	630.4	8	Chutes de Pluie
Snowfall	35.3	31.5	23.3	6.5	0.2	0.0	0.0	0.0	0.0	1.1	15.9	38.6	152.4	8	Chutes de Neige
Total Precipitation	**44.1**	**48.9**	**62.9**	**71.8**	**57.1**	**60.4**	**77.9**	**74.2**	**72.9**	**59.9**	**69.4**	**74.3**	**773.8**	**8**	**Précipitations Totales**
Standard Deviation, Total Precipitation	17.5	32.8	28.6	21.3	23.1	26.8	37.4	36.4	32.9	26.3	20.5	25.6	84.6	5	Écart Type des Précipitations Totales
Greatest Rainfall in 24 hours	24.0	20.8	59.8	46.7	33.8	32.2	73.4	62.5	45.8	37.8	28.7	31.8	73.4		Chute de Pluie Record en 24 heures
Years of Record	11	12	12	12	12	12	12	12	12	12	12	12			Années de Relèves
Greatest Snowfall in 24 hours	18.9	22.9	18.5	16.8	1.5	0.0	0.0	0.0	0.0	7.6	14.5	19.8	22.9		Chute de Neige Record en 24 heures
Years of Record	11	11	12	12	12	12	12	12	12	12	12	12			Années de Relèves
Greatest Precipitation in 24 hours	32.3	27.2	61.3	46.7	33.8	32.2	73.4	62.5	45.8	37.8	28.7	39.4	73.4		Précipitation Record en 24 heures
Years of Record	11	11	12	12	12	12	12	12	12	12	12	12			Années de Relèves
Days with Rain	4	5	7	11	12	10	10	10	11	12	11	7	110	8	Jours de Pluie
Days with Snow	15	11	7	3	0	0	0	0	0	1	6	14	57	8	Jours de Neige
Days with Precipitation	16	13	12	12	12	10	10	10	11	12	15	17	150	8	Jours de Précipitation

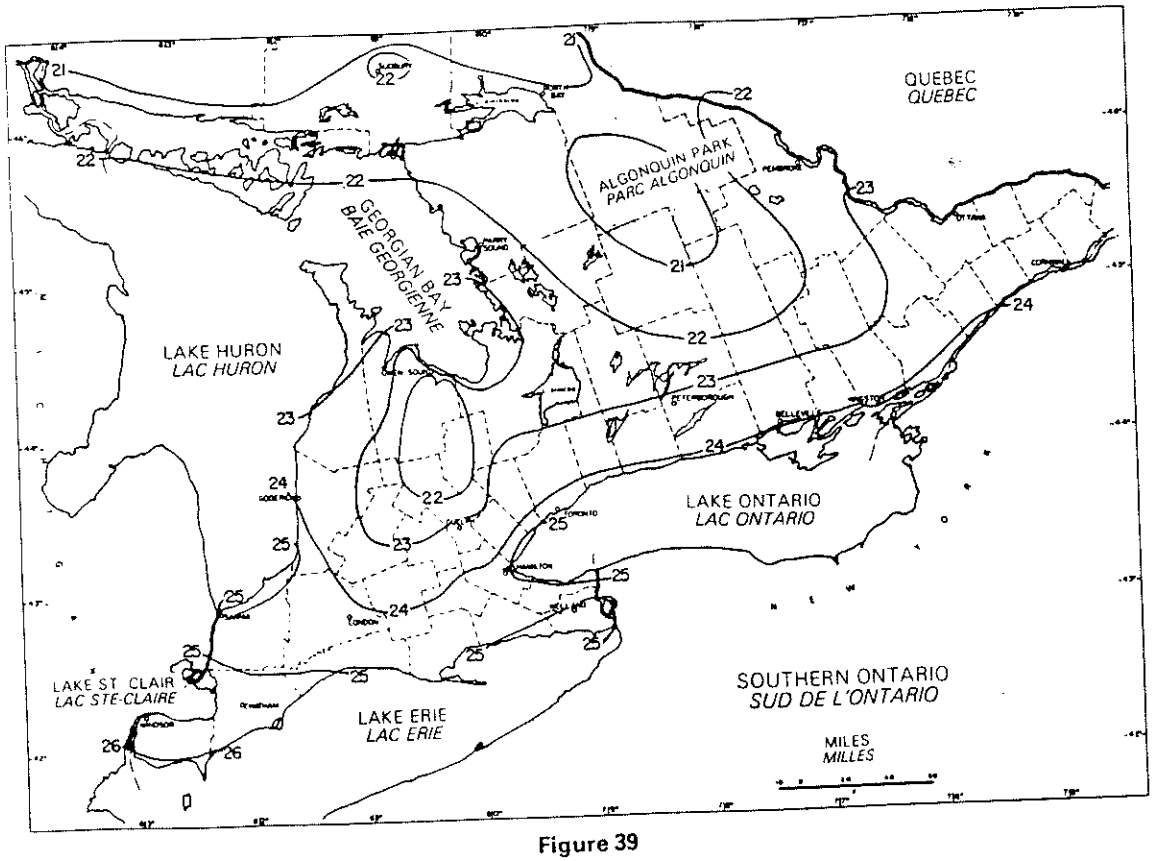


Figure 39

Mean annual potential evapotranspiration (inches)
Évapotranspiration potentielle annuelle moyenne (pouces)

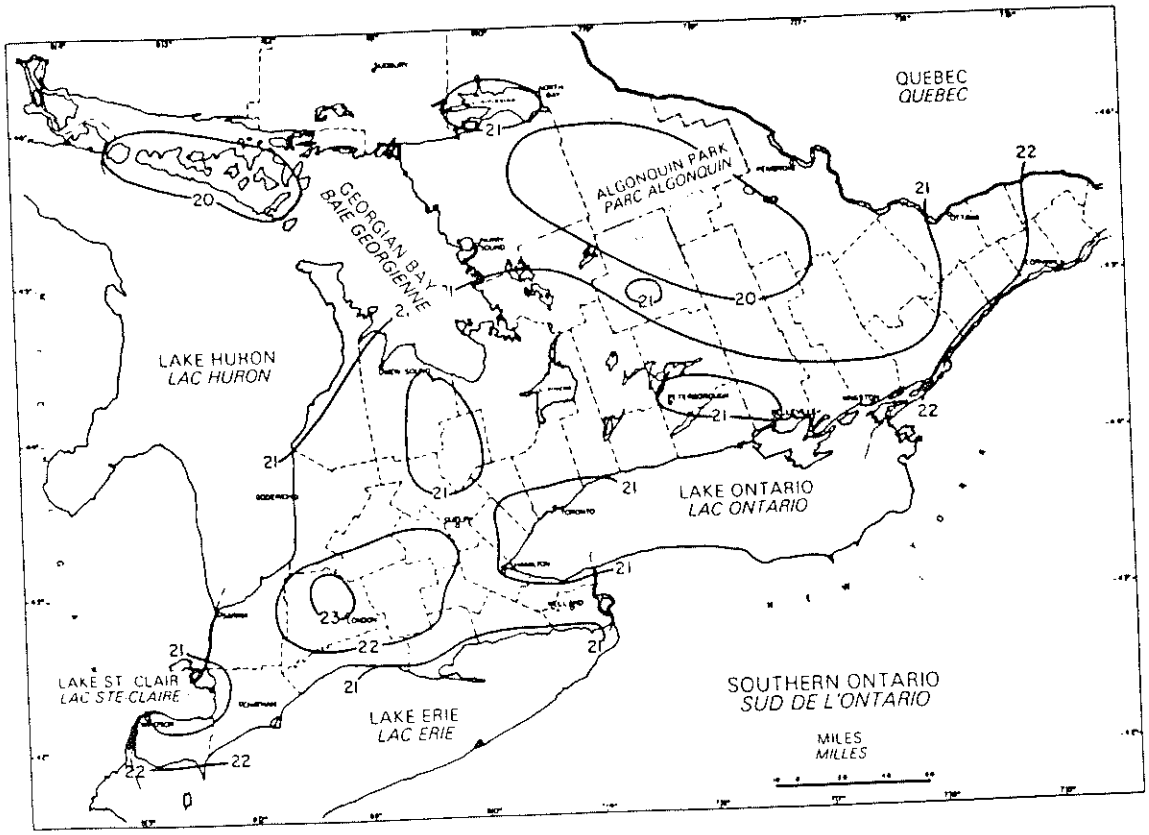


Figure 40

Mean annual actual evapotranspiration (inches) (4 inches storage)
Évapotranspiration réelle annuelle moyenne (pouces) (accumulation de 4 pouces)

CALCULATED LAKE EVAPORATION (MM) 1951-80
EVAPORATION CALCULÉE DU LAC (MM) 1951-80

TABLE 2
TABLEAU 2

		JAN JAN	FEB FÉV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOÛT	SEP SEPT	OCT OCT	NOV NOV	DEC DÉC	
MANITOBA MANITOBA														
THOMPSON A	MEAN						123.6	132.4	107.0	53.5				MOYENNE
	SD						11.8	8.6	17.3	8.9				ET
WILSON CREEK WEIR	MEAN					113.0	109.6	122.4	100.9	59.5	42.4			MOYENNE
	SD					28.7	14.5	11.0	17.8	11.5	3.8			ET
WINNIPEG INT'L A	MEAN					147.7	159.2	169.1	141.6	100.1	63.8			MOYENNE
	SD					24.9	20.0	16.5	20.2	19.9	15.7			ET
WINNIPEG STP	MEAN					118.8	155.9	158.0	132.6	88.1				MOYENNE
	SD					18.1	37.4	15.7	20.2	14.6				ET
ONTARIO ONTARIO														
ATIKOKAN	MEAN					109.6	110.8	128.2	100.5	64.8	39.6			MOYENNE
	SD					23.7	14.1	12.3	11.1	8.4	4.2			ET
BLUE SPRINGS CREEK	MEAN					98.9	115.1	140.4	112.3	71.6	42.0			MOYENNE
	SD					16.0	14.3	15.1	11.0	7.5	9.1			ET
BOWMANVILLE MOSTERT	MEAN					114.9	123.5	142.1	119.3	76.7	48.2			MOYENNE
	SD					16.6	8.7	16.1	14.2	9.7	2.8			ET
BURKETON MCLAUGHLIN	MEAN					94.0	120.1	127.8	109.4	68.5	43.3			MOYENNE
	SD					12.5	12.3	9.2	12.7	7.8	5.0			ET
CAMERON FALLS	MEAN						112.6	123.0	90.6	53.2				MOYENNE
	SD						8.8	13.3	9.5	7.2				ET
DELHI CDA	MEAN					115.5	133.2	141.9	118.0	80.4	49.0			MOYENNE
	SD					24.4	11.2	7.4	16.1	10.5	5.8			ET
ELORA RESEARCH STN	MEAN				77.8	116.5	132.6	142.8	117.3	75.1	43.3			MOYENNE
	SD				1.7	18.7	12.7	10.8	11.3	13.0	5.1			ET
GUELPH OAC	MEAN					122.4	138.4	148.8	118.0	78.3	48.0			MOYENNE
	SD					16.1	18.3	20.0	14.4	8.8	13.2			ET
HAMILTON RBG	MEAN				97.9	111.0	124.6	143.5	123.3	81.3	46.2			MOYENNE
	SD				9.4	15.7	15.0	18.5	17.0	22.2	9.3			ET
HARROW CDA	MEAN				100.8	128.9	147.8	154.1	127.5	92.8	65.9			MOYENNE
	SD				9.5	21.9	12.9	16.7	11.4	13.9	6.5			ET
HARTINGTON IHD	MEAN					102.0	118.4	138.2	120.2	72.9	42.5			MOYENNE
	SD					16.9	16.0	13.3	14.9	10.1	3.3			ET
HORNBY	MEAN					111.4	124.9	151.4	129.0	80.0	49.2			MOYENNE
	SD					18.7	9.6	14.8	12.4	10.7	7.8			ET
KEMPTVILLE	MEAN					123.1	125.3	130.2	113.4	70.8	49.3			MOYENNE
	SD					21.6	10.4	20.2	13.4	6.9	9.8			ET
LANGTON	MEAN					123.9	137.5	155.4	137.8	88.0	35.8			MOYENNE
	SD					21.4	18.0	13.0	18.5	12.6	26.5			ET
LANSDOWNE HOUSE	MEAN					86.9	98.2	105.8	83.7	48.4				MOYENNE
	SD					14.6	16.1	9.6	9.0	12.7				ET
LINDSAY FROST	MEAN					118.1	130.7	149.5	146.3	79.9				MOYENNE
	SD					19.7	5.5	26.9	48.4	25.1				ET

Design Chart 1.07: Runoff Coefficients (Continued)

- Rural

Land Use & Topography[3]	Soil Texture		
	Open Sand Loam	Loam or Silt Loam	Clay Loam or Clay
CULTIVATED Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	 0.22 0.30 0.40	 0.35 0.45 0.65	 0.55 0.60 0.70
PASTURE Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	 0.10 0.15 0.22	 0.28 0.35 0.40	 0.40 0.45 0.55
WOODLAND OR CUTOVER Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	 0.08 0.12 0.18	 0.25 0.30 0.35	 0.35 0.42 0.52
BARE ROCK	COVERAGE[3]		
	30%	50%	70%
Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.40 0.50 0.55	0.55 0.65 0.70	0.75 0.80 0.85
LAKES AND WETLANDS	0.05		

[2] Terrain Slopes

[3] Interpolate for other values of % imperviousness

Sources: American Society of Civil Engineers - ASCE (1960)
U.S. Department of Agriculture (1972)

Appendix E:

Niblett Environmental Survey
Talbot River Tributary

Reach/Site Card

Location	**Talbot River Tributary**								
Project #	**93-032**	Reach	**8**	Photo		Date	**05/Jul/93**	Time	**1000**

Substrata Composition			Stream Morphology		Terrain Characteristics		Instream Cover	
	Stream	Bank	(#) % of Reach		Cultivated		Cut Bank	
Bedrock			Riffle		Pasture		Boulder	
Boulder			Pool		Meadow		Logs&Trees	
Rubble			Run		Upland deciduous		Organic	
Gravel			Flat	**B. pond**	Upland coniferous		Macrophyte	**30 %**
Sand			Length		Swamp deciduous	✓	Combined	
Silt			Width		Swamp coniferous	✓	No cover	
Clay			Depth		Shrub meadow		Overhead Cover	
Muck	**100 %**		Bank Stability		Open meadow		Dense	
Detritus			**High**		Lawn		Partly open	
Marl					Other		Open	**100 %**

Vegetation	
Aquatic	Terrestrial
Coontail	**Grasses**
Arrowhead	**Sedges**
Pondweeds	
Canada w.w.	
Duckweed	
Musk grass	
Cattail	
Bulrush	

Crossectional Profile

Left (facing upstream) Right

Additional Comments:

- a large pond created by beaver activity and road crossing

- Canada w.w - Canada waterweed

* If found please contatct NIBLETT ENVIRONMENTAL ASSOCIATES INC. (705) 277-1929
P.O. Box 160 Bethany, Ontario. L0A 1A0. THANK YOU.

Reach/Site Card

Location	**Talbot River Tributary**								
Project #	**93-032**	Reach	**1**	Photo		Date	**05/Jul/93**	Time	**1400**

Substrata Composition			Stream Morphology		Terrain Characteristics		Instream Cover	
	Stream	Bank	(#) % of Reach		Cultivated		Cut Bank	
Bedrock			Riffle	**(2) 20%**	Pasture	✓	Boulder	
Boulder			Pool	**(1) 10%**	Meadow		Logs&Trees	
Rubble	**10 %**		Run		Upland deciduous		Organic	
Gravel	**10 %**		Flat	**(2) 70%**	Upland coniferous		Macrophyte	
Sand	**70 %**		Length		Swamp deciduous		Combined	**30 %**
Silt			Width	**1.5m**	Swamp coniferous		No cover	
Clay			Depth	**0.1m**	Shrub meadow		Overhead Cover	
Muck	**10 %**		Bank Stability		Open meadow		Dense	
Detritus			**Moderate to Low**		Lawn		Partly open	
Marl					Other		Open	**100 %**

Vegetation	
Aquatic	Terrestrial
Cattail	**Grasses**
Bulrush	
Arrowhead	
Watercress	
Coontail	

Crossectional Profile

Left (facing upstream) Right

Additional Comments:

- **cattle had access to this entire reach**
- **all locations of erosion were caused by cattle**

* If found please contatct NIBLETT ENVIRONMENTAL ASSOCIATES INC. (705) 277-1929
P.O. Box 160 Bethany, Ontario. L0A 1A0 THANK YOU

Reach/Site Card

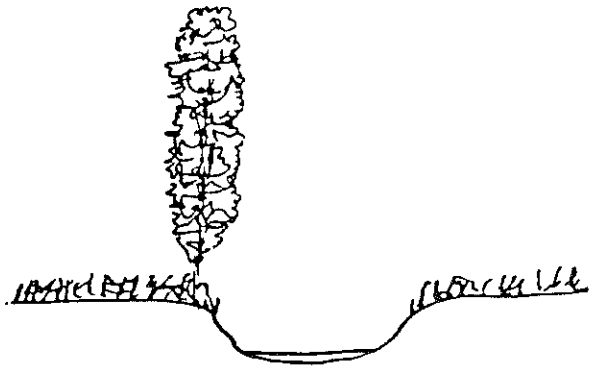
Location	Talbot River Tributary								
Project #	93-032	Reach	2	Photo		Date	05/Jul/93	Time	0830

Substrata Composition			Stream Morphology		Terrain Characteristics		Instream Cover	
	Stream	Bank	(#) % of Reach		Cultivated		Cut Bank	5%
Bedrock			Riffle	(2) 5%	Pasture	✓	Boulder	
Boulder			Pool		Meadow		Logs&Trees	10%
Rubble	5 %		Run		Upland deciduous		Organic	
Gravel	10 %		Flat	(2) 95%	Upland coniferous		Macrophyte	
Sand	75 %		Length		Swamp deciduous	✓	Combined	
Silt			Width	1.0m	Swamp coniferous	✓	No cover	
Clay			Depth	0.1m	Shrub meadow		Overhead Cover	
Muck			Bank Stability		Open meadow		Dense	5%
Detritus			Moderate to Low		Lawn		Partly open	
Marl					Other		Open	95 %

Vegetation	
Aquatic	Terrestrial
Duckweed	Grasses
Bulrush	Cedar
Arrowhead	Maple
Watercress	Ferns
Coontail	Alder
	Sedges

Crossectional Profile

Left (facing upstream) Right



Additional Comments:

- cattle had access to this entire reach
- all locations of erosion were caused by cattle

* If found please contatct NIBLETT ENVIRONMENTAL ASSOCIATES INC. (705) 277-1929
P.O. Box 160 Bethany, Ontario. L0A 1A0. THANK YOU.

Reach/Site Card

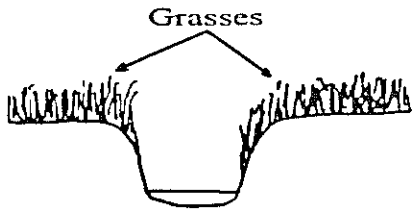
Location	Talbot River Tributary								
Project #	93-032	Reach	3	Photo		Date	05/Jul/93	Time	0845

Substrata Composition			Stream Morphology		Terrain Characteristics		Instream Cover	
	Stream	Bank	(#) % of Reach		Cultivated		Cut Bank	2%
Bedrock			Riffle		Pasture		Boulder	
Boulder			Pool		Meadow	✓	Logs&Trees	
Rubble			Run		Upland deciduous		Organic	
Gravel	5 %		Flat	(1) 100%	Upland coniferous		Macrophyte	
Sand	90 %		Length		Swamp deciduous	✓	Combined	10 %
Silt	5 %		Width	0.75m	Swamp coniferous	✓	No cover	
Clay			Depth	0.25m	Shrub meadow		Overhead Cover	
Muck			Bank Stability		Open meadow		Dense	
Detritus			Moderate to High		Lawn		Partly open	
Marl					Other		Open	100 %

Vegetation	
Aquatic	Terrestrial
Duckweed	Grasses
Bulrush	Cedar
Watercress	Maple
	Ash
	Alder
	Sedges

Crossectional Profile

Left (facing upstream) Right



Additional Comments:

- cattle had access to this entire reach
- 4 springs observed draining to creek
- in some locations the terrestrial grasses have completely overgrown the creek

* If found please contatct NIBLETT ENVIRONMENTAL ASSOCIATES INC. (705) 277-1929
P.O. Box 160 Bethany, Ontario. L0A 1A0. THANK YOU

Reach/Site Card

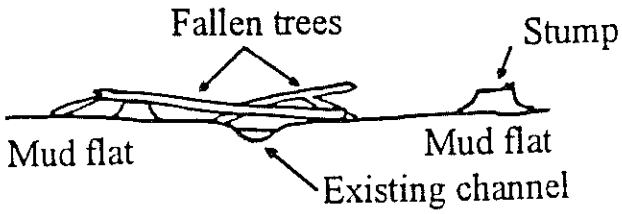
Location	Talbot River Tributary								
Project #	93-032	Reach	4	Photo		Date	05/Jul/93	Time	0900

Substrata Composition			Stream Morphology		Terrain Characteristics		Instream Cover	
	Stream	Bank	(#) % of Reach		Cultivated		Cut Bank	
Bedrock			Riffle		Pasture		Boulder	
Boulder			Pool		Meadow	✓	Logs&Trees	5 %
Rubble			Run		Upland deciduous		Organic	
Gravel			Flat	(1) 100%	Upland coniferous		Macrophyte	30 %
Sand	50 %		Length		Swamp deciduous	✓	Combined	
Silt			Width	1.0m	Swamp coniferous	✓	No cover	
Clay			Depth	0.1m	Shrub meadow		Overhead Cover	
Muck	50 %		Bank Stability		Open meadow		Dense	
Detritus			Moderate		Lawn		Partly open	
Marl					Other		Open	100 %

Vegetation	
Aquatic	Terrestrial
Cattail	**Grasses**
Bulrush	**Sedges**
Watercress	
Coontail	

Crossectional Profile

Left (facing upstream) Right



Additional Comments:

- **creek meanders through valley of old beaver pond, surrounding soils are completely saturated and soft to a depth of 0.3m**
- **several sections of the creek completely overgrown with coontail**

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Reach/Site Card

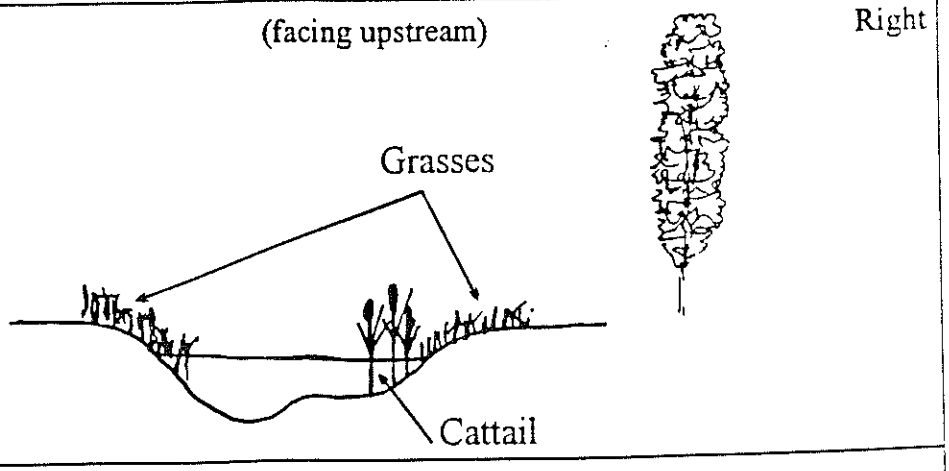
Location	Talbot River Tributary								
Project #	93-032	Reach	5	Photo		Date	05/Jul/93	Time	0915

Substrata Composition			Stream Morphology		Terrain Characteristics		Instream Cover	
	Stream	Bank	(#) % of Reach		Cultivated		Cut Bank	
Bedrock			Riffle		Pasture		Boulder	
Boulder			Pool		Meadow		Logs&Trees	
Rubble			Run		Upland deciduous		Organic	
Gravel			Flat	**B. pond**	Upland coniferous		Macrophyte	**30 %**
Sand			Length		Swamp deciduous	✓	Combined	
Silt			Width		Swamp coniferous	✓	No cover	
Clay			Depth		Shrub meadow		Overhead Cover	
Muck	**100 %**		Bank Stability		Open meadow		Dense	
Detritus			**High**		Lawn		Partly open	
Marl					Other		Open	**100 %**

Vegetation

Aquatic	Terrestrial
Cattail	**Grasses**
Bulrush	**Sedges**
Watercress	**Alder**
Coontail	**Maple**
Pondweeds	**Cedar**
Duckweed	

Crossectional Profile



Additional Comments:

- **beaver pond complex made up of at least three seperate dams**
- **deep open water adjacent to upstream side of dams**
- **upstream portions of beaver ponds flood large fields of grasses and sedges, water depth averages 0.25 meters with width averaging 10 meters**

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Reach/Site Card

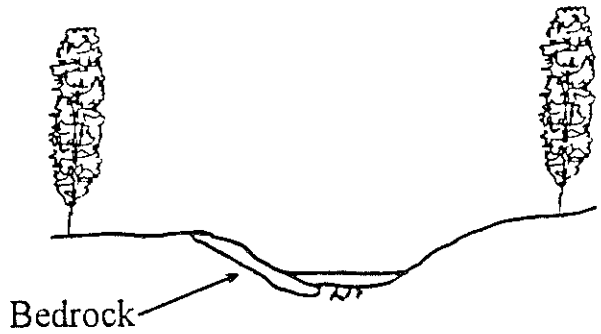
Location	Talbot River Tributary								
Project #	93-032	Reach	6	Photo		Date	05/Jul/93	Time	0930

Substrata Composition			Stream Morphology		Terrain Characteristics		Instream Cover	
	Stream	Bank	(#) % of Reach		Cultivated		Cut Bank	
Bedrock	90 %		Riffle		Pasture		Boulder	
Boulder			Pool		Meadow	✓	Logs&Trees	
Rubble			Run	(1) 100%	Upland deciduous	✓	Organic	
Gravel			Flat		Upland coniferous	✓	Macrophyte	10 %
Sand			Length		Swamp deciduous		Combined	
Silt	5 %		Width	0.50m	Swamp coniferous		No cover	
Clay			Depth	0.10m	Shrub meadow		Overhead Cover	
Muck			Bank Stability		Open meadow		Dense	
Detritus			High		Lawn		Partly open	
Marl					Other		Open	100 %

Vegetation	
Aquatic	Terrestrial
	Grasses
	Sedges

Crossectional Profile

Left (facing upstream) Right



Additional Comments:

- water flowing over bedrock
- cattle access, little erosion due to bedrock
- creek choked with cladophora in several locations

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Reach/Site Card

Location	**Talbot River Tributary**								
Project #	**93-032**	Reach	**7**	Photo		Date	**05/Jul/93**	Time	**0945**

Substrata Composition			Stream Morphology		Terrain Characteristics		Instream Cover	
	Stream	Bank	(#) % of Reach		Cultivated		Cut Bank	
Bedrock	**90 %**		Riffle		Pasture		Boulder	
Boulder			Pool		Meadow	✓	Logs&Trees	
Rubble			Run	**(1) 100%**	Upland deciduous		Organic	
Gravel			Flat		Upland coniferous		Macrophyte	**30 %**
Sand	**40 %**		Length		Swamp deciduous		Combined	
Silt			Width	**0.50m**	Swamp coniferous		No cover	
Clay			Depth	**0.10m**	Shrub meadow		Overhead Cover	
Muck	**60 %**		Bank Stability		Open meadow		Dense	
Detritus			**High**		Lawn		Partly open	
Marl					Other		Open	**100 %**

Vegetation	
Aquatic	Terrestrial
Coontail	**Grasses**
Arrowhead	**Sedges**
Pondweeds	
Canada w.w.	

Crossectional Profile

Left (facing upstream) Right

Thick grasses

No defined channel

Additional Comments:

- **completely overgrown with grasses**
- **upper end at culvert is open, but has dense patches of Canada waterweed and coontail**
- **Canada w.w - Canada waterweed**

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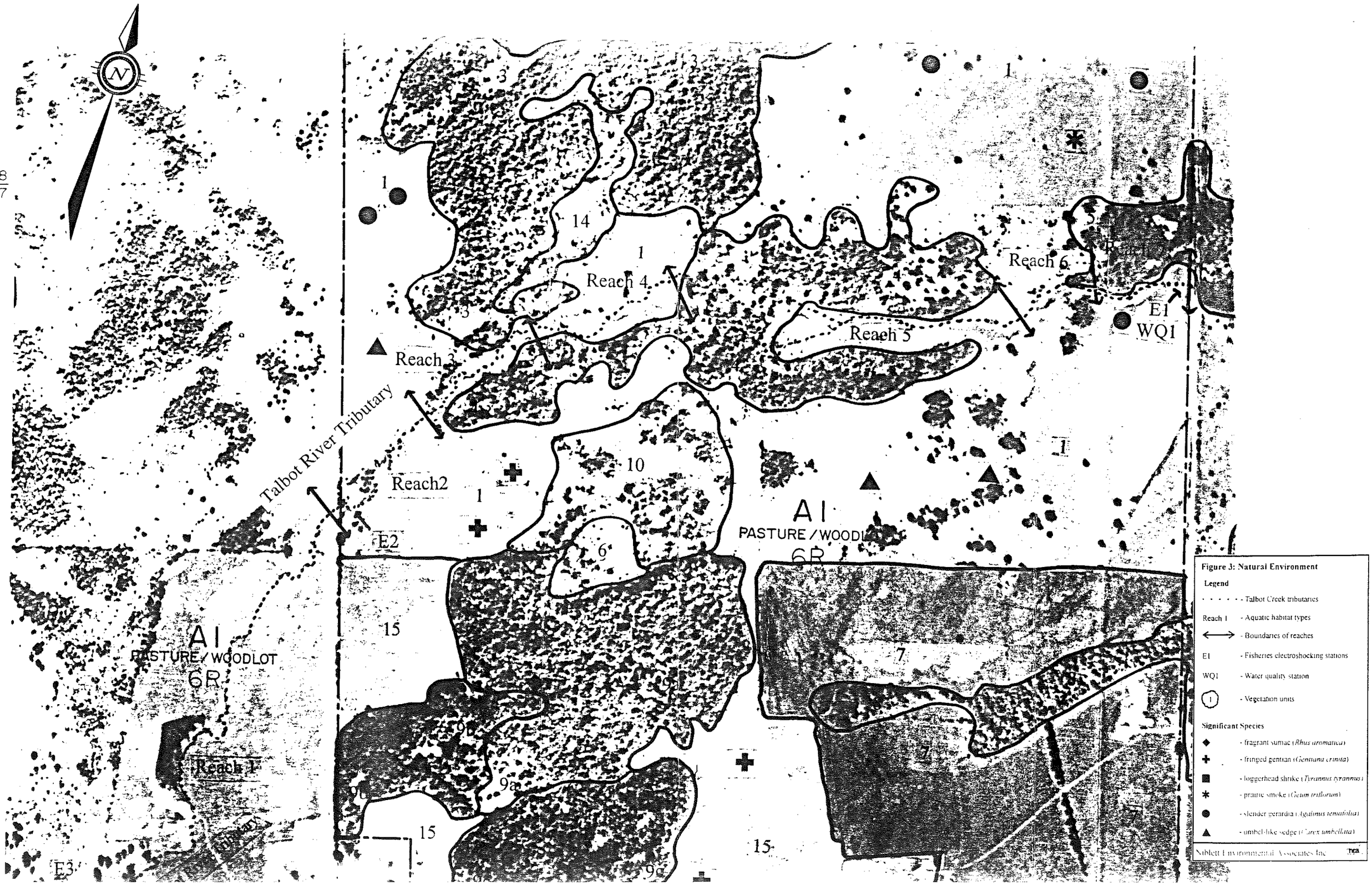
Talbot River Tributary
Reach 3
Reach 4
Reach 5
Reach 6
Reach2
Reach 1
E1
WQ1
E2
E3
A1
PASTURE / WOODLOT
6R
14
10
6
15
9a
9c
7
1
3
5
Figure 3: Natural Environment
Legend
- - - - - - Talbot Creek tributaries
Reach 1 - Aquatic habitat types
<-> - Boundaries of reaches
E1 - Fisheries electroshocking stations
WQ1 - Water quality station
1 - Vegetation units
Significant Species
- fragrant sumac (Rhus aromatica)
- fringed gentian (Gentiana crinita)
- loggerhead shrike (Tyrannus tyrannus)
- prairie smoke (Geum triflorum)
- slender gerardia (Agalinus tenuifolia)
- umbel-like sedge (Carex umbellata)
Nicholl Environmental Associates Inc.