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**Golder
Associates**

GEOCRES No:
31G5-204

REPORT ON

**HIGHWAY 416
'INNOVATION' REPORT
MONITORING AND CONTROL ALTERNATIVES
GROUNDWATER PUMPING AND RECHARGE SYSTEM
LYNWOOD SUBDIVISION
OTTAWA, ONTARIO
CONTRACT AGREEMENT 4004-C-0115
GEOCRES No. 31G-204**

Submitted to:

Ministry of Transportation Ontario
530 Tremblay Road
P.O. Box 9530
Ottawa, Ontario
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June 2006

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June 14, 2006

04-1120-176-4000

Ministry of Transportation Ontario
350 Tremblay Road
P.O. Box 9530
Ottawa, ON K1G 0E4

Attention: Mr. F. Mendoza

**RE: HIGHWAY 416
INNOVATION REPORT
MONITORING AND CONTROL ALTERNATIVES
GROUNDWATER PUMPING AND RECHARGE SYSTEM
LYNWOOD SUBDIVISION
OTTAWA, ONTARIO
CONTRACT AGREEMENT 4004-C-0115
GEOCRES No. 31G-204**

Dear Sir:

Please find attached our Innovation Report on the monitoring and control alternatives in regards for the potential upgrades to the groundwater pumping and recharge system at the Lynwood subdivision in Ottawa, Ontario.

We trust that this report is sufficient for your present purposes. If you have any questions concerning this report, please call us.

Yours truly,

GOLDER ASSOCIATES LTD.

M.I. Cunningham, P.Eng.
Associate

F.J. Heffernan, P. Eng.
MTO Designated Contact



MIC/FJH/kdc

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cc Mr. Tony Sangiuliano, P.Eng. – MTO Pavements and Foundations



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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO) to propose and evaluate monitoring and control alternatives for the possible upgrades to the groundwater pumping and recharge system between Highway 416 and the Lynwood Subdivision in Ottawa, Ontario.

The scope of work for this assignment is outlined in Golder Associates Ltd. proposal numbered P41-2098, dated October 2004, that forms part of the Agreement Number 4004-C-0115 for this project. The work was carried out in accordance with the Quality Control Plan for this project dated February 2004.

2.0 PROJECT BACKGROUND

The Lynwood subdivision is located immediately west of Highway 416 and south of Highway 417 in Ottawa, Ontario, as shown on the Key Plan, Figure 1. This subdivision was built in the early 1960's, prior to the construction of Highway 416 which was completed in 1998.

Highway 416 extends southerly from Ottawa, providing a four-lane median-divided highway connection to Highway 401. Within Ottawa, at the highway's northerly end, Highway 416 connects to Highway 417, which is the only east-west freeway in the city. The Highway 416-417 interchange is located in the west part of Ottawa. Immediately south of that interchange, Highway 416 climbs up to the south. That climb is made 'in cut', and passes to the east of the Lynwood subdivision. The geology in that area consists of about 5 to 10 metres of sensitive marine clay ("Champlain Sea clay" or "Leda Clay") overlying a sand deposit, overlying a thin layer of glacial till, overlying dolomitic limestone bedrock. The bedrock surface is at about 15 metres depth. The natural groundwater level is typically about 2 metres below ground surface.

The cut for Highway 416 is about 5 to 10 metres deep and extends into the sand deposit. The cut therefore had the potential to lower the regional groundwater level. That water level lowering could have caused consolidation of the overlying surficial sensitive clay deposit in the surrounding areas and settlement of the houses in the Lynwood subdivision.

The cut was therefore constructed within a hydraulic barrier, constructed using slurry wall techniques. Both cement-bentonite and diaphragm wall construction were used as shown in Figures 2 and 3. The hydraulic barrier extends down to the bedrock surface.

Subsequent to the hydraulic barrier construction, it was determined that a section of the cement-bentonite wall leaked in several locations adjacent to the Lynwood Subdivision. Two attempts were made to repair that leak. First, a parallel section of diaphragm wall was installed along two sections of the wall. That work decreased the rate of leakage. Subsequently grouting of the area was attempted, without there being a significant impact on the rate of leakage.

A groundwater recharge system was therefore constructed between the leak and the Lynwood subdivision. That system began operation in about 1995/96 and has operated on an essentially continuous basis since that time.

3.0 EXISTING RECHARGE SYSTEM

3.1 System Overview

This section of the report provides a broad overview of the recharge system as it presently exists. More specific details on each component of the system are provided in Section 3.2 of this report.

The locations of the pumping and recharge wells are indicated on Figure 2. The system pumps water from "pumping wells" within the hydraulic barrier enclosure, adjacent to the southbound lanes of the highway, and re-injects the water into the sand aquifer on the 'outside' of the hydraulic barrier, between the barrier and the subdivision.

The system has two "pumping wells", numbered 3 and S5, as indicated on Figure 2. Each pumping well is equipped with a submersible pump and these pumps operate in alternate 12 hour shifts. The water is pumped up from within the cut, passes through a valve and flow meter chamber, and then over the hydraulic barrier. The water is then re-injected via 6 "recharge wells", numbered RW-1 and RW-4 to RW-8 inclusive, as also indicated on Figure 2. Recharge wells RW-2 and RW-3, which are no longer part of the system and are not indicated on Figure 2, were replaced with new wells after these wells became blocked.

The sand deposit is very heterogeneous, so not all of the wells are equally effective. If excessive flow is directed to a well, it simply flows out over the top of the well casing and onto the ground surface (Figure 4).

The effectiveness of the groundwater recharge is monitored in four piezometers. Three of those piezometers, numbered P-4B, 89-6/97-13B and 89-8 as shown on Figure 5, are located within the subdivision itself. The fourth piezometer is located immediately adjacent to the recharge well field and that piezometer (numbered 90-26 on Figures 2 and 5) contains "high" and "low" water level alarms. If the water level in that piezometer falls below or rises above those alarm levels, an alarm company (currently Honeywell) alerts MTO Electrical staff., who in turn contact Golder Associates. A Golder Associates field technician then visits the site to investigate the cause of the alarm (i.e., either high or low water), and adjusts the system as necessary.

Adjustments are made by opening or closing the main valves on the supply lines from each well, located in the flow meter chamber (Figures 6 and 7); the pumps themselves are not adjusted directly.

There are also individual valves at each of the recharge wells, located in the recharge chambers adjacent to each well, as shown in Figures 8 and 9. These valves can be used to adjust the distribution of flow between the individual recharge wells, as required, to redistribute (i.e., balance) the flows. The general operating objective is to have the water level in each recharge

well close to the top of the well casing, but not overflowing. By these criteria, it is intended that each well be operating at its capacity.

Typically the overall recharge rate (and well balance) is adjusted twice per year, in response to seasonal precipitation. For example, the flow rate is often increased in June, before the dry summer months, and then decreased again in the fall.

The recharge wells periodically lose capacity and effectiveness. Approximately every 2 to 3 years some form of maintenance is required. This maintenance is triggered by either the overall pumping rate falling below about 25 IGPM (despite all of the recharge wells operating at capacity, as described above), and/or the water levels in the subdivision falling below the specified target level. When that situation occurs, the wells are chlorinated and purged, and usually regain most of their previous capacity. However, additional wells have previously had to be installed to restore the system's capacity.

The initial pumping capacity of the system was 62 IGPM. The current system capacity is 25 IGPM, which is just barely sufficient to maintain the groundwater levels in the subdivision at the specified level of no more than 1 m below the levels prior to construction of Highway 416. At pumping rates of more than about 25 IGPM at this time, the additional water overflows the recharge well casings.

Golder Associates has been monitoring the operation and maintenance of this system since its start of operations in 1995/96. At present, Golder staff measure the water levels in the four piezometers (three in the subdivision and one at the well field), inspect the conditions of the system components, and provide a report to the MTO four times per year (February, June, August, and November). A previous such report is attached in Appendix A, as an example. A Golder Associates field technician also visits the site every two weeks to check whether the wells are overflowing and whether water is ponding on the ground. When ponding of overflow water is observed, the flow balance is adjusted, and possibly the overall flow rate reduced, to correct the condition. The concerns with ponding water relate to possible breeding of mosquitoes, which is a public health concern due to West Nile virus. Possible ice build-up around the wells in the winter months is also a concern.

3.2 System Components

The pumping and recharge system is shown in Figure 2 and a more detailed description of the system components is provided below:

- A. Electrical Vault and Electrical/Communications Control Panel: Three phase 600 V electrical power is fed to the system from the electrical feed for the high-mast lighting along Highway 416. The feed is via buried cable to the electrical vault, and then

- distributed to the control panel and pumps. The electrical vault and electrical control panel are accessed only by MTO Electrical personnel. The electrical control panel is shown on Figure 12 and also contains the alarm control system and cellular phone connection.
- B. **Pumping Wells:** Two pumping wells are located east of (i.e., within) the hydraulic barrier enclosure. The installation details of the wells are shown on Figure 10 and consist of up to 4.6 metres of stainless steel screen with 1.0 millimetre slot sizes. The well screens are 203 millimetre diameter stainless steel, with welded stainless steel end caps. Each pump is connected to a 50 millimetre galvanized steel riser pipe, which uses a pitless adapter (Dickens 5-20 50 mm) to connect to the polyethylene water piping at a depth of 1.2 metres below ground surface. A 50 millimetre galvanized steel puller pipe runs from the pitless adapter to above ground surface. A steel cap and protection pipe cover the recharge wells at ground surface.
- C. **Pumps:** Each pumping well has a submersible pump. The submersible pumps are GRUNDFOS 1500 WATT, model 75S20-3 type pumps. There is a lower level cut-off, which consists of a WARRICK series 3Y suspended wire with 316 steel tip, to terminate pump operation should the water level in the pumping wells become too low. The pumps are powered via buried electrical cable from the electrical vault manhole. The pumps do not operate simultaneously, but rather in alternating 12hr cycles, with change over occurring at 12pm and 12am. These pumps have a nominal capacity of 75 IGPM, although the manufacture's rating curves indicate the regular operating range of this pump to be between 45 and 95 IGPM, depending on the head of water being generated. When first installed in 1995/96, the pump/system capacity was recorded as being 65 IGPM.
- D. **Piping:** Water is pumped from the pumping wells in 75mm OD high density polyethylene piping with slip-on stainless steel clamped joints. The piping is located at 1.2 metres depth below ground surface. The two water lines from the pumping wells are pumped to a flow meter chamber, where they join, and a single piping line exits the flow meter chamber, crosses over the hydraulic barrier, and connects to the recharge wells at recharge well 6 (RW-6). Further piping extends from there to the other recharge wells, connected in a north-south line.
- E. **Flow Meter Chamber:** The water lines from the two pumping wells join in the flow meter chamber (Figures 6 and 7). Each water line has a valve, before connecting into a single 'outgoing' water line. An inline flow meter (turbine type) is located in the water piping shortly after the junction. The inline flow meter has a remote readout in the electrical control panel. The chamber is drained and generally free of water.

- F. **Recharge Wells:** There are six recharge wells. The construction details for a typical recharge well are shown in Figure 11. RW-1 and RW-4 were installed prior to construction of Hwy. 416, in August 1994 and 1995 respectively. RW-1 is approximately 9 metres deep and consists of a 3 metres length of screen with 0.5 millimetre slot sizes. RW-4 is approximately 12 metres deep and consists of a 3 metre length of screen with 1.0 millimetre slot sizes. RW-5 and RW-6 were installed in 1997 by a subcontractor to augment the recharge capacity of the system. RW-7 and RW-8 were installed in 2002. RW-7 is 10 metres deep and consists of a 1.5 metre length of screen with 0.76 millimetre slot sizes. RW-8 is 13.5 metres deep and consists of a 1.5 metres length of screen with 1.0 millimetre slot sizes. The well screens are all constructed with 203 millimetre diameter stainless steel casings, with welded stainless steel end caps. The downpipe is schedule 80 PVC 50mm diameter pipe, which uses a pitless adapter (Dickens 5-20 50 mm) to connect to the polyethylene water piping 1.2 metres below ground surface. A 50 millimetre galvanized steel puller pipe runs from the pitless adapter to above ground surface. A steel cap and protection pipe cover the recharge wells at ground surface.
- G. **Recharge Chambers:** A buried recharge chamber (Figures 8 and 9) is located beside each recharge well and contains the valve on the branch piping that diverts recharge groundwater from the main pipe carrying the recharge flows to the individual well. That valve can be used to adjust the flow to each well. These chambers are not drained and are generally flooded.
- H. **High/Low Alarms:** An alarm system is located in BH 90-26, which is located slightly west of the well field. The system consists of two "float" style monitors, which activate whenever the water is above elevation 87.2 metres or below 85.71 metres. The "low" water level alarm had originally been set at elevation 85.9 metres, but was lowered in 2001 due to recurring low water level alarms; that lower alarm level has been shown to be acceptable in regards to meeting the target water levels in the subdivision. When either alarm is triggered, the Honeywell security company is notified via a cellular phone connection, location in the electrical control panel. MTO Electrical personnel are then contacted by Honeywell.
- I. **Piezometers:** The groundwater levels in Lynnwood subdivision are measured in the three piezometers (P-4B, 89-6/97-13B and 89-8). The water level is also measured in the piezometers 90-26, adjacent to the well field. The variation in these levels over time is shown on Figures 13 and 14. The piezometers consist of 1.25 millimetre diameter PVC piping. They are all screened in the sand aquifer. Borehole records for these four piezometers are provided in Appendix B.

4.0 UPGRADE OBJECTIVES

The objective of this assignment is to propose and evaluate options for retrofitting the current system, particularly with regards to the monitoring and inspection of the system, but also possibly with regards to the system control. More specifically, the objective of this assignment is to evaluate options pertaining to improving the efficiency and effectiveness of the groundwater monitoring and system control.

The existing system has the following drawbacks:

- The labour cost associated with the monitoring, inspection, and control of the system.
- The delay time associated with mobilizing to the site and subsequent reporting of the conditions. For example, when an alarm occurs, it could be several days before staff are able to mobilize to the site and several more days before the Ministry is aware of the current conditions and cause of the alarm.
- The monitoring and inspection visits are only made at periodic intervals throughout the year and therefore the conditions that occur between those visits are never known.
- Since the site inspections and monitoring visits are only carried out periodically, and therefore the recharge system could be operating below capacity for extended periods of time.
- Locating and accessing the piezometers in the subdivision is difficult in the winter, requiring excavation of snow banks.
- The current flow meter can only be read by accessing the flow meter chamber, which is a 'confined space' as defined by the Occupational Health and Safety Act of Ontario. Special health and safety equipment and procedures are therefore required to access it.
- The current alarm system only notifies one person, at MTO Electrical, who is not in fact directly responsible for the adjustments to the system. It would be preferable if notification could be given to a larger group of people. The alarm system also does not distinguish between the causes of the alarm (e.g., 'high' versus 'low' water levels).
- The alarm system does not alert MTO if a system failure occurs (e.g., if one pump fails); alarms are only generated if the water levels drop below or rise above predetermined levels.

The MTO has therefore identified the following objectives for this project:

- A list of alternatives is to be prepared to retrofit or revamp the existing system, such as remote monitoring and automated data acquisition.
- A summary of advantages and disadvantages for each alternative is to be provided, in relation to the current monitoring and maintenance.
- A breakdown is to be provided of the estimated costs for design, manufacture, supply, installation, and maintenance for each alternative.
- A summary is to be provided of the short term and long term improvements/benefits for each alternative.
- A recommended preferred alternative is to be identified.

Ideally, the recommended alternative will significantly reduce the frequency of site visits (and therefore the labour cost), be more cost-effective, and will result in a recharge system that operates at or near capacity over the long term.

In a broad sense, the options associated with upgrading the system relate to the following components/activities:

1. Options for monitoring the groundwater levels in the subdivision and at the well field.
2. Options for monitoring the *operation* of the recharge system.
3. Options for *controlling* the operation of the recharge system.
4. Options for the alarm system, such as what conditions generate an alarm as well as who is alerted and how they are alerted.
5. In addition, although options for reducing the leakage through the hydraulic barrier were specifically excluded from the Ministry's terms-of-reference for this assignment, a brief discussion is included herein, at the request of district staff, on some options that might deserve future consideration.

5.0 MONITORING, CONTROL, AND ALARM ALTERNATIVES

5.1 General

In this section of the report, several options are proposed for achieving the monitoring, control, and alarm objectives listed previously. Some of the options associated with each item are common and/or necessary to be installed together. As such, following a discussion of the options associated with each component, several alternatives are proposed for 'packaging' these options together.

For all of these options, the existing control panel should be replaced. The existing panel does not meet current electrical safety regulations. The panel is also poorly labelled, such that the functions of some of the controls and instruments are unknown. It would be difficult, in the future, for control of the system to become the responsibility of different staff. The panel is also not well protected and opening of the panel in inclement weather (such as for emergency repairs) should be avoided.

It is therefore proposed that a new heated, ventilated, and lighted walk-in enclosure be installed, with a new electrical and communications control panel that conforms to electrical safety regulations.

The existing communications system also relies on a cellular phone connection. That connection has been acceptable in the past for the simple alarm system that is currently in-place. However the installation of a more sophisticated monitoring and control system will require greater data transfer, and would therefore best be serviced using a direct telephone line. In the long term, a direct telephone line is also less costly. Therefore, if any of the remote monitoring or control options proposed in this report are adopted, it will be preferred to service the site with a buried telephone cable, from the existing telephone line on Cassidy Road. That phone line would be connected to the electrical-communications-control panel in the enclosure.

The cost of the enclosure alone is estimated at \$5,000.

The cost for the basic control panel is estimated \$10,000, with additional costs depending on the controls and instrumentation that are ultimately included. The costs for that instrumentation are provided separately.

Bell Canada's cost to provide a phone line hook-up is \$200, but additional costs (of probably less than \$1,000) would be incurred to trench the cable onto the site.

5.2 Groundwater Level Monitoring Options

Three options that could be considered in regards to monitoring the water levels in the four 'monitoring' piezometers are as follows:

1. Continue with the current system of taking manual measurements.
2. Install transducers and data loggers in the wells that would record the groundwater levels periodically (e.g. daily) and be manually downloaded at periodic times over the year.
3. Install transducers in the wells, connected to a communications system that would allow remote reading or downloading of the water levels.

The first option would maintain the current system, and is therefore not discussed further in this section, given that the objective of this report is to evaluate options for *upgrading* the system. The 'do nothing' option is discussed further in Section 5.8 of this report.

The second option has the advantage that little or no additional infrastructure would be required. That is, the transducers and data loggers would be installed in the existing wells, with no additional communications equipment. And this option would also provide a record of the water levels that occurred between readings. However the data would not be any more available to Ministry or Consultant staff. The data would only be available as frequently as the data loggers are downloaded, which would presumably be at the same frequency that water levels are currently monitored. So this option would only generate additional data than is currently collected. This option would have essentially the same labour effort and cost as the current system. In fact, greater effort might be required due to the complexities of downloading the dataloggers and processing the data. The delay time between measurement and reporting would also not be any shorter than with the current system. It is not therefore considered that this option has significant useful benefit for the Ministry.

It is therefore proposed that any option associated with upgrading the water level monitoring would involve *remote* monitoring. The primary challenge associated with these upgrades relates to the three 'remote' piezometers within the Lynwood subdivision. Photographs of those three locations are provided on Figure 15. These three piezometers are located in areas that are a significant distance from power or communications (such as telephone or hydro poles). Extending power or phone lines to these locations would require considerable trenching and excavation along the boulevards and across/under residents' driveways, as well as possibly across/under City roadways. The permission of the City and numerous homeowners would be required. Reinstatement of that trenching would be very expensive. Further, although trenchless installation of the cables might be technically feasible, at least in concept, there would be complexities associated with not damaging the water, sewer, and gas services to the houses. The cabling could need to be installed at significant depth to avoid these services. This option is therefore considered to be technically challenging and likely costly, particularly in comparison to

wireless communication which, with current technology, has become a very technically feasible and relatively economic option.

Therefore only wireless communication is considered feasible for these three piezometers.

It is also considered that the instrumentation in these three piezometers will need to be battery powered. As discussed above, it will not be feasible to provide power directly to the piezometer locations without extensive trenching through the subdivision. It is also not considered feasible to provide solar power panels, unless mounted on poles, due to the risk of vandalism. However, several of these instruments are located on the front lawns of private residences and pole-mounted solar panels would be rather unsightly and unwelcome by the homeowners.

Based on these conditions, three geotechnical instrumentation suppliers were contacted to obtain quotes on the required instrumentation. These suppliers are Roctest, Solinst, and RST. The transducers suggested by the three suppliers are as follows:

- **Solinst- *Mini LT Levelogger***
- **Roctest- *Geonivo 4-20mA* water level indicator and Geolog data logger**
- **RST- *VW2100* vibrating wire piezometer, connected to the CR1000 data logger**

Product information for these transducers and data loggers are attached in Appendix C.

Data collected at the three remote monitoring wells can be transmitted by radio or cellular communication device. Roctest's and RST's system both use radio communication to a Remote Telemetry Unit (RTU), which would be located at the well field within the electrical-communications-control enclosure. The RTU would be connected via phone modem to the office computer. In contrast, Solinst's system uses an RTU at *each* well, with a built-in CDMA cellular modem, which connects to the Bell Mobility cellular phone network. Each 'remote' piezometer is therefore a stand-alone monitoring unit which communicates directly with the office computer. One advantage of the Solinst system, therefore, is that there would be no risk of electrical interference with the other equipment in the electrical-communications-control enclosure.

To collect and transmit the data, Roctest proposes to use a Geomation OutDAQ RTU with phone modem connection, located in the electrical-communication-control enclosure. RST proposes to use a similar system, with a CR1000 Data Logger with modem connection. Product information for both pieces of equipment is provided in Appendix D. For the Solinst telemetry system, no instrumentation is required at the well field (i.e., within the electrical-communications-control enclosure) related to data collection from the 'remote' piezometers, since each well is supplied

with its own modem. Product information for the Solinst telemetry system is also included in Appendix D.

All three suppliers could also provide a small enclosure which would be placed adjacent to each 'remote' piezometer and would contain the wireless communications equipment. That enclosure would also house the battery and, for some of the systems, a data logger as well. A small concrete pad would need to be constructed at each 'remote' piezometer site and the enclosure would be bolted to it. The challenge with these enclosures is to also protect the antenna from vandalism, which would typically be mounted externally from the enclosure. Both Roctest and RST generally supply fibreglass enclosures and propose to provide custom-made oversized enclosures within which the antenna would be mounted internally. That internal mounting may limit the range of the antenna, and would need to be tested in regards to communication with the RTU at the well field. A photograph of Roctest's fibreglass enclosure is provided on Figure 16.

In contrast Solinst has a readily available *steel* enclosure that would be more resistant to theft and vandalism. The antenna cannot be mounted internally in a steel casing, but could be mounted externally and Solinst can provide an ABS plastic cover over top of it. Figure 15 also shows a photograph of Solinst's antenna cover and steel enclosure, which could be bolted to a concrete pad (i.e., ground mounted). Solinst's system is considered to be the most durable of the three enclosures.

It would likely be necessary to obtain the permission of both the residents and the City to install these enclosures.

All three systems will require barometric correction of the water pressure data. That is, the recorded water pressure data would include the effects of varying barometric pressure acting on the water surface within the piezometers. To remove the effects of that varying pressure when assessing the actual groundwater *level* fluctuations from the water *pressure* data, the barometric pressure on the day of the measurement also needs to be recorded and subtracted from the data. The system should therefore also include a barometric sensor.

As discussed above, all of the systems will need to be battery powered. Based on discussions with these suppliers, it is expected that the battery life for these systems would generally be about one year, assuming that water level measurements are not made on a more frequent than daily basis and also assuming only weekly or possibly bi-weekly downloading of the data (i.e., weekly polling). Battery life might be extended somewhat by taking even less frequent measurements, such as weekly or even monthly; the measurement frequency could be set at any desirable level, recognizing that one benefit of automating this system is that more continuous data can be recorded. However the manufacturers indicate that, for any of these measurement frequencies, one year may be a practically maximum time between battery recharge/replacements.

Of the three systems that have been proposed by the suppliers, the Solinst system is considered to be most the most developed, and is intended for this specific type of application. The other suppliers are proposing somewhat 'custom' systems, rather than 'off the shelf' products. These systems do not appear to be common packages that they produce, and thus more development and testing effort could be required. The Solinst system may therefore be more readily supplied and installed, with less new design work. The Solinst system might therefore ultimately be found to be more reliable.

The instrumentation described above relates to the three 'remote' piezometers in the subdivision (P-4B, 89-6/97-13B and 89-8). The monitoring of piezometer 90-26 is somewhat simpler because it is located at the well field and therefore in close proximity to the electrical-communications-control enclosure. For all three suppliers (Roctest, Solinst, and RST), borehole 90-26 would be instrumented with the same transducer as proposed for the three 'remote' piezometers, but the transducer would be connected by buried cable to the electrical-communications-control enclosure. For the Roctest and RST systems, the transducer would be connected to the same RTU/logger that also collects and transmits the data from the three 'remote' piezometers. For the Solinst system, for which the three 'remote' piezometers operate independently with direct cellular connection, a separate RTU and phone modem (direct line, not cellular) would be installed in the electrical-communications-control enclosure.

A remote transducer could also be used at piezometer 90-26, identical to the three piezometers in the subdivision, but at greater cost than connection by buried cable. The cost of trenching the cable from piezometer 90-26 to the electrical-communications-control enclosure is relatively small (probably less than \$500) compared to the costs of an additional telemetry unit (at least \$2000), plus the annual costs of replacing/recharging batteries, phone connections, etc. There is also an unknown risk of potential electrical interference between the electrical system and wireless communication at the well field; direct connection of piezometer 90-26 to the electrical-communications-control panel is considered to likely reduce that risk. In addition, should in the future it be decided to no longer monitor the water levels in the subdivision but only those at the well field then, if piezometer 90-26 is connected directly by buried wire and not by modem, then no future cellular phone charges would be incurred. For these reasons, it is proposed that the transducer at piezometer 90-26 be connected by buried cable to the electrical-communications-control enclosure.

The costs for the instrumentation vary widely with the supplier, between about \$15,000 and \$20,000. The lowest cost estimate was provided by Solinst.

5.3 System Monitoring Options

It is considered that there are two main parameters that would be most useful in regards to monitoring the system operation, as follows:

- a. The water levels in the recharge wells. i.e., monitoring whether or not they are overflowing and therefore whether or not they are operating near capacity.
- b. The overall pumping rate.

These two parameters address the main 'operational' criteria of the current periodic monitoring and inspection program.

It is not proposed that monitoring of the water level in the *pumping* wells be included as one of the parameters in this monitoring program. The existing pumps have low-level cut-offs and are therefore protected against drawing the water level down.

In regards to the water level monitoring in the recharge wells (item a), one option would be to continue with the current protocol, which involves visually observing for overflowing of the recharge. This 'do nothing' option is however not discussed further in this report. Instead, it is proposed that the water levels in the recharge wells be monitored using the same type of instrumentation used to monitor the water level in borehole 90-26. Those water level measurements could then be reported in comparison to the top-of-casing levels to determine whether the each well is overflowing and/or operating near capacity (i.e., with the water level just below the top-of-casing). The data cables for those instruments would be routed to the electrical-communications-control enclosure via buried trenches.

It would be necessary to monitor the water level at all six of the recharge wells, and not just at a single well, since the wells operate quite independently; i.e., it is not always the same wells which overflow.

At present, the wells are often overflowing, but only at a very low rate, such that no water accumulates on the surrounding ground; the rate of infiltration is greater than the rate of overflow. So, if the water levels in the recharge wells were monitored with transducers, alarms indicating an 'overflow' condition might be generated quite frequently, without there being actual ponding of water and a need to respond and adjust the system. However preventing the overflow condition is also the simplest measure for preventing the actual ponding of water and this can be made more effective with only minor modifications. In particular, it is recognized that the current casing levels are somewhat low; the current casing levels correspond almost exactly to the water level associated with the minimum flow rate required to maintain the groundwater levels in the subdivision. But higher water levels in the well casings are also not desirable, and may not in fact be feasible, without flooding the well field area due to excessively high groundwater levels; i.e., water could be forced to exfiltrate onto the ground surface. A simple solution would therefore be to slightly raise the top of the well casings (i.e., add additional casing), by about 0.5 metres, so that the system could operate at its current capacity, but without actually overflowing the wells. And, if the current water/casing levels were set as

the target levels, and not as the new top-of-casing level, measuring of the water levels in the recharge wells with transducers would then be a very practical way of monitoring for overflow/ponding, but without also generating numerous alarms.

If the overall flow rate is to be monitored remotely (item b), the existing flow meter could be replaced with a magnetic flow meter. This flow meter has no moving parts and therefore requires no maintenance and has a very long life expectancy. Product information for such a flow meter is attached in Appendix E. Flow meters of this type are available with a precision and accuracy that is more than acceptable for this project. The flow meter would be installed within the current flow meter chamber and the cable from the flow metre would be connected to the electrical-communications-control enclosure via a buried trench. Replacing the existing flow meter not only allows remote monitoring, but also avoids the health and safety challenges associated with 'confined space' entry of the flow meter chamber; confined space entry would be only required for installation of the new flow meter and not for the periodic monitoring thereafter, which would be carried out remotely.

In summary, the water levels in the recharge wells would be monitored using transducers and the overall flow rate could be monitored using a magnetic flow metre. The costs for instrumenting the six recharge wells, including design, equipment, and installation, is estimated at about \$12,000, based on the Solinst pricing and assuming that the four 'monitoring piezometers' are also already being instrumented, such that some of the hardware will be common to both systems. The cost for the magnetic flow meter alone is estimated at \$5,000, although the total cost including trenching as well as the communication and control panel upgrades is estimated at \$10,000.

Depending on the level of control that might be chosen (as discussed in the next section of this report) it could also be useful to monitor the flow rates to the individual recharge well. The instrumentation required to monitor the individual flow rates is the same instrumentation for monitoring the overall flow rate. The costs for that additional instrumentation, with six flow meters, are estimated at \$30,000.

5.4 System Control Options

Two general options exist for the system, namely *remote control* of the system or *automated control*.

For either option, the control panel would be equipped with a programmable logic controller (PLC) that would be the main control component.

The fundamental system parameter that can most realistically be controlled is the overall flow rate (i.e., pumping rate). This could be accomplished by installing a Variable Frequency Drive

(VFD) on the three-phase power supply to each well. The VFD controls the frequency of the AC power supply to each pump and therefore controls the pump speed and overall flow rate. Those VFDs could be made remotely controllable, from the office computer, via the phone line connection to the PLC. Documentation on an appropriate PLC and VFD is included in Appendix F.

Alternatively the PLC could control the VFDs through a feedback loop (also known as a PID loop), with set-points established for the water level in the recharge wells, such that the system would automatically adjust to operate at the optimum flow rate. This automated control option would, in theory, allow the system to adjust the pumping rate in accordance with the actual demand on the system. For example, in the spring, when the rate of natural infiltration is high and the groundwater levels typically rise, less water can be recharged in the wells without causing them to overflow. One of these wells could be equipped with a transducer and data logger, connected to the PLC which would then adjust the VFDs accordingly.

The challenge with the latter option is that there are six recharge wells that all respond differently to changes in the natural ground water level. It would only be practical to have the PLC respond to changes in one of those water levels and therefore the system may not be able to adjust itself properly to have the optimum flow rate in regards to all six wells (i.e., to have wells operating at capacity). In addition, there is a time lag (likely several days) between changing the pumping rate and the system reaching a new equilibrium. Although with appropriate programming it would be feasible to have the system respond accordingly, it would probably require several adjustments to the programming before the correct system response would be achieved.

It is therefore considered that the first option (i.e., remote control of the flow rate) is more practical.

Another option that has been investigated would be to have remote control over the flow balance to *each* recharge well (and not just control of the *overall* flow rate). That control would be accomplished by means of electrically actuated control valves on the piping to each well. Each well would also need to be equipped with its own magnetic flow transmitter. It is not considered practical, using current technology, to equip the system in this manner for *automated* control (i.e., with feedback loops responding to the water level in each well). Further, although it would be technically feasible to have *remote* control of the system in this manner, the current process of balancing of the flows between the wells requires very delicate adjustments since each recharge well adjustment affects the flow to all of the other wells as well. It may be only marginally feasible to carry out those same adjustments remotely. In addition, rebalancing of the flows is required fairly infrequently and this task is not therefore an overly costly part of the overall operation of this system. Upgrading the system to allow this level of remote control is not

therefore likely to be cost effective. Hence this option is not proposed for consideration for the current system upgrades.

In summary, remote or automated control of the overall pumping rate could be accomplished using VFDs on the electrical supply to the pumping wells, controlled with a PLC.

The costs for the PLC and VFDs are estimated at \$5, 000.

If the control system is to be *automated* (but with manual override control), the additional hardware costs are limited, but additional programming time and effort will be required to set-up the system. An additional \$5,000 is estimated to set-up automated control over the flow rate.

If flow transmitters and electrically actuated control valves were to be installed on the water piping to each recharge well, the additional cost is estimated at about \$50,000. These costs are well in excess of the labour cost associated with mobilizing to the site to carry out the re-balancing of the flows and this option is not therefore proposed to be included in the system upgrade.

5.5 Alarm Options

At present, notification of an 'alarm condition' (typically high or low water levels in borehole 90-26) are transmitted via cellular communication to Honeywell, who then phone MTO Electrical personnel. A drawback of this system is that, depending upon the availability of staff, some length of time could be required for the notification to be relayed to the personnel (presently Golder staff) who are actually responsible for the system operation. In addition, MTO personnel who are not *directly* responsible for the system (e.g., MTO Foundations) can be left unaware that adjustments to the system are having to be carried out.

It should be noted however that an immediate response to an alarm is also not generally required. The system's primary function is to maintain the groundwater levels in the permeable sand deposit that underlies the Lynwood subdivision so that the piezometric pressures in the overlying clay deposit are not drawn down below critical levels, so that the deposit does not consolidate, and hence the houses do not experience damaging settlements. However, since the consolidation of clay is a slow process, the piezometric levels in the underlying sand deposit would need to be drawn down and maintained at those low levels for weeks or months for damaging settlement to begin to occur. So there is no need for an immediate (i.e., same day) response to most alarms. From that perspective, an emailed alarm notification would be acceptable; a direct phone call by the alarm company is not necessary.

However, if the alarm is triggered by component failure, it could conceivably take several weeks to organize the replacement of the component and therefore it is desirable that the notification be

fairly broad so that, even if one key person is unavailable at the time of the alarm (such as is quite likely during the dry summer season when many staff are on vacation), there is not an unnecessarily long delay in responding. It would therefore be preferable if the alarm notifications could be more broadly distributed. Ideally, the alarm distribution list should include MTO Foundations, MTO Ottawa Contracts office, MTO Ottawa Electrical, and Consultant staff.

Based on the above, it is proposed that a data logger and autodialer would be linked to the PLC in the control panel with the capability of notifying by email a list of designated individuals should an 'alarm condition' occur. The additional hardware costs for this alarm system are estimated at \$2,000.

In regards to the conditions which actually trigger an alarm, all or any of the monitored parameters could be used. Alarm trigger levels could be set for:

- Low and high water levels in the subdivision;
- Low and high water levels at the well field;
- Overflow conditions (i.e., high water levels) in the recharge wells; and,
- Low flow rates (such as 'no flow', indicating system malfunction).

There is not considered to be any significant cost premium associated with the number of parameters included in the alarm system.

5.6 Packaged Monitoring & Control Options

The preceding discussion provided options for upgrading the various individual system components and monitoring activities. However ultimately an overall 'package' will need to be selected, which will include only selected system upgrades. Five options that may be considered for the system upgrade, in increasing order of functionality, are as follows:

1. Remote monitoring of the four piezometers.
2. Remote monitoring of the four piezometers and of the recharge flow rate.
3. Remote monitoring of the four piezometers, the six recharge wells, and of the recharge flow rate.
4. Remote monitoring as noted for Option 3, but with *remotely* controlled flow adjustment using VFDs.
5. Remote monitoring as noted for Option 3, with *automated* flow control.

Option 1. Remote monitoring of the four piezometers. This option would capture the basic critical data, which is whether or not the water levels in the subdivision are being maintained. However no data on the functioning or condition of the system would be collected. Periodic site

visits (bi-weekly) for routine inspections would still be required to confirm that the wells are not overflowing and that the system is operational. Site visits for manual adjustments of the system would still be required.

Option 2. Remote monitoring of the four piezometers and of the recharge flow rate. This option would capture the key data currently collected during the monitoring sessions and would confirm, via the flow rate data, that the system is indeed operational. However no data would be available on whether or not the wells are overflowing and therefore bi-weekly visits would still be required. Visits to the system would also still be required to carry out manual adjustments.

Option 3. Remote monitoring of the four piezometers, the six recharge wells, and of the recharge flow rate. This option would capture essentially *all* of the data collected during both the four-times yearly monitoring sessions as well as the bi-weekly inspections. It could be confirmed that, at any time, the groundwater levels are being maintained, the system is operational, and the recharge wells are not overflowing (i.e., that the system is operating near capacity). Routine site visits for inspection or monitoring would not be necessary. Visits to the site would only be required when system adjustments were necessary, or for at least one annual inspection of the overall system condition.

An examination of the costs for this option, as discussed subsequently in Section 5.7, identifies that instrumenting the three 'remote' piezometers is a significant part of the overall cost. However instrumenting these piezometers does not in fact greatly reduce the annual labour cost, since the manual recording of the water levels is only carried out four times per year and is a task with fairly limited effort. Further, the reporting costs are not reduced, regardless of whether the water levels are downloaded electronically or recorded manually. Therefore a cost/benefit analysis would not favour the installation of the 'remote' piezometers. Therefore, an additional option is proposed, as follows:

Option 3A. Remote monitoring of 90-26, the recharge wells, and the flow rate. For this option, four yearly visits would still be required to record the water levels in the subdivision, but the system operation could be monitored remotely. Bi-weekly site visits for inspections would not be necessary. Visits to the site would only be required when system adjustments were necessary, or for at least one annual inspection of the overall system condition. The costs for this option are also significantly less than Option 3.

Option 4. Remote monitoring as noted for Option 3, but with *remotely* controlled flow adjustment using the VFDs. This option would eliminate the need for site visits to adjust the flow, when the system is overflowing or not working near capacity (i.e., when the flow rate could be increased). However those visits are only infrequently required (generally no more than once or twice per year) and are therefore not very costly. Further, when an adjustment to the overall flow rate is carried out, it is also generally necessary to re-balance the flows between the individual wells. As described previously, it is not considered cost-effective to also provide remote control over the flow balance (using individually controlled valves at each well) and therefore visits to the site would still be required after every flow adjustment. There may not

therefore be any real cost savings associated with having remote control over the overflow rate since visits to the site would still be required. The only advantage may be that the flow rate could be adjusted quickly. Further, 'confined space' entry to the flow meter chamber would be avoided; several days can be required to organize the equipment and staff (team of two) required for that work. Therefore, if automated control was provided, the flow rate could be adjusted almost instantaneously, but rebalancing of the flows, which does not involve 'confined space entry' could be carried out several days later. Visits to the site would also still be required for at least one annual inspection of the overall system condition.

Option 5. Remote monitoring as noted for Option 3, with *automated* flow control. The additional cost associated with this option is about \$10,000 which, in the short term, significantly exceeds the annual cost of having to make the adjustments either manually or remotely. Over the longer term (say, over a more than ten year time frame), this option may become economic. There is however some risk that the system will never be able to adjust to an 'optimum' flow rate (that is, the maximum possible flow being recharged into the ground), if *all* wells are to be working near peak capacity. Personnel would still need to visit the site to periodically re-balance the flows. Visits to the site also would still be required for at least one annual inspection of the overall system condition.

The advantages and disadvantages of the monitoring and control options for the pumping and recharge system are summarised in Table 1. The costs are summarized in Section 5.7 of this report.

A sixth option would be the 'do nothing' option, which would involve no change in the current system operation. However, even for this 'do nothing' option, replacement of the control panel would still be required to have a system that complies with electrical safety regulations. The costs for this option are also discussed in Section 5.7 of this report.

5.7 Costs

Preliminary cost estimates have been developed for the monitoring and control options proposed above, but it should be noted that these costs can vary significantly depending on the equipment selected, the construction contractor, the desired monitoring frequency and the life span of the selected system. The costs presented here should only be assumed to be valid for comparison purposes.

Currently the monitoring is conducted four-times yearly, with bi-weekly 'overflow' checks, and the cost of this manual monitoring provides a baseline for comparison. Based on the last two years of system operation, the monitoring and control of the Lynnwood recharge system costs about \$1,300 per month. This figure covers the routine costs of monitoring, reporting, and basic

maintenance, and is therefore the annual cost associated with the 'do nothing' option (i.e., Option 6).

For the five options provided above, plus the 'do nothing' option, the estimated costs are as follows:

Option	Design Cost	Equipment Cost ¹	Installation and Set-up Cost	Total Initial Cost	Annual Cost ²
1. Four piezometers	\$9,000	\$30,000	\$13,000	\$52,000	\$16,000
2. Four piezometers and flow rate	\$9,000	\$40,000	\$17,000	\$66,000	\$16,000
3. Four piezometers, flow rate, and six recharge wells	\$10,000	\$50,000	\$18,000	\$78,000	\$12,000
3A. 90-26, flow rate, and six recharge wells	\$7,000	\$40,000	\$15,000	\$62,000	\$12,000
4. Same as Option 3, but with <i>remote</i> flow control	\$12,000	\$55,000	\$20,000	\$87,000	\$12,000
5. Same as Option 3, but with <i>automated</i> flow control	\$14,000	\$55,000	\$25,000	\$94,000	\$12,000
6. Do Nothing	\$3,500	\$15,000	\$7,000	\$25,500	\$16,000

Notes:

1. Equipment costs include transducers, loggers, modems, enclosures, new control panel and enclosure, flow meters, and phone line hook-up.
2. Annual costs include quarterly data collection, reporting, weekly overflow checks (as required), and twice annual adjustments.

The Annual Maintenance Costs given above include only the system monitoring and adjustments. Major maintenance needed to maintain the recharge capacity (such as chlorination or flushing), which are common costs to all of the options, have not been included.

It should be noted that about \$15,000 of the equipment costs and \$5,000 of the installation and set-up costs provided in the table above are associated just with replacing the existing control panel with a proper enclosure and panel that complies with current codes. Even if no system upgrades are proposed, the existing panel should be replaced and these costs would be incurred. These are therefore fixed costs that are common to all options.

The design costs included in the above table include estimated effort associated with selecting system components, developing drawings and specifications for the work, and assisting with the tendering process. However these costs are not intended to be a quotation for that work. Since no Terms of Reference for that work have yet been developed, these costs should be considered to be relative costs only.

5.8 Preferred Alternative

The advantages and disadvantages of the monitoring and control options for the pumping and recharge system are summarised in Table 1.

It is noted that Options 1 and 2 provide effectively no reduction in the annual operating costs from the current condition. These options only provide faster access to the data on the effectiveness of the system. No real reduction in effort is realized.

Only with Options 3 to 5 would there truly be less effort associated with monitoring the system performance, since essentially all or most of the key system parameters (groundwater levels, flow rate, and overflow condition) would now be remotely accessible.

Notably, Options 4 and 5, which allow remote or automated control over the flow rate adjustment, do not further reduce the annual costs in comparison to Options 3 and 3A, since visits to the site would still be required following each adjustment to re-balance the flows to have *all* of the wells operating at capacity.

The preferred options are therefore either Option 3 or Option 3A. These options have estimated initial costs of \$78,000 and \$62,000 respectively. If the fixed cost of \$20,000 for the needed control panel replacement is removed, the true additional initial costs (versus the do-nothing of just replacing the panel) would be \$58,000 and \$42,000, respectively. Both of these options provide a modest \$4,000 expected reduction in the annual operating cost. So the pay-back periods versus the current costs are about 14 and 10 years, respectively. The life of this monitoring system is difficult to predict but, considering technology changes that could occur (such as in software and communication), it is quite possible that another system upgrade could be required in another 10 years. That is, in fact, the length of time that the current monitoring system has been in operation. Based on that assumption, there is in fact little value, from a purely cost perspective, in investing significant capital when the payback period approaches or exceeds the system life. However, of the two, Option 3A is considered preferred from the shorter payback period.

In summary, of the upgrade options, Option 3A is considered to provide the most cost-effective and practical alternative. The need for stand-alone monitoring installations in the subdivision is

eliminated, which are some of the most challenging and expensive potential components. Additionally, intrusive structures will not be required within the subdivision itself.

Notwithstanding the above analysis, which focuses on the *upgrade* options for this system, the costing data indicates that the 'do nothing' alternative may in fact be a very feasible choice. Over a ten year period, not accounting for inflation or present value of future expenditures, the cost would be \$185,500. For comparison, the costs over the same period for Option 3A would be almost the same, at \$182,000. These costs are essentially equal. The disadvantage of this 'do nothing' option is that data on the system operation and the water level at the well field cannot be obtained as quickly as with Option 3A. However, considering that system operation has, to date, been generally acceptable, the current delay time needed to obtain that data may not be sufficiently problematic to justify the upgrades with Option 3A.

6.0 CAPACITY UPGRADES

The preceding section of this report discussed various options for upgrading the monitoring and/or control of the Lynwood Recharge system. An analysis of the costs indicates that, even with a variety of system upgrade options, the annual operating costs of this system remain high. In fact, the operating costs provided in Section 5.7 do not include all the periodic well maintenance that is required, such as chlorination and flushing/surging. And, even with that maintenance, the wells do appear to ultimately lose their capacity over time, requiring the installation of new wells.

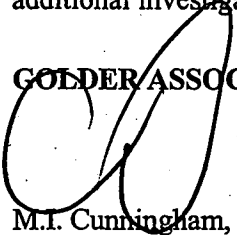
From that perspective, it appears that a real reduction in the operating costs of this system would only be achieved by either eliminating the need for the system altogether, or possibly by reducing the required rate of pumping. If, for example, the required rate of pumping could be reduced by half, then the time period between well maintenance sessions could be reduced. The overall life span of the wells could also be extended, since they could be allowed to loose more capacity before being replaced.


In theory, it should be feasible to completely or partially seal the leakage by means of grouting, or by constructing additional sections of parallel hydraulic barrier. It is understood that previous attempts at grouting about 10 years ago were both costly and ineffective. However there have been some advances in the development of grout mixes that might warrant a reassessment of this option. In particular, it is understood that the presence of steep groundwater flow gradients over the leakage area may have made the previous grouting unsuccessful. With the current use of admixtures, grouts can be produced with low mobility and anti-washout properties. Hot bitumen grouting could also be considered. However, it is also understood that the nature of the leak is not in fact well understood. Two sections of parallel hydraulic barriers exist in this area and the leakage may be occurring though the single section of barrier that exists in between. Before any additional grouting or the construction of additional sections of hydraulic barrier could be considered, additional investigation would need to be carried out to specifically determine the nature of the leakage.

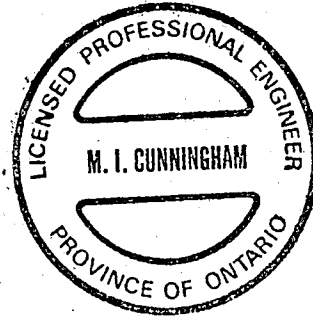
Alternatively, a simpler option that might be effective at reducing the required rate of pumping would be to re-locate the existing pumping wells away from the leakage area. Those wells are believed to have been installed into the overburden aquifer. The pumping from those wells will have created a localized lowering of the surrounding groundwater level. If that is the case, and the radius of that groundwater level lowering extends to the nearby area of leakage, then the pumping would in fact be increasing the hydraulic gradient across the leakage area, which in turn increases the required rate of pumping. Therefore placing the wells further away from the leakage area could reduce that rate of leakage, and the required rate of pumping. Consideration could therefore be given to relocating those wells about 100 metres north. The estimated cost for installing those wells, as well as lengthening the water lines and electrical cables, and re-locating

the pumps to those new wells, is in the range of about \$5,000 to \$10,000, although some additional investigation and design work could also be required.

GOLDER ASSOCIATES LTD.


M.I. Cunningham, P.Eng.
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Designated MTO Contact



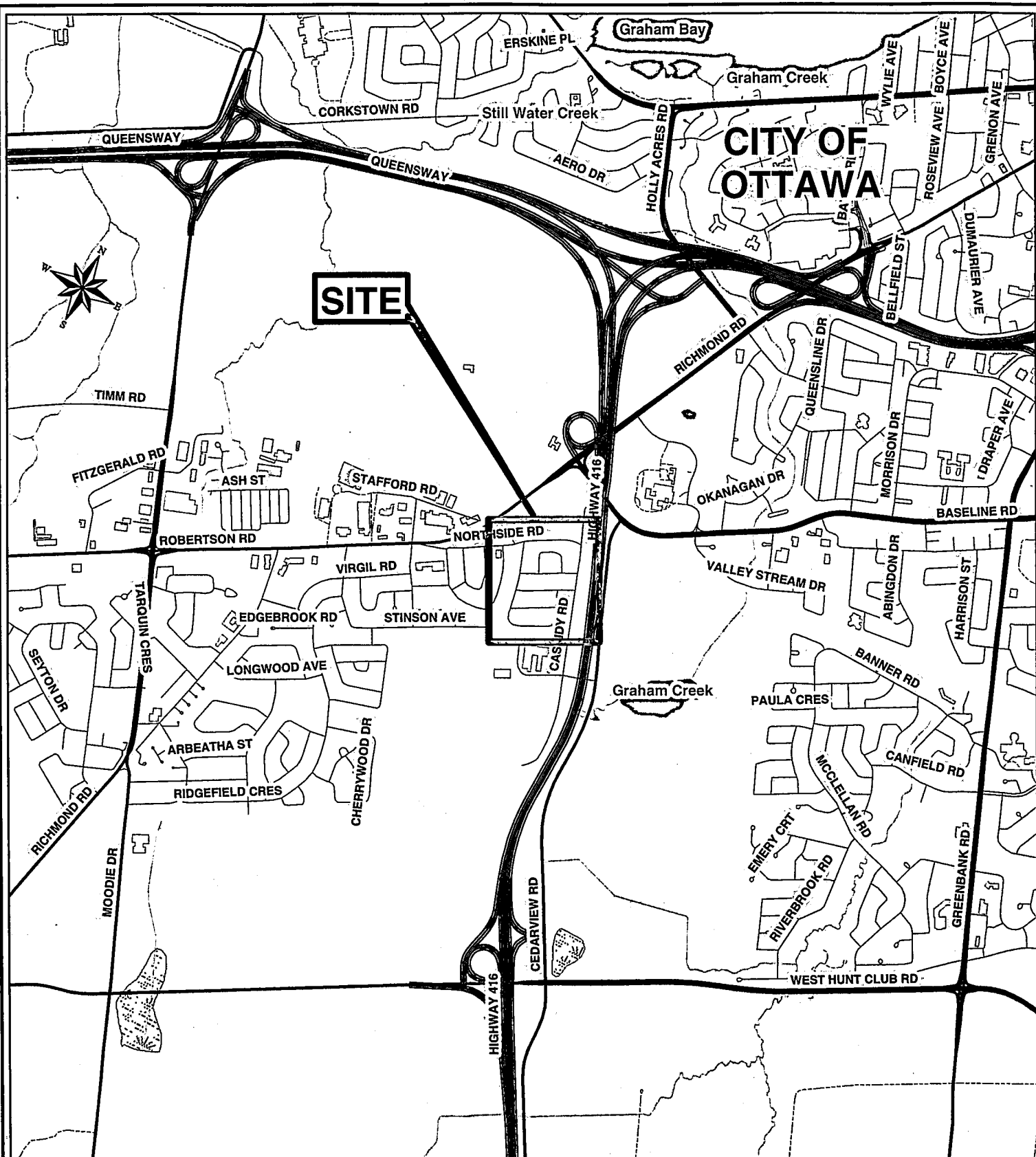
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TABLE 1
SYSTEM UPGRADE OPTIONS EVALUATION

MONITORING AND CONTROL OPTION	ADVANTAGES	DISADVANTAGES	SHORT-TERM BENEFITS	LONG-TERM BENEFITS
Option 1. Instrument the four 'remote' piezometers	<ul style="list-style-type: none"> Minimum required equipment and design effort. 	<ul style="list-style-type: none"> Have no data on system operation or overflow condition. Still need bi-weekly visits No reduction in labour cost from existing program. Are unable to adjust flow rate without visiting site. 	<ul style="list-style-type: none"> Have 'on demand' access to water level data. Site visits not required for groundwater level monitoring. No challenges with obtaining winter water level data 	<ul style="list-style-type: none"> Will have more complete data on water levels between monitoring sessions.
Option 2. Instrument the four remote piezometers and flow rate	<ul style="list-style-type: none"> Can remotely assess groundwater levels and confirm that system is operating 	<ul style="list-style-type: none"> Still need bi-weekly visits to assess whether have overflow. No reduction in labour cost from existing program. Are unable to adjust flow rate without visiting site. 	<ul style="list-style-type: none"> Same as Option 1 No 'confined space' entry to flow meter chamber required 	<ul style="list-style-type: none"> Same as Option 1 Will have remote confirmation that system is operational.
Option 3. Instrument the four 'remote' piezometers, the flow rate, and the six recharge wells	<ul style="list-style-type: none"> Obtain all the key data from the current monitoring program. Site visits only required for flow adjustments or maintenance. 	<ul style="list-style-type: none"> Are unable to adjust flow rate without visiting the site 	<ul style="list-style-type: none"> Same as Option 2 Bi-weekly site visits not required. 	<ul style="list-style-type: none"> Have essentially full remote data on system operation and groundwater levels.
Option 3A. Instrument 90-26, the flow rate, and the six recharge wells	<ul style="list-style-type: none"> Avoids costly 'remote' piezometer installations in the subdivision 	<ul style="list-style-type: none"> Don't have 'on demand' access to groundwater level data for subdivision. Are unable to adjust flow rate without visiting the site 	<ul style="list-style-type: none"> Have 'on demand' access to system operation data. 	<ul style="list-style-type: none"> Bi-weekly site visits for 'overflow' checks not required.

MONITORING AND CONTROL OPTION	ADVANTAGES	DISADVANTAGES	SHORT-TERM BENEFITS	LONG-TERM BENEFITS
Option 4. Same as Option 3, but with <i>remote</i> flow control	<ul style="list-style-type: none">• Don't need to mobilize to the site to change flow rate	<ul style="list-style-type: none">• More complex system to install• Still need site visits for flow balancing.	<ul style="list-style-type: none">• Are able to rapidly adjust flow rate	<ul style="list-style-type: none">• Should be able to more consistently have system operating near capacity.
Option 5. Same as Option 3, but with <i>automated</i> flow control	<ul style="list-style-type: none">• Less user control should be required	<ul style="list-style-type: none">• Very complex system to install• Still need periodic visits for flow balancing	<ul style="list-style-type: none">• System can respond to water level changes without user control	<ul style="list-style-type: none">• System should be able to operate more consistently at its capacity.



SPECIAL NOTE

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REFERENCE

Digital Base Map Data Supplied by DMTI Spatial Inc., Canmap 2004
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 18

0 170 340 680 1,020 1,360
Meters

PROJECT

LYNWOOD RECHARGE SYSTEM

TITLE

KEY PLAN



PROJECT No. 041120176-4000		
DESIGN	P.J.M.	Feb. 2006
CHECK	B.C.	Feb. 2006
REVIEW	M.M.	

SCALE: 1:25,000 REV. 0

FIGURE: 1



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SCALE Not to Scale

DATE FEB. 2006

DESIGN

CADD S.L.

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REVIEW

TITLE

PUMPING AND RECHARGE SITE

FILE No. 041120176-4000-03.dwg

PROJECT No. 04-1120-176 REV.

HIGHWAY 416

FIGURE

3



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TITLE

OVERFLOWING RECHARGE WELL

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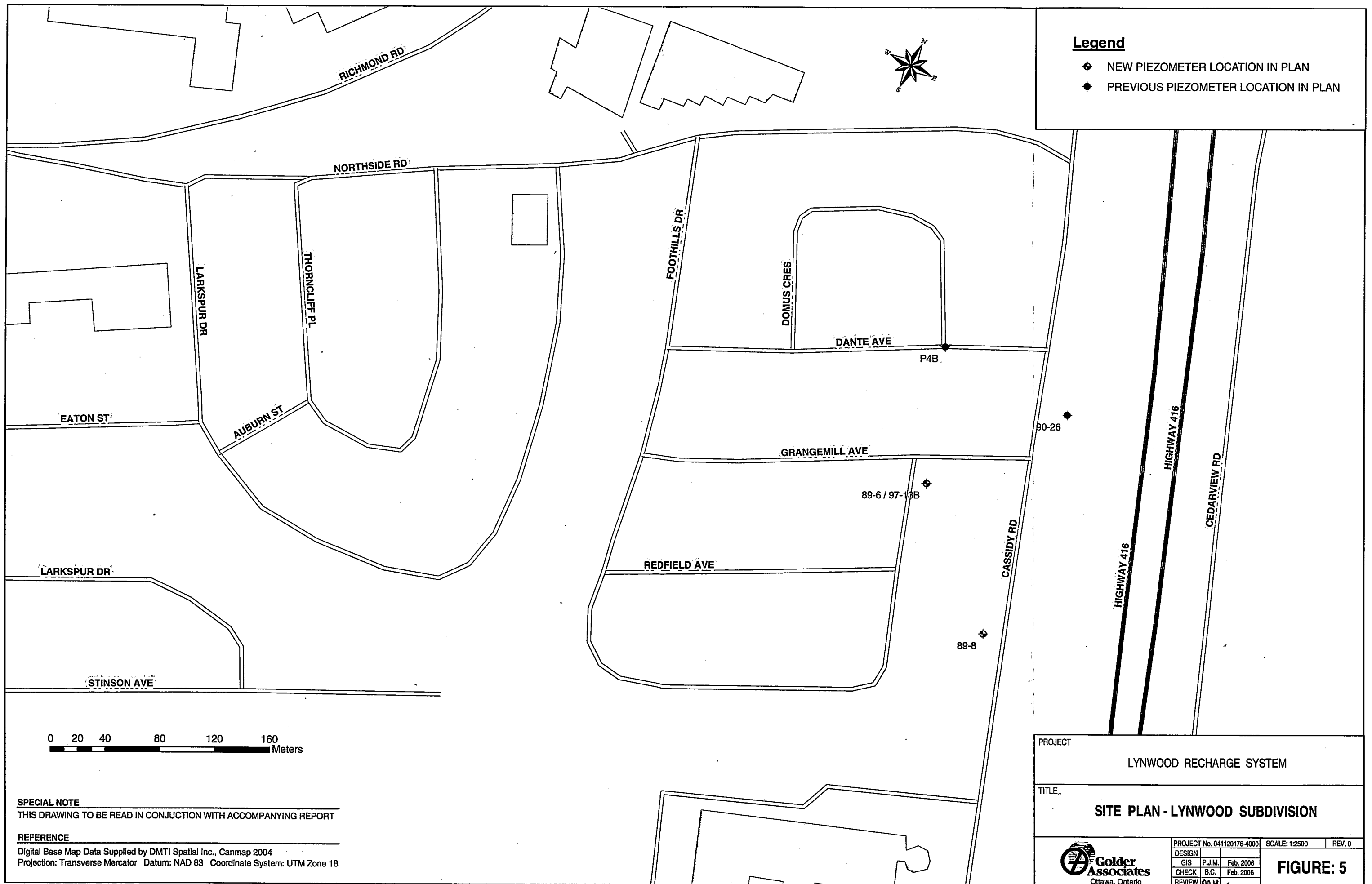
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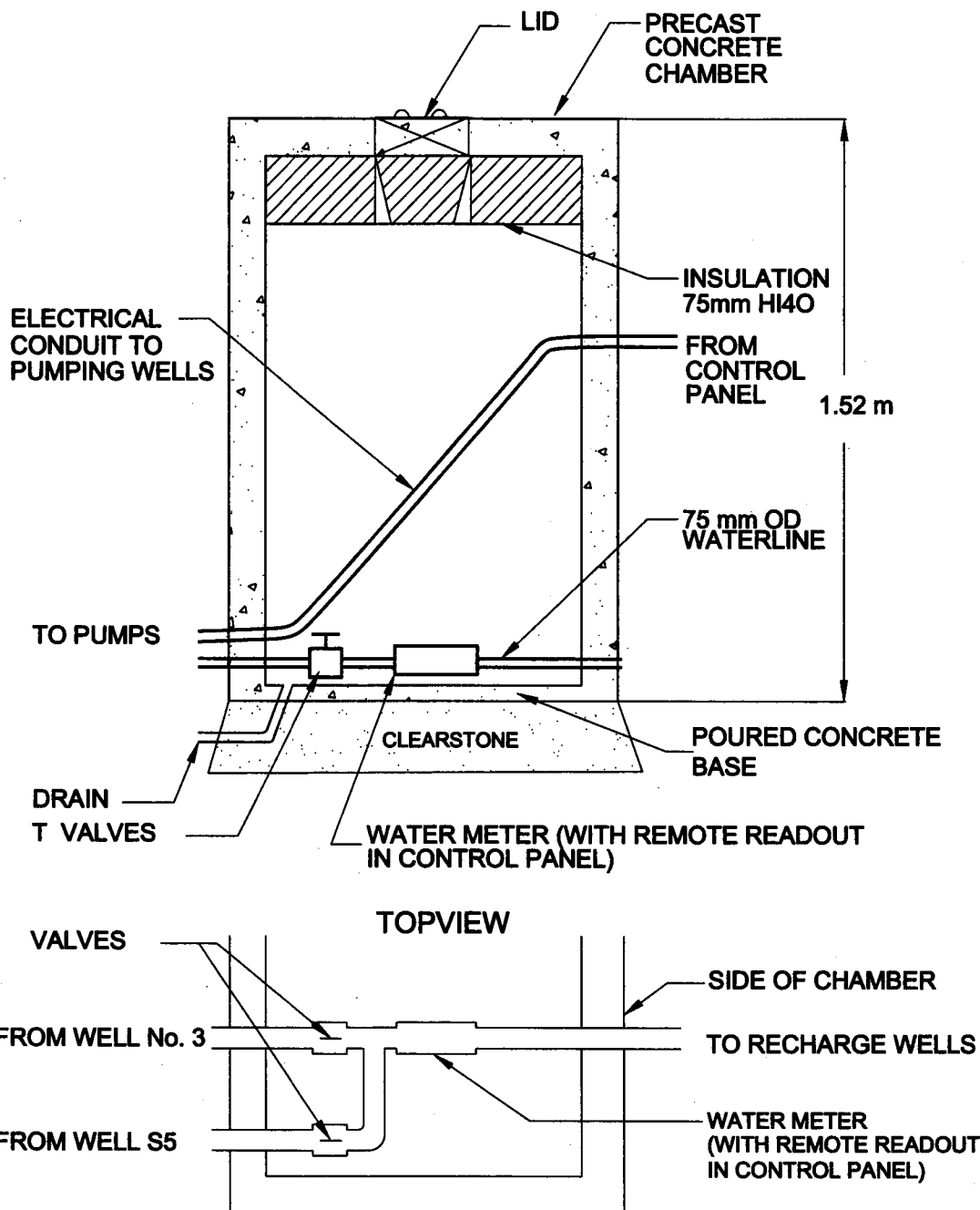
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FIGURE

4

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REVIEW

TITLE

FLOW METER CHAMBER

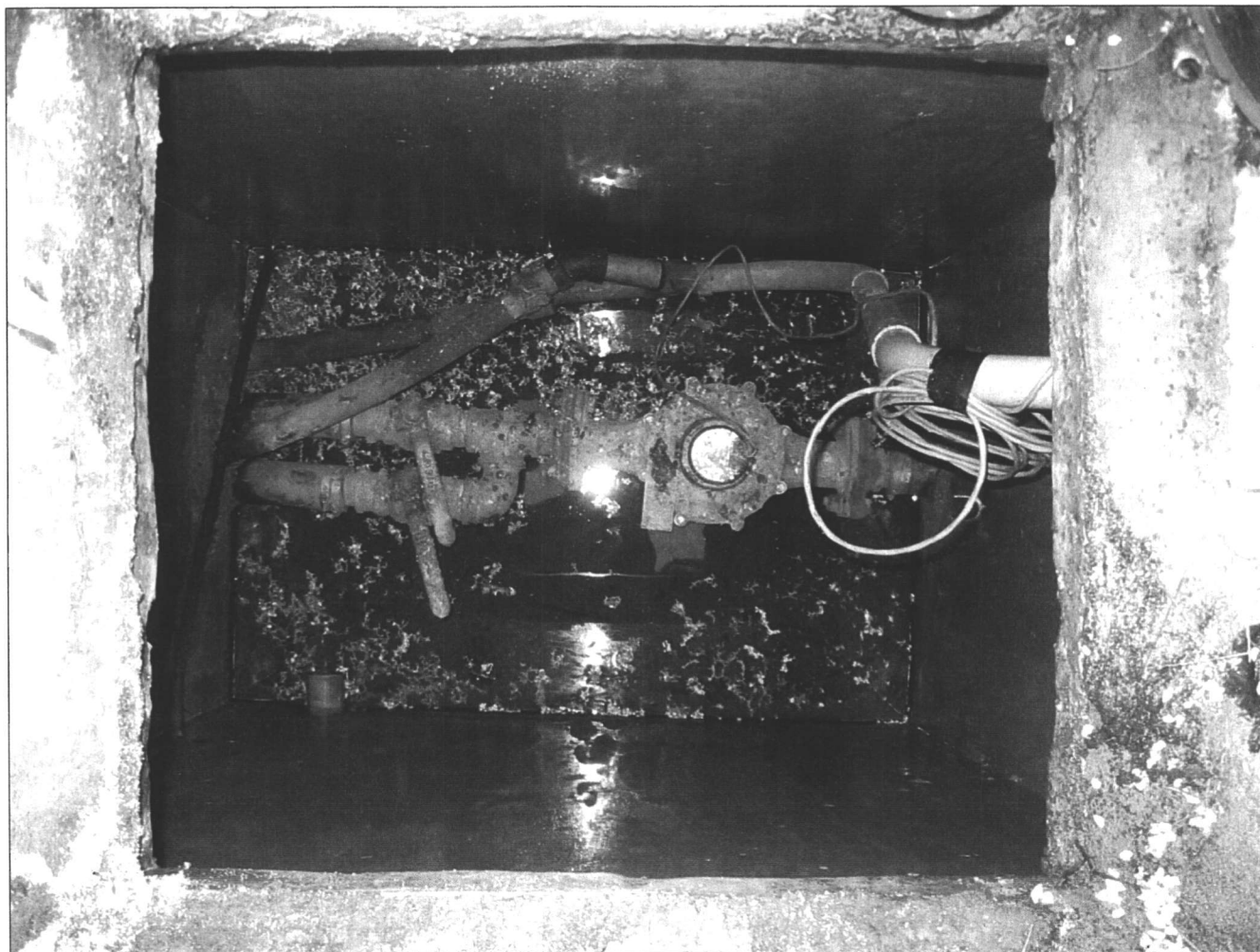
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PROJECT No. 04-1120-176 REV.

HIGHWAY 416

FIGURE

6



SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT



SCALE Not to Scale

DATE FEB. 2006

DESIGN

CADD S.L.

CHECK *mu*

REVIEW

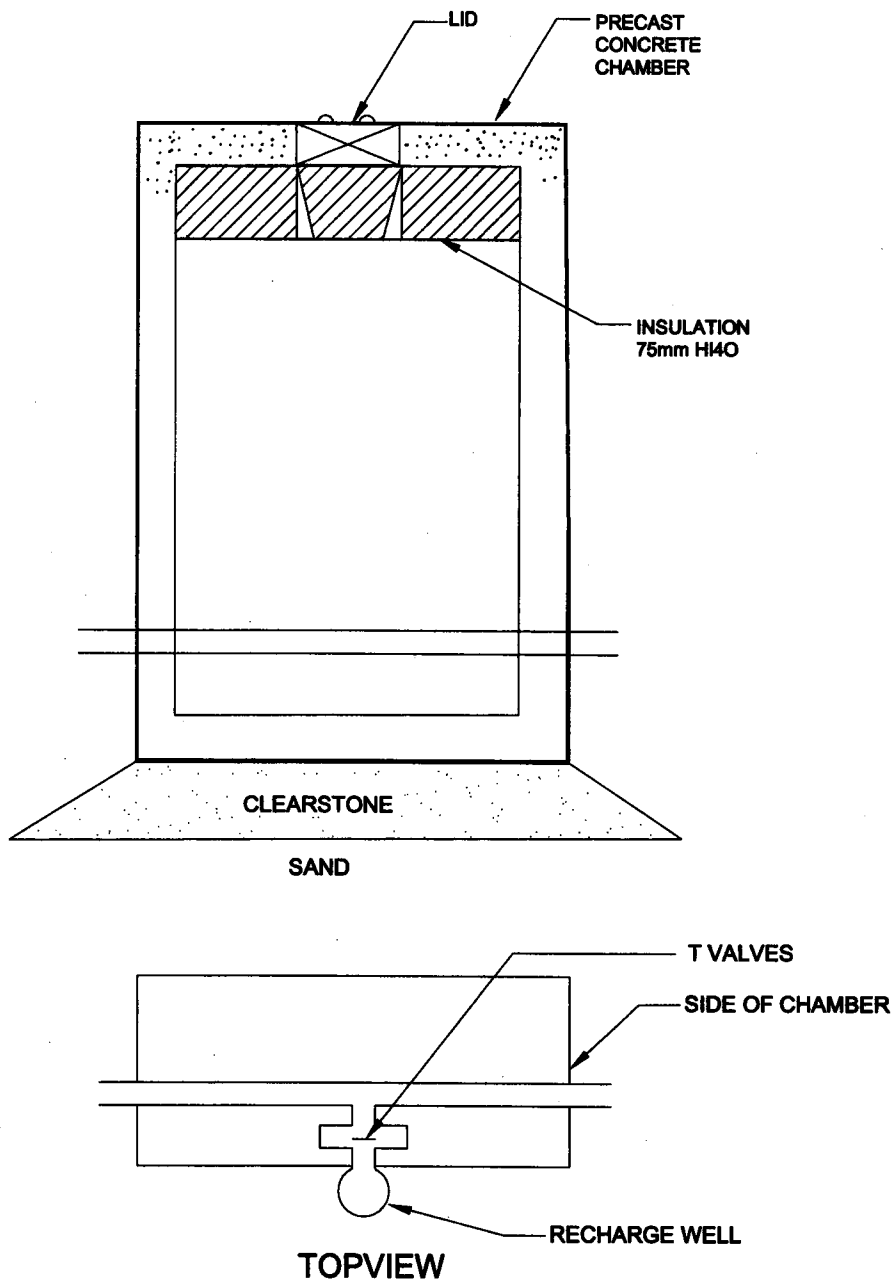
TITLE

FLOW METER CHAMBER

HIGHWAY 416

FIGURE

7



SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT

Drawing file: 041120176-4000-08.dwg Mar 20, 2006 - 9:33am



FILE No. 041120176-4000-08.dwg
PROJECT No. 04-1120-176 REV.

SCALE Not to Scale
DATE FEB. 2006
DESIGN
CADD S.L.
CHECK *ML*
REVIEW

TITLE

RECHARGE CHAMBER

HIGHWAY 416

FIGURE

8



SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT



SCALE Not to Scale

DATE FEB. 2006

DESIGN

CADD S.L.

TITLE

RECHARGE WELLS AND CHAMBERS

FILE No. 041120176-4000-09.dwg

CHECK *mu*

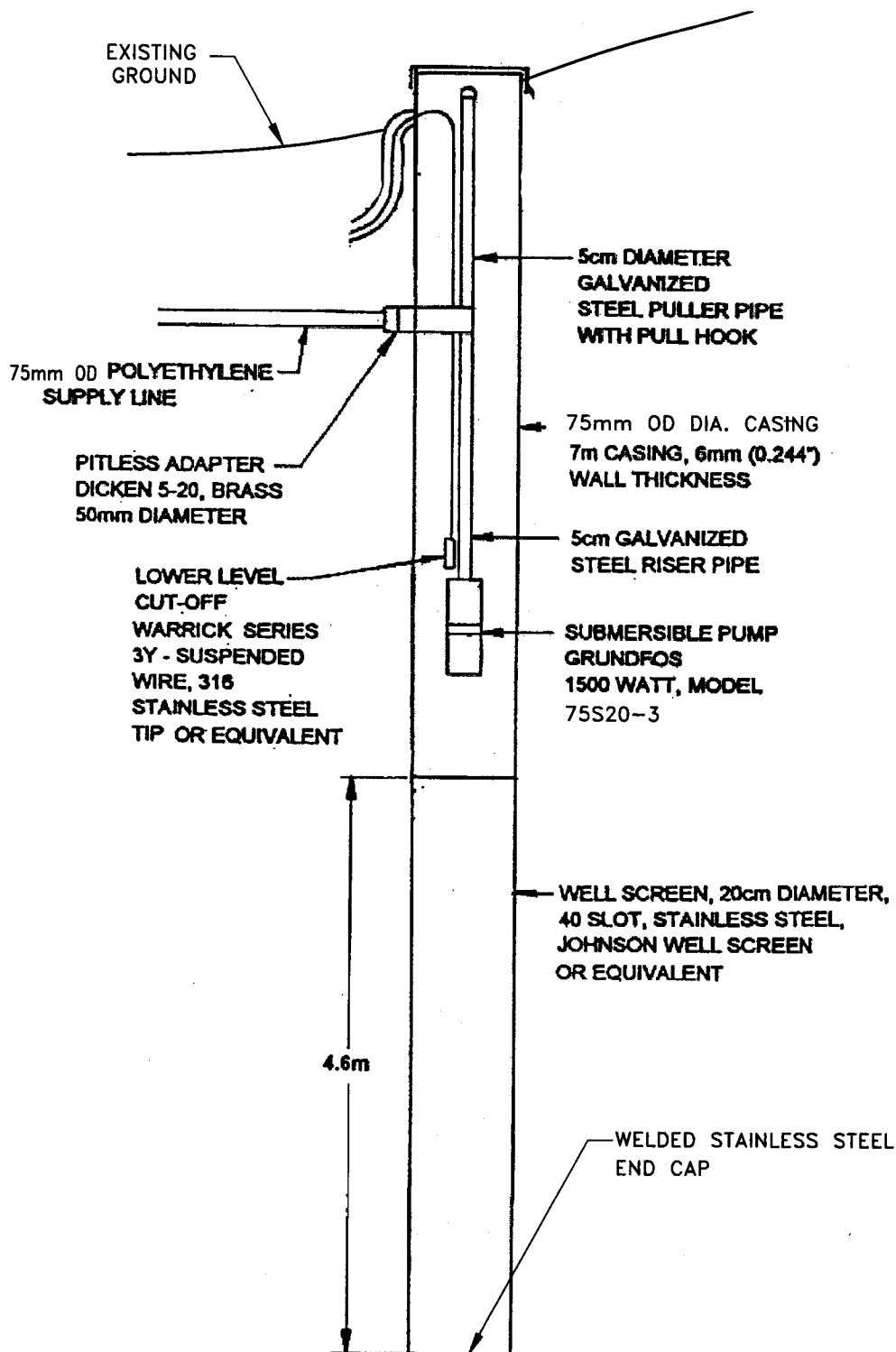
PROJECT No. 04-1120-176 REV.

REVIEW

HIGHWAY 416

FIGURE

9



SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT



SCALE Not to Scale

DATE FEB. 2006

DESIGN

CADD S.L.

CHECK *WLL*

REVIEW

TITLE

PUMPING WELL

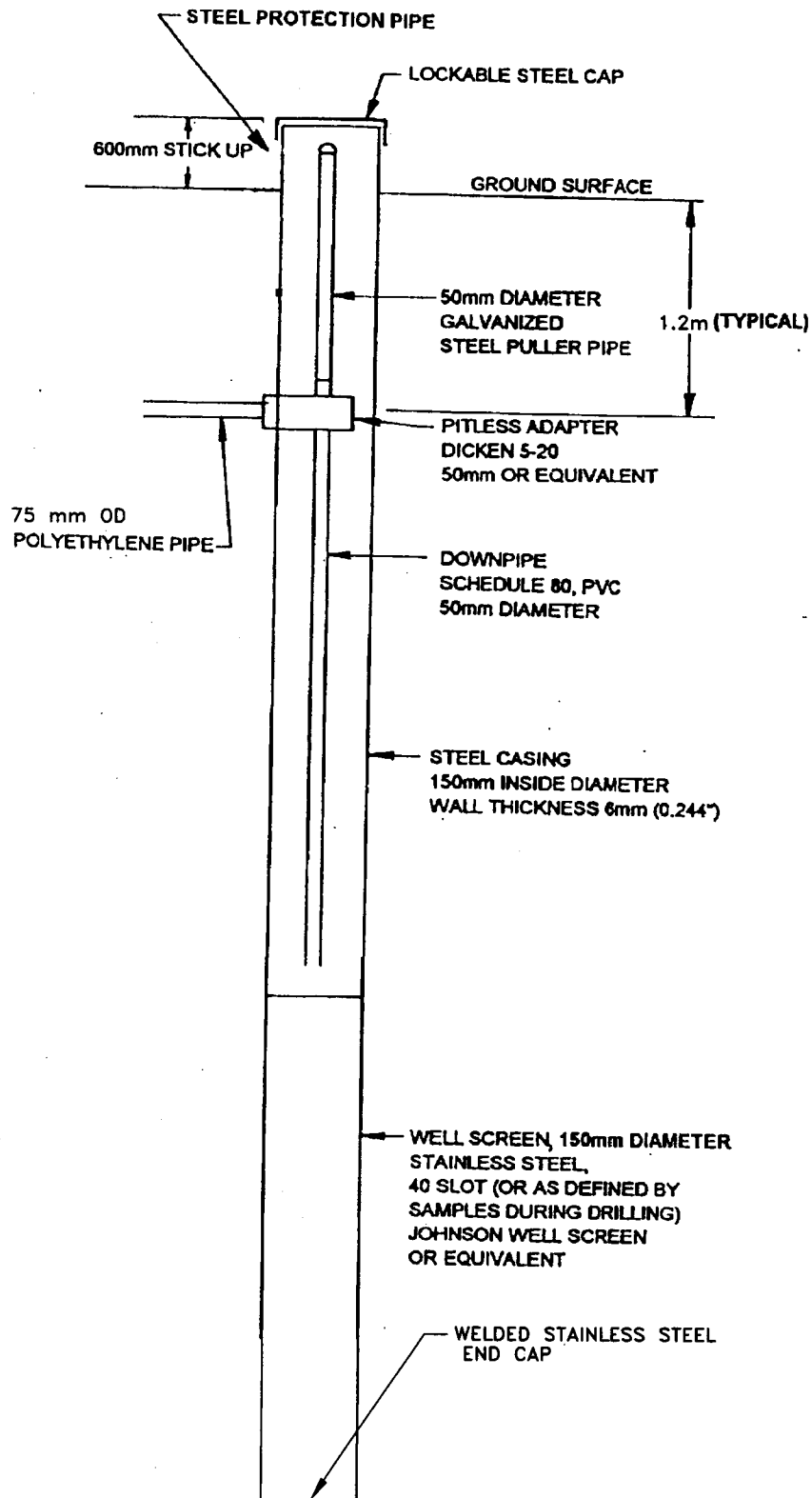
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PROJECT No. 04-1120-176 REV.

HIGHWAY 416

FIGURE

10



SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT



SCALE Not to Scale

DATE FEB. 2006

DESIGN

CADD S.L.

CHECK

REVIEW

TITLE

RECHARGE WELL

FILE No. 041120176-4000-11.dwg

PROJECT No. 04-1120-176 REV.

HIGHWAY 416

FIGURE

11



SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT



SCALE	Not to Scale
DATE	FEB. 2006
DESIGN	
CADD	S.L.
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REVIEW	

TITLE

PUMP ELECTRICAL- CONTROL PANEL

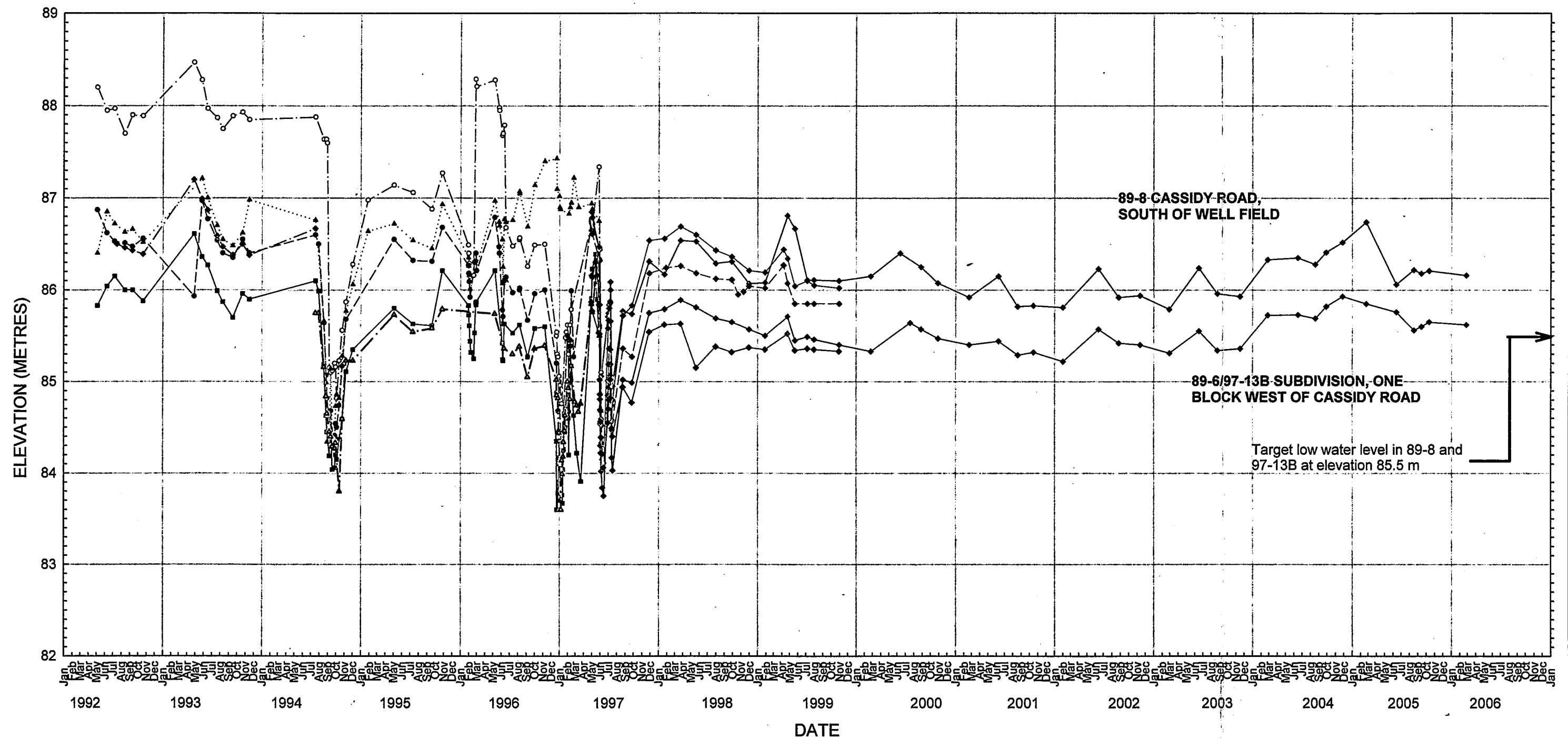
FILE No. 041120176-4000-12.dwg

PROJECT No. 04-1120-176 REV.

HIGHWAY 416

FIGURE

12



- BH 89-6B (Destroyed June 2, 1997)
- BH 89-8
- BH 90-W29A (Destroyed after July 18, 1994)
- BH 89-7 (Destroyed June 13, 1997)
- BH 89-9 (Destroyed June 13, 1997)
- BH 89-2A
- 97-13B (89-6B Replacement)
- New 89-8
- New 89-7
- New 89-9
- New 89-2A

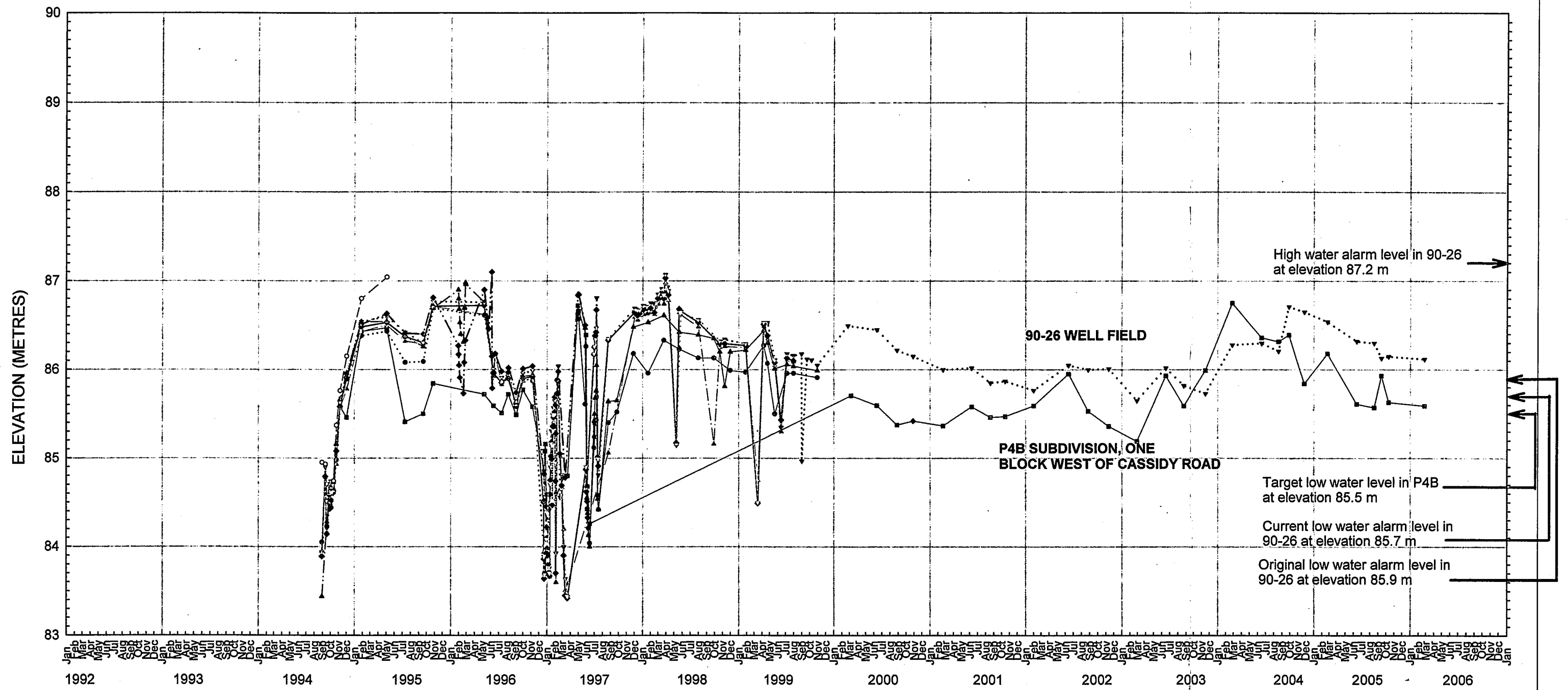


Date: March 2006
Project: 04-1120-176

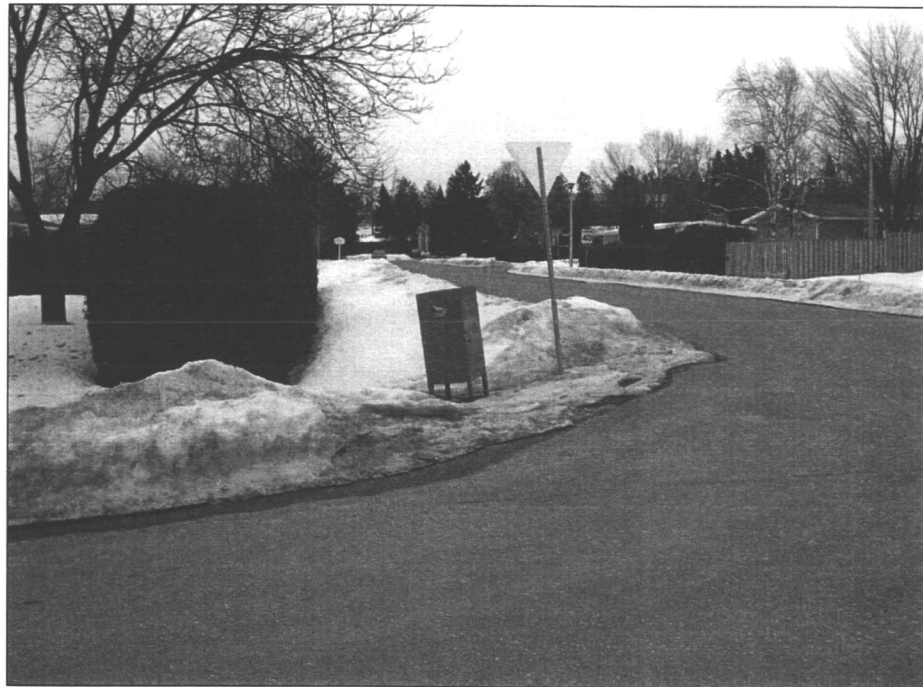
Drawn: JAS
Chkd: me

GROUNDWATER LEVELS

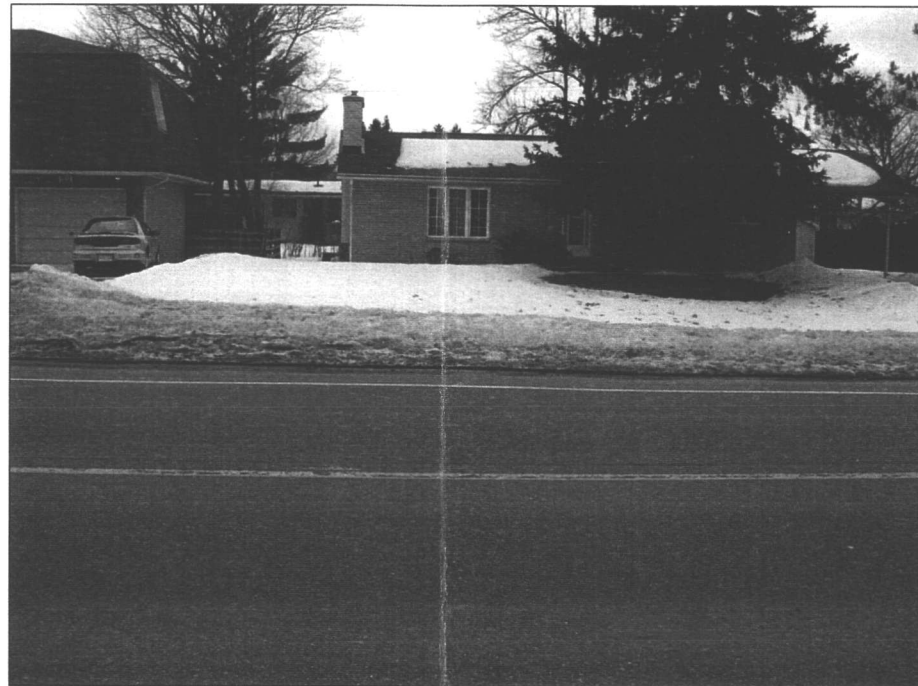
FIGURE 13



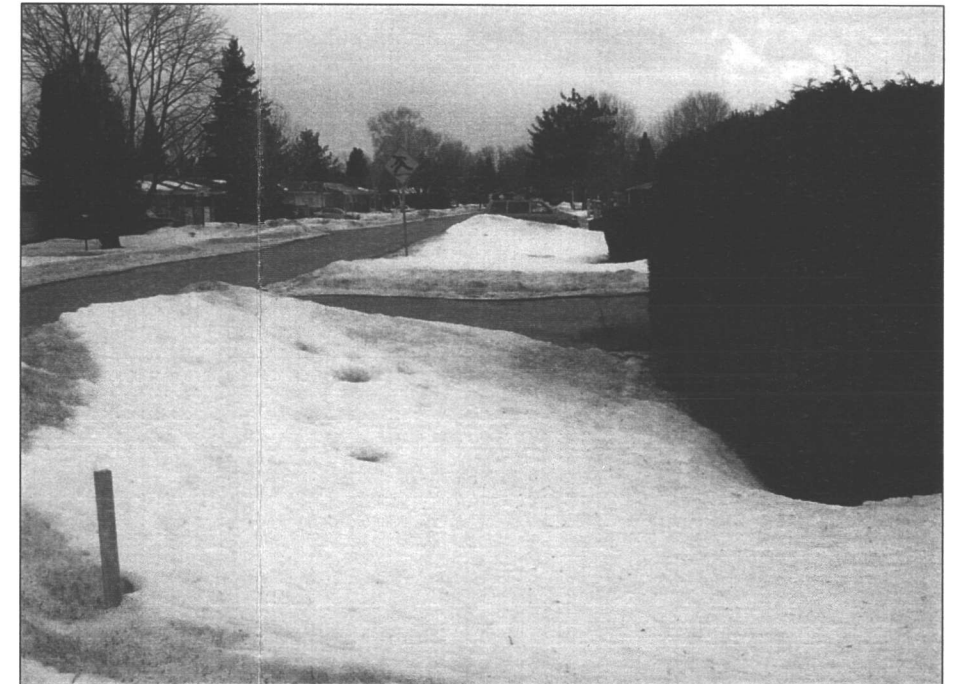
- ▲— BH 90-24A
- ◆— BH 90-25
- ...●... BH 90-26
- ▲— OLYMPIC WELL
- BH 89-4
- ...●... BH 88-4B
- BH P4B
- ◆— BH P5 (Destroyed June 13, 1997)
- New P4B
- ▲— New P5



89-6
97-13



89-8



P-4B

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT



FILE No. 041120176-4000-15.dwg
PROJECT No. 04-1120-176 REV.

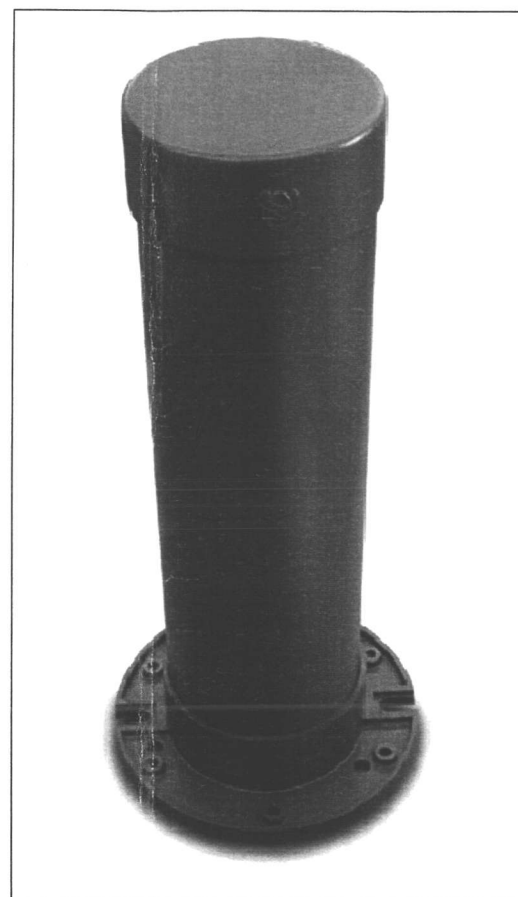
SCALE N.T.S.
DATE Mar. 2006
DESIGN
CADD S.L.
CHECK *ml*
REVIEW

TITLE
**"REMOTE" PIEZOMETER LOCATIONS,
IN LYNWOOD SUBDIVISION**

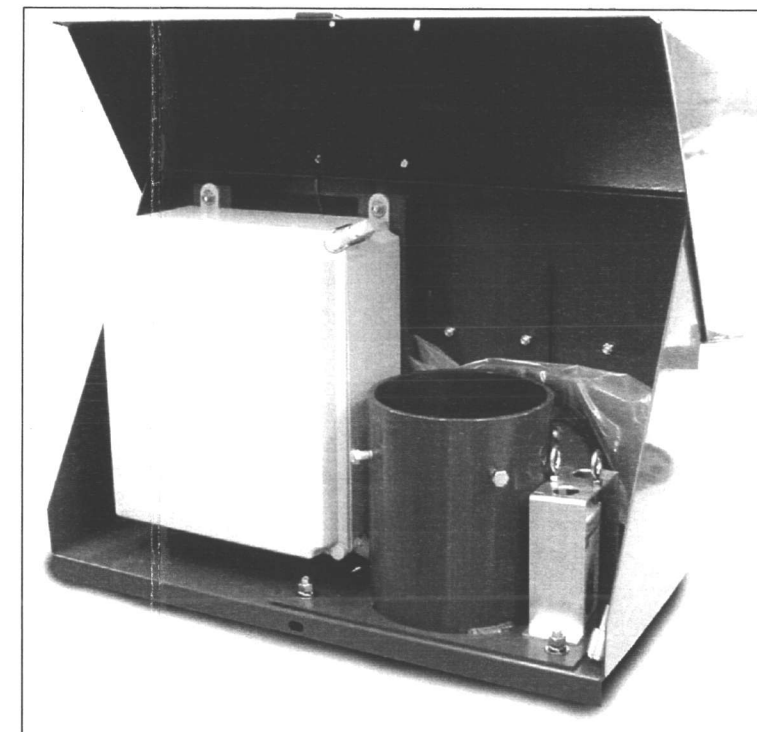
FIGURE
15



ROCTEST ENCLOSURE




SOLINST ANTENNA



SOLINST ENCLOSURE

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT

 <p>Golder Associates Ottawa, Ontario</p>	SCALE	N.T.S.	<p>ENCLOSURES FOR REMOTE PIEZOMETERS</p>	<p>FIGURE 16</p>
	DATE	Mar. 2006		
	DESIGN			
	CADD	S.L.		
	CHECK	<i>mu</i>		
FILE No. 041120176-4000-16.dwg	PROJECT No. 04-1120-176	REV.		
		REVIEW		

APPENDIX A

**MONITORING LETTER
PROJECT NUMBER 04-1120-176 (1000)
MARCH 13, 2006**

Golder Associates Ltd.

32 Steacie Drive
Kanata, Ontario, Canada K2K 2A9
Telephone 613-592-9600
Fax 613-592-9601



March 13, 2006

04-1120-176 (1000)

Ministry of Transportation Ontario
530 Tremblay Road
P.O. Box 9530 Terminal
Ottawa, Ontario
K1G 0E4

Attention: Mr. F. Mendoza

**RE: GROUNDWATER LEVEL MONITORING
AND RECHARGE SYSTEM COMPONENT INSPECTION
LYNWOOD VILLAGE SUBDIVISION
OTTAWA, ONTARIO
CONTRACT AGREEMENT 4004-C-0115**

Dear Sir:

This letter provides the results of groundwater level monitoring and recharge system component inspection at the Lynwood Subdivision in Ottawa (formerly Nepean), Ontario, carried out under contract agreement 40004-C-0115.

GROUNDWATER LEVELS

The groundwater levels in the recharge wells and selected monitoring wells were measured on February 24, 2006. The results are provided on the attached Tables 1 and 2. The groundwater level at monitor 90-26 (adjacent to the well field) on this date was at elevation 86.12 metres which is above the low water alarm level (presently set at elevation 85.71 metres, originally set at 85.9 metres, Figure 2).

The measured groundwater level in borehole 89-8 to the south along Cassidy Road was at elevation 86.16 metres (Figure 1). In the northern portion of the subdivision, the groundwater levels in P4B and 89-6/97-13B were 85.59 metres and 85.62 metres, respectively (Figures 1 and 2). These three groundwater levels are all above the minimum target elevation of 85.5 metres.

Two of the six recharge wells (well 1 and 8) were just slightly overflowing, however the water levels in the remaining three wells were generally between about 0.04 to 0.08 metres of the top of



casing and therefore operating near their capacity. The exception is well 6, with a water level 1.88 metres below the casing level, but that well is a low capacity well and accepts only a small portion of the overall recharge flow.

The flow meter was registering a flow rate of 26 IGPM and, since only two of the recharge wells are just slightly overflowing, this is still considered to be the effective rate of recharge. In view of the current acceptable well levels and that the recharge wells are operating near capacity, it is not proposed to change the recharge flow rate at this time.

RECHARGE SYSTEM COMPONENT INSPECTION

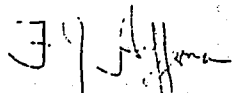
Selected recharge system components were inspected on February 24, 2006. The results of that inspection are summarized on the attached Table 3.

We trust that this letter is sufficient for your present requirements. If you have any question concerning this letter, please call us.

Yours truly,

GOLDER ASSOCIATES LTD.

M.I. Cunningham, P.Eng.



F.J. Heffernan, P.Eng.

JAS:MIC:FJH:cr:kc

n: active 2004 1120 geotechnical 04-1120-176 mto lynwood nepean 04-1120-176 ltr-022 13 march 2006.doc

Attachments:

Tables 1 to 3
Figures 1 and 2

cc: Mr. Tony Sangiuliano – MTO Pavements and Foundations

TABLE 1

GROUNDWATER LEVELS IN MONITORING WELLS
February 24, 2006

Monitoring Well Number	Elevation of Groundwater Level (metres)
P-4B	85.59
89-6/97-13B	85.62
89-8	86.16
90-26	86.12

TABLE 2

GROUNDWATER LEVELS IN RECHARGE WELLS
February 24, 2006

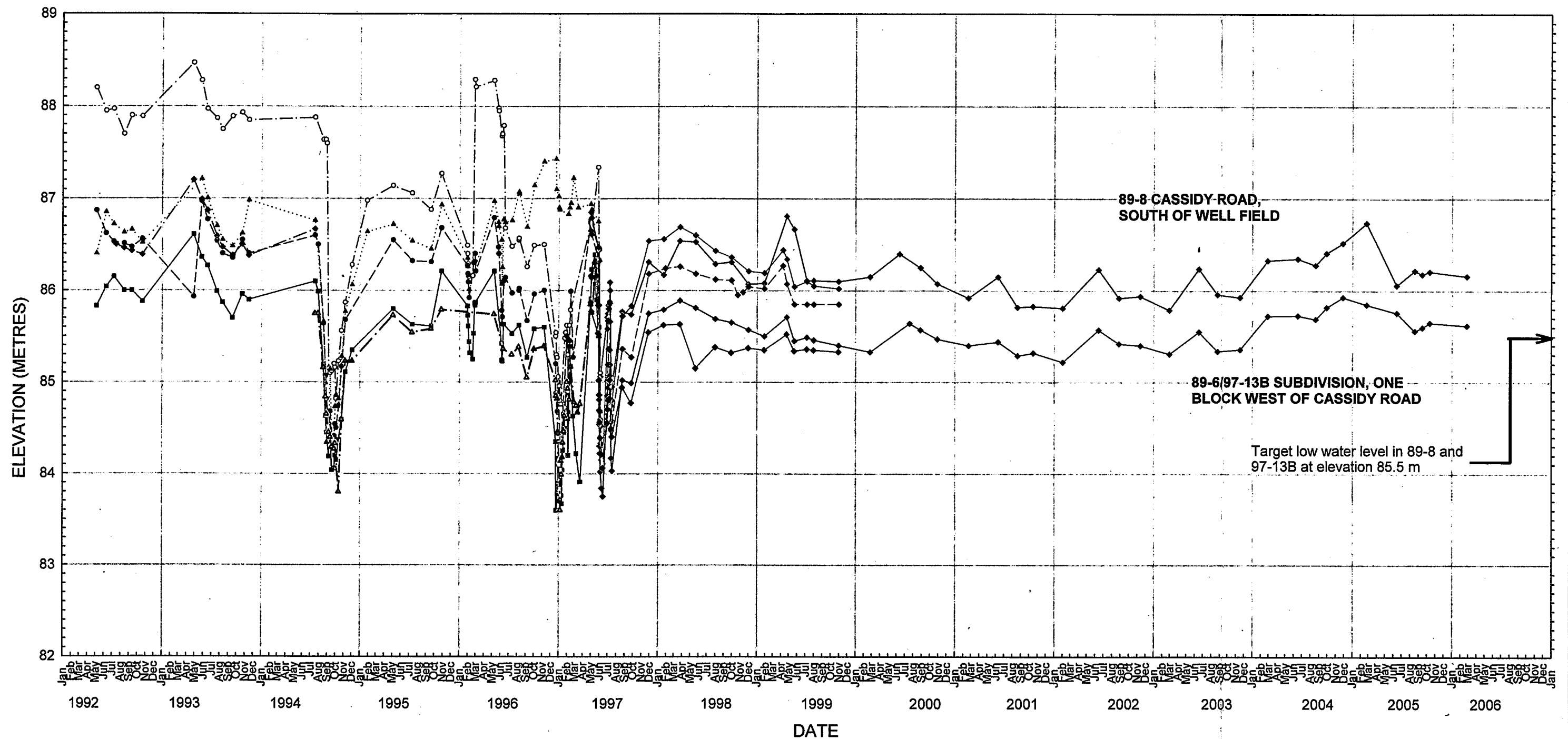
Recharge Well Number	Water Level Depth From Top of Casing (metres)
1	0.00 – Note 1
4	0.08
5	0.04
6	1.88
7	0.06
8	0.00 – Note 1

Note 1: Recharge well just slightly overflowing.

TABLE 3

PUMPING/RECHARGE SYSTEM COMPONENT INSPECTION CHECKLIST

ITEM		INSPECTION COMMENTS February 24, 2006
Well No. 3	- visually check well	OK
Well S5	- visually check well	OK
Flow Meter Chamber	- check valves - flow meter - check drainage - check polyethylene piping - check electrical conduit - check insulation - check lid	OK OK. OK. OK OK OK OK
Electric Pump Control Panel	- check pump changeover - check high/low water level alarm - check condition of cover	OK OK OK
Electric Vault/Manhole		Not accessed, on instruction of MTO electrical.
Recharge Wells	- visually check wells	OK
Recharge Chambers	- check valves - check drainage - check insulation - check lids	Under water OK OK OK
Drain Chamber	- check piping - check lid	OK OK
Low Water Level Alarm (at 90-26	- check functionality	OK
High Water Level Alarm (at 90-26	- check functionality	OK



- BH 89-6B (Destroyed June 2, 1997)
- BH 89-8
- BH 90-W29A (Destroyed after July 18, 1994)
- BH 89-7 (Destroyed June 13, 1997)
- BH 89-9 (Destroyed June 13, 1997)
- BH 89-2A
- 97-13B (89-6B Replacement)
- New 89-8
- New 89-7
- New 89-9
- New 89-2A

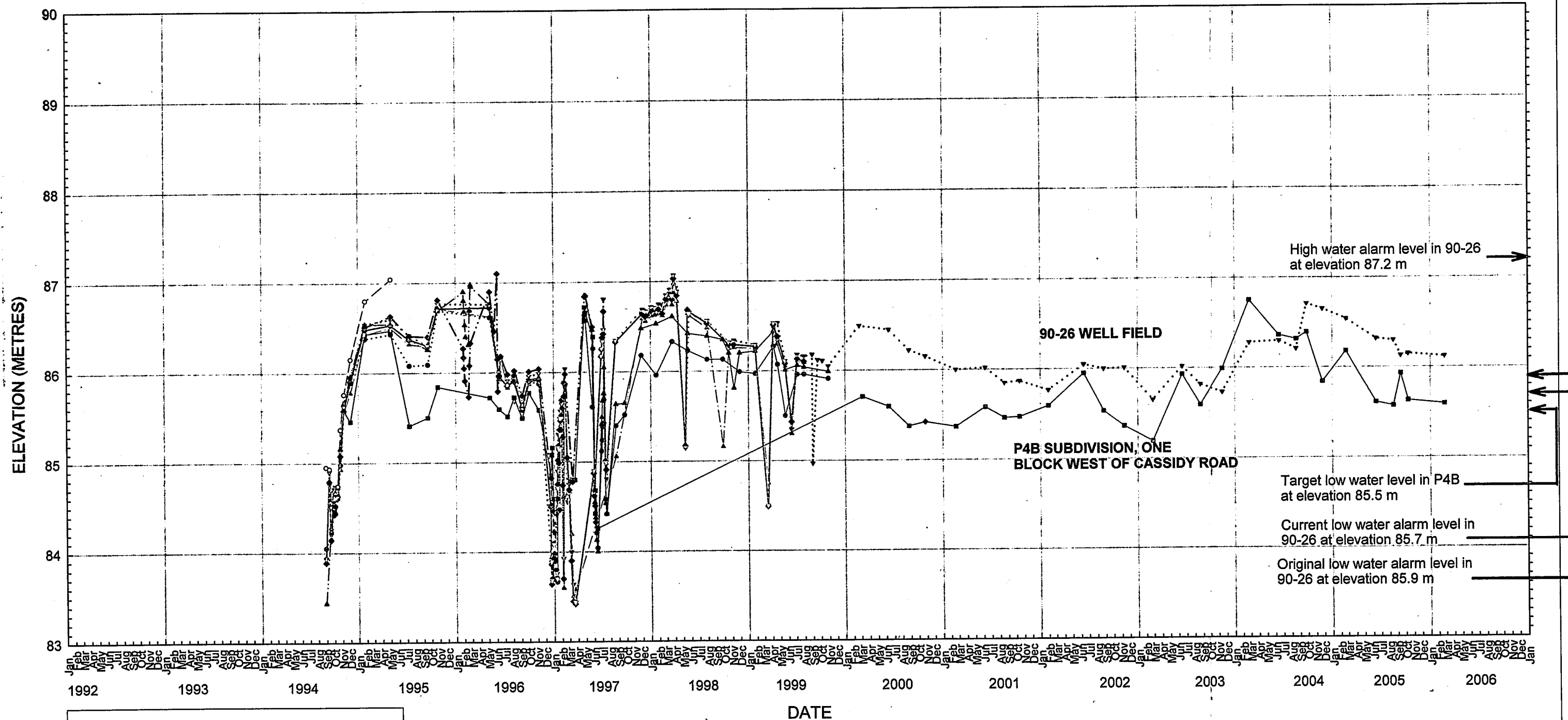


Date: March 2006
Project: 04-1120-176

Drawn: JAS
Chkd: *[Signature]*

GROUNDWATER LEVELS

FIGURE 1



- ▲— BH 90-24A
- ◆— BH 90-25
- ...●... BH 90-26
- ▲— OLYMPIC WELL
- BH 89-4
- ...●... BH 88-4B
- BH P4B
- ◆— BH P5 (Destroyed June 13, 1997)
- New P4B
- ▲— New P5



Date: March 2006
Project: 04-1120-176

Drawn: JAS
Chkd: *mv*

GROUNDWATER LEVELS

FIGURE 2

APPENDIX B

BOREHOLE RECORDS: P-4B, 89-6/97-13B, 89-8, AND 90-26

PROJECT: 97-1-2015

LOCATION: SEE FIGURE 2

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 97-1

BORING DATE: April 24-25/97

SHEET 1 OF 3

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



97-13B

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLLOT ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH C _u , kPa	nat. V. + rem. V. -	WATER CONTENT, PERCENT W _p			
0		GROUND SURFACE	87.82								
		TOPSOIL	87.77								
		Very stiff grey-brown SILTY CLAY (weathered crust)	0.15								
1											
2											
3											
4		Gray SILTY CLAY, some sandy layers with depth	84.57 3.36								
5											
6											
7											
8											
9											
10		Compact gray SANDY SILT, some gravel, some fine sand layers/bands	78.53 8.30	1	SO DO	13					
		CONTINUED ON NEXT PAGE		2	SO DO	27					

POWER AUGER
200 mm Dia. Hollow Stem Augers

Flash Mount
Silica Sand
Bentonite Seal
Native Backfill
Bentonite Seal
Silica Sand

BH 97-13
Pg 1

DATA INPUT: A:2015-9713.BH

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: PH

CHECKED: MLC

PROJECT: 971-2018

RECORD OF BOREHOLE 97-1

SHEET 2 OF 3

LOCATION: SEE FIGURE 2

BORING DATE: April 24-25/97

DATUM: GEODEIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa 21 41 61 81				WATER CONTENT, PERCENT Wp ——— W ——— Wt			
10	POWER AUGER 200 mm Dia. Helical Stem Augers	CONTINUED FROM PREVIOUS PAGE		2	SS	27							
11		Borehole continued by rock coring. Refer to Record of Drillhole 97-13	78.91 11.01	3	SS	24							
12													
13													
14													
15													
16													
17													
18													
19													
20		CONTINUED ON NEXT PAGE											

DATA INPUT: A32018-9713.BK

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: PH

CHECKED: MLC

PROJECT: 971-2015

LOCATION: SEE FIGURE 2

INCLINATION: AZIMUTH:

RECORD OF DRILLHOLE: 97-17

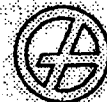
DRILLING DATE: April 24-25, 1997

DRILL RIG:

DRILLING CONTRACTOR:

SHEET 2 OF 3

DATUM: GEODETIC



DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH % RETURN	FR-FRACTURE		F-FAULT		SM-SMOOTH		FL-FLEXURED		DAMAGED CORE INDEX	NOTES WATER LEVELS INSTRUMENTATION
								CL-CLEAVAGE		J-JOINT	P-POLISHED	R-ROUGH	ST-STEPPED	UE-UNEVEN	W-WAVY		
								SH-SHEAR		S-SUCKEN/SIDED	PL-PLANAR	C-CURVED					
		CONTINUED FROM PREVIOUS PAGE															
10		CONTINUED FROM BOREHOLE 97-13															
11		BEDROCK SURFACE		78.91													
		Dolomitic limestone BEDROCK, thin to thickly bedded, some shale partings and sandstone seams		11.01													
12					4												
13					5												
14					6												
15		END OF DRILLHOLE		72.98 14.84													
16																	
17																	
18																	
19																	
20		CONTINUED ON NEXT PAGE															

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DEPTH SCALE:

1 to 50

Golder Associates

LOGGED: PH

DATE:

CHECKED: mic

PROJECT: 971-2038
LOCATION: SEE FIGURE 2

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE No. 8

BORING DATE: April 17, 1987

SHEET 1 OF 2

BATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



89-8

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLLOT ELEV. DEPTH (m)	NUMBER TYPE	BLOWS/0.3m	SHEAR STRENGTH C _u , kPa	nat.V - + 0 - ● rem.V - ● U - 0	WATER CONTENT, PERCENT W _p	W		
0		GROUND SURFACE	88.86								
		TOPSOIL	0.00								
		Grey-brown SILTY CLAY (weathered crust)	0.30								
1											
2											
3											
4		Grey SILTY CLAY	3.35								
5											
6											
7		Grey SANDY SILT, some gravel (GLACIAL TILL)	7.01								
8											
9											
10											

POWER AUGER
200 mm Dia. Hollow Stem Augers

BH 89-8
Pg 1

Flush Mount
Casing
Silica
Sand
Native
Backfill

CONTINUED ON NEXT PAGE

Borehole
Seal

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: PH

CHECKED: MIC

PROJECT: 071-2066

RECORD OF BOREHOLE No. 8

SHEET 2 OF 2

LOCATION: SEE FIGURE 2

BORING DATE: April 17, 1997

DATUM: GEODEIC

SAMPLER HAMMER: 63.5kg; DROP: 760mm

PENETRATION TEST HAMMER: 63.5kg; DROP: 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE	BLWS/0.3m	SHEAR STRENGTH C _u , kPa	nat.V. + rem.V. -	q - ● u - ○		
10	POWER AUGER 500 mm Dia. Hollow Stem Auger	CONTINUED FROM PREVIOUS PAGE									
11		Grey banded, SANDY SILT, and medium sand (transition)		75.29 10.67	1	86 DO	12				
12		Compact medium-course SANDS, trace silt		77.37 11.59							
13		END OF BOREHOLE		76.00 12.98							
14											
15											
16											
17											
18											
19											
20											

Pg 2

Silica
SandTop of Pipe
at El. 88.91m

DATA INPUT: A:\2034-002.BH

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: PH

CHECKED: M.C.

RECORD OF BOREHOLE No 90-26

METRIC

W P 146-74-00-3

LOCATION Co-ords N 5 021 090; B 350 915

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY D.J.S.

DATUM Geodetic

DATE May 10, 1990

COMPILED BY A.C.

CHECKED BY A.C.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
87.7	Ground Surface												
87.5	Topsoil												
85.3	Silty clay (weathered crust) Grey Brown												
83.3	Silty Clay Grey		1	SS	PM								
82.2	Sandy silt, to silty sand, some gravel Loose to Compact Grey		2	SS	4								
78.6	Sand, fine to coarse, trace silt Compact to Dense Grey		3	SS	39								
			4	SS	29								
			5	SS	36								
			6	SS	25								
			7	SS	24								
9.1	End of Borehole												

Concrete

Native Backfill

Water level in well
screen at elev. 86.4
metres on July 12, 1990.

Bentonite

Cave Material

32 mm PVC #10
Well Screen

BH 90-26

PROJECT: 921-2158

LOCATION: See Plan

SAMPLER: HAMMER, 63.6kg, DROP: 760mm

RECORD OF BOREHOLE P4

BORING DATE: Nov. 12, 1994

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER: 63.6kg, DROP: 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, K, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH C _u , kPa nat.V - + 0 - ● rem.V - ● U - ○		
0		Ground Surface	88.23 0.00						
		Brown sand and gravel (FILL)							Bentonite Seal Native Backfill
1			87.47 0.78						
2		Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)		1	SS	7			
3			84.88 3.35	2	SS	1			Bentonite Seal Granular Filter Standpipe B
4		Stiff grey SILTY CLAY	83.88 4.57	3	SS	1			Bentonite Seal Native Backfill
5				4	SS	1			
6		Loose to compact grey sandy silt, some gravel and clay (GLACIAL TILL)		5	SS	10			
7				6	SS	5			
8			80.15 8.08	7	SS	27			
9				8	SS	8			Native Backfill
10		Dense to very dense grey stratified fine SAND		9	SS	8			
11				10	SS	8			
12		Dense to very dense grey sandy silt, some gravel and clay (GLACIAL TILL)	78.71 11.52	11	SS	48			Granular Filter Standpipe A
13		End of Hole Auger Refusal	78.22 12.01	12	SS	> 100			Bentonite Seal

Power Auger
200mm Dia. (Hollow Stem)

BH P4

DATA INPUT: C:\BP4\154.DBF

DATA INPUT: C:\SP4-136.DRF

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: A.F.C.

CHECKED: AC

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APPENDIX C

TRANSDUCER AND LOGGER PRODUCT INFORMATION FOR PIEZOMETERS

Levellogger Gold

The NEW Levellogger® Gold represents the next generation of water level dataloggers. Vastly improved over previous versions, the Levellogger Gold is completely designed, developed and manufactured in-house, in the tradition of all Solinst high quality products.

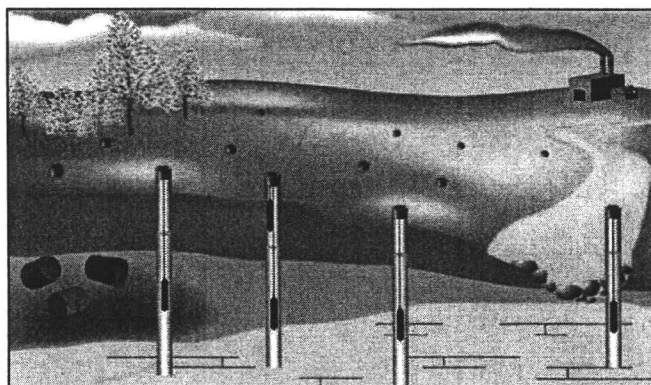
The Levellogger Gold offers higher resolution and high accuracy of 0.05%, for a much reduced price. The Levellogger Gold has improved transducer, temperature and clock accuracies. Altitude, water density and improvements to temperature and barometric compensations also add to the significant increase in accuracy and instrument stability. A Zirconium Nitride coating resists corrosion.

The Levellogger is a water level and temperature recording device. It combines a datalogger, 10-year battery, pressure transducer and temperature sensor, in a small, minimal maintenance, 7/8" x 6" (22 mm x 154 mm) stainless steel housing. The sealed Faraday cage design greatly simplifies maintenance and provides protection against electrical spikes caused by lightning.

High accuracy, long-term stability and an internal battery that lasts for 10 years when reading every minute, make Levelloggers the ideal devices for recording water levels. A Barologger provides the easiest and most accurate method of barometric compensation.

Applications

- Pumping and slug tests
- Watershed, drainage basin and recharge
- Stream gauging, lake levels and reservoirs
- Harbor and tidal fluctuation monitoring
- Wetlands and stormwater run-off monitoring
- Tank level monitoring
- Long-term water level monitoring in wells, surface water bodies and seawater environments



Features

- Self-test capability
- Backward compatible
- Maintenance-free, water-tight design
- Protected from power surges, such as lightning
- Real-time viewing; data can be exported
- Radio or cellular telemetry
- User-selectable, 30 line sampling schedule

Memory Improvements

The Levellogger Gold memory allows a maximum of 40,000 readings of level and temperature, set up in individual logs. The user has a choice of slate or continuous logging modes when operating in linear mode. In event-based and schedule sampling, memory is a form of circular slate, which starts logging from the end of the last log and wraps around to eventually overwrite older logs, but which will stop at the start of the current log. A separate redundant memory provides backup of the last 1200 readings, which can be accessed by a Diagnostic Utility program.

Downloading Improvements

The Levellogger Gold offers 4 download options: 'All Data' downloads the complete log, or the user can save time by selecting 'Append Data', when only new data is desired. A selected period of time prior to the last date stamp can be downloaded using 'Partial Download'. 'Recover Previous Log' is a safeguard in case the Levellogger has been restarted without downloading data. A complete data dump is also available as a feature of the Diagnostic Utility, which downloads all available memory in the Levellogger Gold.

More Accurate than Ever

The Levellogger Gold has a typical accuracy of 0.05% net FS, a resolution of 0.0006 to 0.002% depending on range, a Barologger with algorithms based on air not water, improved altitude, density, temperature and barometric compensation, as well as a more accurate clock.

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Levellogger Operation

Solinst has made programming the Levellogger Gold extremely intuitive. Simply place the Levellogger in the optical reader or connect to the direct read cable. All in one screen, fill in the information fields for location, project ID, sample mode and rate, altitude, density adjustment and any desired offset.

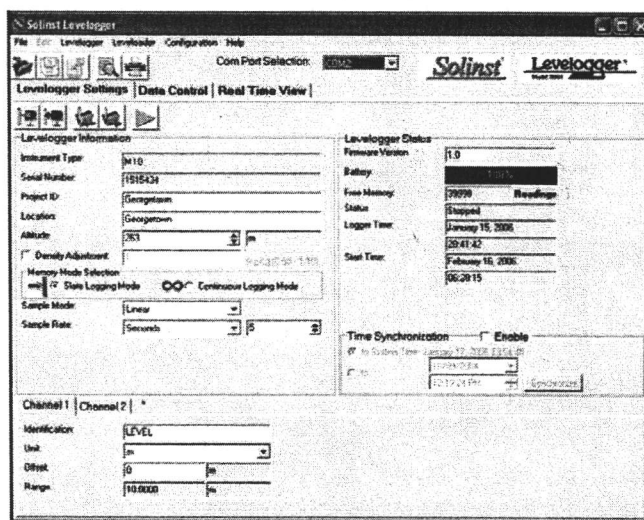
Levellogger time may be synchronized to the computer clock, or the Levellogger II clock, or it can be user defined. There are options for immediate start or a future start time. The percentage battery life remaining and the amount of free memory are indicated on the programming screen.

A manual measurement of the initial water depth is usually taken at each location, and noted as a base line measurement. When a Barologger is used for barometric pressure measurement, it is set above high water level in one location on site. If direct read cables are being used, data can also be viewed, logged on demand and retrieved from the Levellogger at any time using a Leveloader or a portable computer.

Sampling Option Improvements

Solinst has added a very flexible, user-selectable sampling schedule, as well as the standard linear and event-based sampling options. Linear sampling can be anywhere from 0.5 seconds to 99 hours. Event-based sampling can be set to record when the level changes anywhere from 0.1% up to 25% of the full range of the logger. Readings will be checked at the selected time interval and discarded if not \geq the percent change selected, but recorded if the condition has been matched or exceeded.

The Schedule option allows up to 30 schedule items, each with its own sampling rate of seconds, minutes or hours, and a duration of seconds, minutes, hours, days or weeks. A running total of sample time and number of readings available are indicated and updated. Templates of these Schedules, and Levellogger Settings, can be saved for easy re-use.



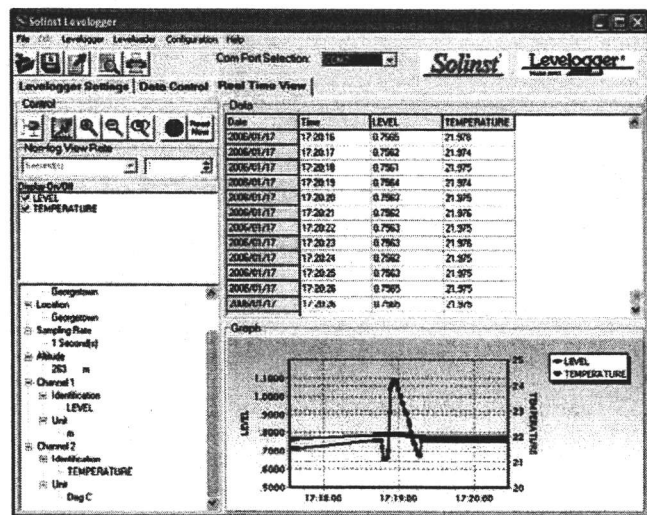
Levellogger Settings Window

Data Download, Viewing and Export

Data is downloaded to a PC with the click of a screen icon or with the push of a button on the Leveloader. Collected data is retained in the Levellogger until it has been written over. The level data downloaded from a Levellogger has already been automatically compensated for temperature and altitude and the temperature data is also downloaded. Barometric compensation of the Levellogger data is performed by a Wizard that can be used to input elevation offsets and adjust for Barometric efficiency. The software allows immediate viewing of the data in graph or table format using the 'Real Time View' option. It also allows easy export into a spreadsheet or database for further processing.

Backward Compatibility

The software can be used with any type of Levellogger including previous versions and any product in the Levellogger family including, Leveloaders, telemetry and the Rain Logger.



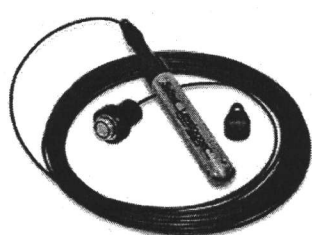
Real Time View Window

Use of Direct Read Cables

When it is desired to get real-time data and communicate with Levelloggers without removal from the water, they can be deployed using direct read cables.

The lower end of the direct read cable has a miniaturized infra-red optical reader. The top cap of the Levellogger is removed and the direct read cable is threaded in its place. In turn, the upper end of the cable is attached to a portable computer or Leveloader, via a USB or RS232 PC Interface Cable. This allows viewing of the data, downloading and/or programming in the field.

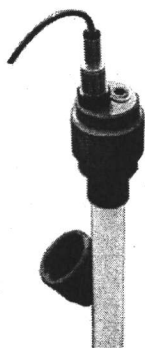
The full benefits of a sealed Levellogger with no vent tube or electrical cable connection are also maintained. The logger is still sealed from all electrical interference through a Faraday cage design. Cable handling problems are minimized.



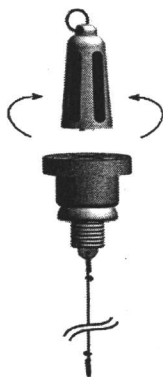
Levellogger connected to Direct Read Cable



PC Interface Cable and 2" Wellcap and Cover



PC Interface Cable connected to the Direct Read Cable



Enviro Cap[™] lockable cap and key used with Wireline and Hooks

Helpful Utilities

The 'Self-Test Diagnostic Utility' can be used in case of an unexpected problem. It checks the functioning of the program, calibration, backup and logging memories, the pressure transducer, temperature sensor and battery voltage, as well as enabling a complete Memory Dump, if required. A Firmware Upgrade will be available from time to time, to allow upgrading of the Levellogger Gold, as new features are added.

Direct Read Cable Specifications

Direct read cables are available for attachment to any Levellogger, new or old, in standard lengths of: 50', 100', 200', 250', 350', 300' and 15 m, 30 m, 60 m, 80 m, 100 m. Custom cable lengths up to 1640 ft. (500 m) are also available to fit particular monitoring situations, as required. Cable markings are available upon request.

The 1/10" dia. (2.54 mm) coaxial cable has an HDPE outer jacket for strength and durability. A stranded stainless steel braided conductor gives non-stretch accuracy.

The upper end of the direct read cable is fitted with a connector that can act as a well cap for a 1" well. This connector fits Solinst Levellogger well caps designed for 2" or 4" wells, and can easily be tethered at surface in other situations.

Use of Suspension Wireline

Levelloggers may also be suspended in the water on wireline. This is a very inexpensive method of deployment, and if in a well, allows the Levellogger to be easily locked, out of sight and inaccessible to anyone without a special key.

Solinst has adapted the Enviro Cap[™] by adding a vent hole in the cap to allow for the equalization of barometric pressure in the well. The well cap has a convenient eyelet from which to suspend the Levellogger. It slips into the casing and is locked in place with the tamper-proof key, as shown.

The Enviro Caps are available sized for 2" and 4" wells. Well caps for other sizes of well can also be used.

Accurate Barometric Compensation

Levelloggers measure absolute pressure (water pressure + atmospheric pressure) expressed in feet, meters or centimeters of water column.

The most accurate method of obtaining changes in water level is to compensate for atmospheric pressure fluctuations using a Barologger. This avoids any time lag in the compensation calculation and any errors introduced due to moisture buildup, kinking or damage to vented cable. The new Barologger Gold uses algorithms based on air rather than water pressure, which gives superior accuracy. The recorded barometric information can also be very useful to help determine barometric lag and/or barometric efficiency of the monitored aquifer.

The Data Compensation Wizard in the Levellogger software greatly simplifies the barometric adjustment of the water level measurements by using the synchronized data from one on-site Barologger with all the Levelloggers.

The overall results give more reliable, highly accurate level data than that obtained when using high maintenance and expensive vented cable.

Levellogger Gold Specifications

Level Sensor:	Piezoresistive Silicon in 316L Stainless Steel
Accuracy (Typical):	0.05% net FS
Accuracy (Max Error):	0.1% net FS
Stability of Readings:	Superior, low noise
Resolution:	0.002 to 0.0006% FS
Normalization:	Automatic Temp Compensation
Temperature Sensor:	Platinum Resistance Temperature Detector
Temp. Sensor Accuracy:	± 0.05°C
Temp. Sensor Resolution:	0.003°C
Temp. Comp. Range:	-10 to +40°C
Response Time:	< 1 minute
Battery Life:	10 Years - based on one reading/min
Clock Accuracy:	± 1 minute /year
Operating Temperature:	-20°C to 80°C
Maximum # Readings:	40,000 of level and temperature
Memory:	Superior reliability EEPROM Slate, rollover and redundant backup of last 1200 logs
Communication:	Optical Infra-Red Interface, Serial at 9600 Baud, Conversion to RS232 or USB Computer Connection
Size:	7/8" x 6" (22 mm x 154 mm)
Weight:	6.3 oz (179 grams)
Backwards Compatibility:	Full
Corrosion Resistance:	Zirconium Nitride (ZrN) Coating
Other Wetted Materials:	316-L Stainless Steel, Delrin, Viton
Sampling Modes:	Linear, Event and User-Selectable with 30 separate line items
Measurement Rates:	0.5 sec to 99 hrs
Barometric Compensation:	Software Wizard and one Barologger in local area (approx. 20 miles/30 km) radius

Models	Resolution	Accuracy (typical)	Water Fluctuation Range
Barologger	0.002% FS	± 0.003 ft., 0.1 cm	Air Only
F15, M5	0.001% FS	± 0.010 ft., 0.3 cm	13.1 ft., 4 m
F30, M10	0.0006% FS	± 0.016 ft., 0.5 cm	29.5 ft., 9 m
F60, M20	0.0006% FS	± 0.032 ft., 1 cm	62.3 ft., 19 m
F100, M30	0.0006% FS	± 0.064 ft., 1.5 cm	95.1 ft., 29 m
F300, M100	0.0006% FS	± 0.164 ft., 5 cm	325 ft., 99 m

Conductivity Levellogger: See Model 3001 LTC Data Sheet for details

Levelloaders

The USB Levelloader II is an advanced data transfer unit designed to store and transfer rapidly from all past and present Levellogger models. 2Mb of flash memory allow storage of multiple data files, and battery indicator and memory status allow more functionality.

You can reprogram Levellogger sampling regimes, altitude and instrument location. It offers the option of password protection and holds up to 380,000 data points (or 256 log files).

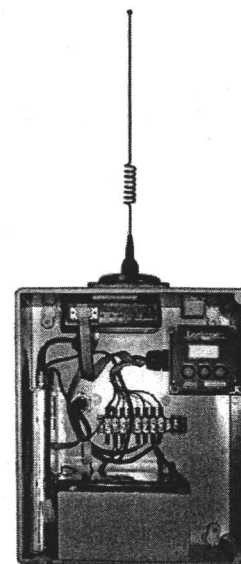
Simply hook up a Levelloader to a direct read cable or Levellogger and download; move on to the next location and then back to the office for transfer to the computer. The basic Levelloader I with RS232 connector is also available. (See Levelloader Series Data Sheet)



STS Telemetry

Solinst offers a variety of telecommunications options to transfer data from Levelloggers and Rain Loggers in the field to your location including radio, GSM & CDMA digital cellular, and land-line telephone.

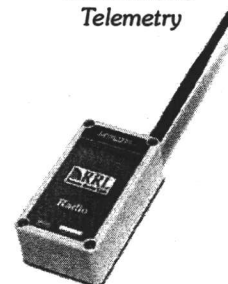
Solinst Telemetry software allows self-management of the Levellogger data, and is suitable for large or small systems. An STS can control up to 400 remote Levelloggers, Barologgers or Rain Loggers, with selectable automated reading schedules, as well as high and low level alarm options. Long term cost savings come from time saved through automated data collection and reduced travel costs.



Remote STS Telemetry

Radio Telemetry

The inexpensive RRL Radio Telemetry is ideal for short range applications up to 1000 ft. (300 m). Distances can be increased using superior antennae or by using some radios as 'repeater' stations. The RRL uses modbus protocol suitable for hook up to SCADA systems. (See Data Sheets 9100 and 9200)



Radio Telemetry

4–20 mA WATER LEVEL INDICATOR AND DATALOGGER

Models GEONIVO and GEOLOG

APPLICATIONS

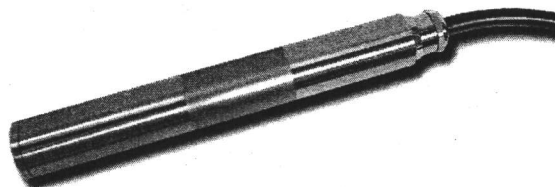
The GEONIVO sensor is designed for free water, bore-hole or tank water level measurements. This sensor can be read continuously and remotely with the use of the field datalogger model GEOLOG.

DESCRIPTION

The GEONIVO uses a pressure-sensitive element from Keller. This element is a micro-machined piezoresistive silicon chip floating in a silicone filling fluid, which gives the sensor excellent long-term stability and very good resistance to vibrations and pressure peaks.

The sensitive element is combined with an electronic module using Keller's ASIC Progress technology. The electronic module has no preset potentiometer and is compound-filled.

The GEOLOG is a small datalogger designed for field applications where data from 1 to 4 sensors are to be logged. Its low power consumption makes it easy to install, with no requirements such as large batteries or power lines. Its memory allows data storage over long periods, diminishing on-site travel costs. The GEOLOG comes with an easy-to-use software allowing scan rate and parameter setting, as well as data transfer.



FEATURES

- Sturdy overall construction suited for field applications
- Barometric compensation with double capillary tubing integrated into signal cable with moisture trap
- Current loop output 4–20 mA (2 leads), compatible with most readout units
- Field datalogging generating spreadsheet-compatible files

SPECIFICATIONS

MODEL	GEONIVO
Range	50 to 20 000 kPa
Accuracy	±0.5% F.S.
Typical	±0.2% F.S.
Long term stability	≤0.2% F.S. / year
Thermal drift	
Zero	≤0.01% F.S. / °C
Sensitivity	≤0.015% F.S. / °C
Signal output	4–20 mA
Power supply	8–28 VDC
Thermistor	3 kΩ (see model TH-T)
Self-compensation temperature range	–10 to +80°C
Material	316 stainless steel
Transducer	Piezoresistive relative pressure transducer with current loop signal 4–20 mA, 2 wires
Filter	Stainless steel, ~50 kPa, ~10 kPa low air entry Ceramic, ~1 µm, ~450 kPa high air entry
Cable	IRC-41AV
Dimensions	28.6 mm OD
Length	200 mm
Weight	0.9 kg
MODEL	GEOLOG
Range	4–20 mA signal
Accuracy	±5 mA
Resolution	0.5 mA
Processor	16 bits
Power supply	12 V
Channel	1 (standard), 2 or 4 (optional)
Memory	Up to 64 kb per channel (8 kb standard) EEPROM equivalent to 1000 to 16 000 measurements
Interfacing	RS-232
Batteries	Two 1.5 Volt, alkaline, type C
Autonomy	Depends on number of channels (typically 3 months with one channel and one reading per hour)
Case	Watertight (1 m), shock resistant, ABS, 160 × 100 × 60 mm
Humidity control	Moisture trap

ORDERING INFORMATION

Please specify:

- Range
- Cable length
- Readout instruments

The RST Vibrating Wire Piezometer provides excellent long-term accuracy, stability of readings and reliability under demanding geotechnical conditions. Vibrating Wire Piezometers are the electrical piezometers of choice as the frequency output of VW devices is immune to external electrical noise, and able to tolerate wet wiring common in geotechnical applications.

The vibrating wire piezometer senses pressure by means of a metal diaphragm attached to a vibrating wire element. When pressure is applied to the diaphragm, its deflection is sensed by the vibrating wire element – i.e. the tension in the wire is reduced, and the resonant frequency of the vibrating wire is changed as a result. The vibrating wire is induced to vibrate, and then the resonant frequency is measured via an electromagnetic coil circuit. The resulting frequency is precisely related to the pressure.

The frequency signal is exceptionally immune from cable effects, including length (to several kilometers), splicing, resistance, noise pickup, and moisture. The vibrating wire coil circuit contains no semiconductor devices and has built-in ionized gas discharge device protection against transient damage. As a result, the vibrating wire piezometer provides excellent reliability in typical geotechnical situations – i.e. long outdoor cables buried in saturated soil.

The piezometer is equipped with a standard sintered stainless steel porous filter to prevent soil particles from contacting the diaphragm. A thermistor is built into the piezometer body to permit temperature measurement and temperature compensation of the piezometer. Standard construction is all stainless steel. RST vibrating wire piezometers are shipped with extremely tough polyurethane-jacketed foil-shielded cable for maximum endurance in field conditions.

FEATURES

- Field proven reliability and accuracy.
- Will tolerate wet wiring common in geotechnical applications.
- Immune from external electrical noise.
- Signal transmission of several kilometers.
- Cable lengths may be changed without affecting the calibration.
- High accuracy, i.e. a low pressure vented model will measure water level changes as small as 0.05 mm (0.02 in.).
- Thermistor for temperature measurement is standard.
- Negligible displacement of pore water during the measurement process.
- Hermetically sealed, stainless steel construction.
- Heavy case to minimize reading errors caused by overburden pressure.
- Data logger compatible.
- Integral lightning protection.

FUNCTIONS

- Assessing performance and investigating stability of earth fill dams and embankments.
- Slope stability investigations.
- Monitoring water levels in wells & standpipes.
- Monitoring pressures behind retaining walls and diaphragm walls.
- Monitoring pore pressures during fill or excavation.
- Monitoring pore pressure in land reclamation applications.

VW2100 Standard Vibrating Wire Piezometer

VW2100-HD: Heavy Duty Vibrating Wire Piezometer

VW2100-DP: Drive Point Vibrating Wire Piezometer

VW2100-L:
Low Pressure Vented
Vibrating Wire Piezometer

VW2100-MM:
Micro-Miniature
Vibrating Wire Piezometer

Specifications may change without notice. EL800030

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The RST Instruments
Management System
is certified to
ISO 9001:2000



OPERATING PRINCIPLE

Vibrating Wire Piezometers contain a high tensile steel wire with a fixed anchor at one end and are attached to a diaphragm at the other end. The wire is electrically plucked, with the resonant frequency of vibration proportional to the tension in the wire. This frequency induces an alternating current in a coil, which is detected by the readout unit and can then be converted to a pressure.

ELECTRICAL CABLE

PART	DESCRIPTION
EL380004	Two twisted pairs cable with polyurethane jacket.

Other types of cables, depending on site conditions and atmospheric reference requirements, are available upon request. These include Vented, FEP, PVC, Polyurethane, and Armored varieties.

VIBRATING WIRE PIEZO SPECIFICATIONS

DESCRIPTION	SPECIFICATIONS
Over range	2 X F.S.
Resolution	0.025% F.S. minimum
Accuracy	0.1% F.S.
Operating Temperature	-20 to 80°C (-4 to 176°F)
Diaphragm Displacement	<0.001 cc at F.S.
Thermal Zero Shift	<0.05% F.S./°C
Materials	Hermetically sealed stainless steel housing
Thermistor Matching	±0.5°C
Thermistor Resolution	0.1°C
Thermistor Accuracy	0.5°C
Filter	50 micron sintered filter. (High air entry alumina filter 1, 3, 5 Bar available)

ORDERING INFORMATION

PART	DESCRIPTION	PRESSURE RANGE	DIMENSION
VW2100	Standard model for general applications.	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	19 mm Ø X 133 mm 0.75 in. Ø X 5.23 in.
VW2100-HD	Heavy duty piezometer for direct burial in fills and large dam embankments.	0.07, 0.175, 0.35, 0.7, 1.0, 2.0 3.0, 5.0, 7.5 MPa	38.1 mm Ø X 203 mm 1.5 in. Ø X 8.0 in.
VW2100-HHP	High pressure transducer with NPT port.	5.0, 7.5, 10, 25, 50, 75, 100 MPa	25.4 x 143 mm 1 in. Ø X 5.63 in.
VW2100-DP	Drive point model with CPT adapter.	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	33 mm Ø X 432 mm 1.31 in. Ø X 17 in.
VW2100-L	Low Pressure, unvented.	70, 175 kPa	25 mm Ø X 133 mm 1 in. Ø X 5.23 in.
VW2100-LV	Low Pressure vented.	70, 175 kPa	25 mm Ø X 133 mm 1 in. Ø X 5.23 in.
VW2100-M	Miniature version – 17.5 mm diameter.	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	17.5 mm Ø X 133 mm 0.68 in. Ø X 5.23 in.
VW2100-MM	Micro-miniature version – 11.1 mm diameter.	0.35, 0.7 MPa	11.1 mm Ø X 165 mm 0.43 in. Ø X 6.5 in.

VIBRATING WIRE PIEZO OPTIONS (Specify when ordering)

Heavy-duty bodies for embankment use.

Push-in drive points for soft soils

High air entry ceramic filters to exclude air

Low range and vented piezometers

Titanium construction for use with corrosive fluids

Multi-point/mixed type sensor strings

Kevlar™ reinforced cable

ANCILLARY EQUIPMENT (Specify when ordering)

VW2106 Vibrating Wire Readout

Dataloggers

Terminal stations

Electrical cable

Cable splice kits

Installation geotextile and socks

Increased lightning protection

Specifications may change without notice. ELB0003O
Kevlar™ is a registered trademark of
E. I. duPont de Nemours and Company or its affiliates.

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INSTRUMENTS

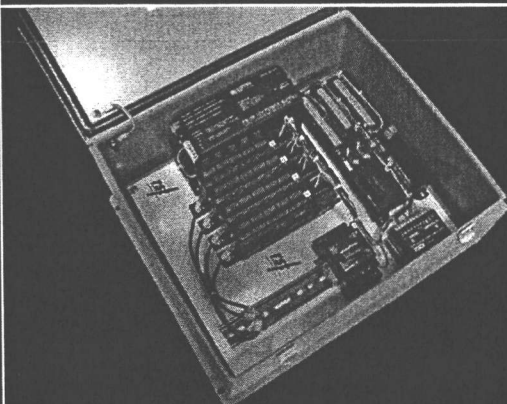
RST Instruments Ltd.
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Email: info@rstinstruments.com
www.rstinstruments.com

The CR1000 Datalogger is a multi-channel data logger designed for reliable, remote monitoring under demanding geotechnical conditions. It provides sensor measurement, timekeeping, data reduction, data/program storage and control functions. Data values are stored in tables with a time stamp and record number. The CR1000 is capable of monitoring all types of sensors including vibrating wire, servo-accelerometer, linear potentiometer, strain gauge, thermistor, electrolevel, etc.

The standard CR1000 datalogger includes 2 Mbytes of memory for data and program storage. Data and programs are stored either in a nonvolatile Flash memory or RAM. A lithium battery backs up the RAM and real-time clock. The CR1000 also suspends execution when primary power (BPALK, PS100) drops below 9.6 V, reducing the possibility of inaccurate measurements. The CR1000 can be augmented with peripherals to form a data acquisition system; many CR1000 systems can be networked to form a local or regional monitoring network.

Battery-backed SRAM memory, and clock, ensure that data, programs, and accurate time is maintained while the CR1000 is disconnected from its main power source.

Multiplexers, such as the RST Flexi-Mux, can increase the number of sensors that can be measured by the CR1000 by sequentially connecting each sensor to the datalogger. Several multiplexers can be controlled by a single CR1000.



FEATURES

2 Mbytes standard memor; 4 Mbytes optional memory.

Program execution rate of up to 100Hz.

CS I/O and RS-232 serial ports.

13-bit analog to digital conversions.

16-bit H8S Hitachi Microcontroller with 32-bit internal CPU architecture.

Temperature compensated real-time clock.

Background system calibration for accurate measurements over time and temperature changes.

Data values stored in tables with a time stamp and record number.

Battery-backed SRAM memory, and clock, ensure that data, programs, and accurate time is maintained while the CR1000 is disconnected from its main power source.

FUNCTIONS

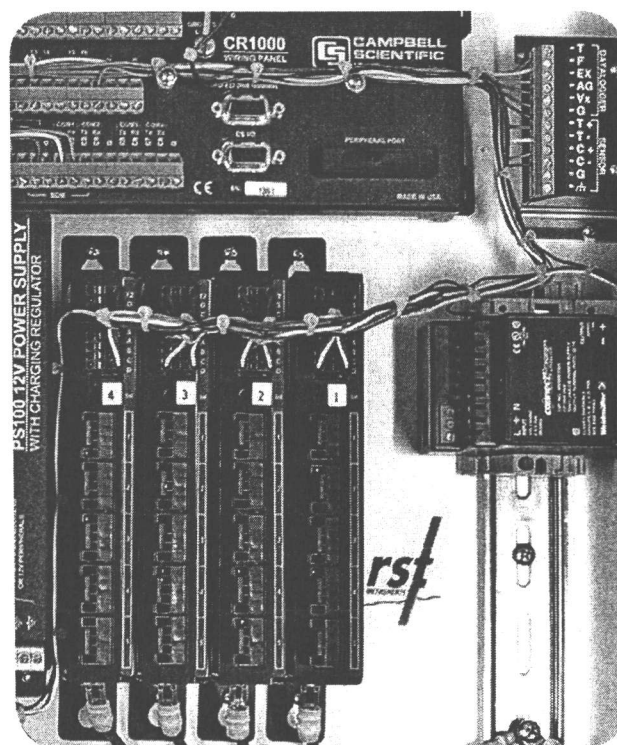
Remote datalogging of various types of geotechnical instrumentation used in dams, tunnels, bridges, mines, and natural slopes.

Alarm triggering when movement reaches a preset critical rate or levels reach a present value.

Real time data logging and analysis.

ORDERING INFORMATION

Part Number	CR1000
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Specifications may change without notice. ELB0028A

rst
INSTRUMENTS

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Email: info@rstinstruments.com
www.rstinstruments.com

The RST Instruments
Management System
is certified to
ISO 9001:2000



COMMUNICATION PROTOCOLS

The CR1000 supports three communication protocols: traditional, PAKBUS®, and Modbus. The traditional communication protocol is connection-based.

The PAKBUS® communication protocol improves upon traditional communications for datalogger networks. PAKBUS® networks have the distributed routing intelligence to continually evaluate links. Continually evaluating links optimizes delivery times and, in case of delivery failure, allows automatic switch over to a configured backup route.

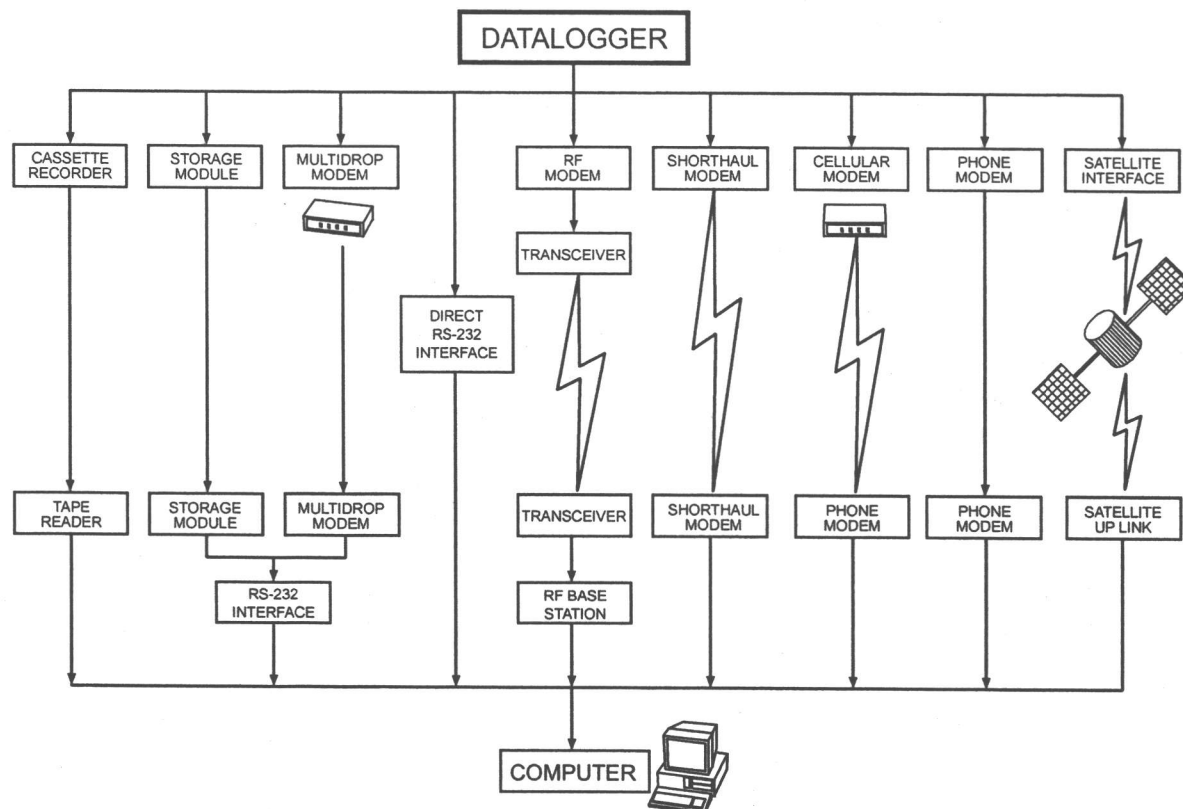
The Modbus protocol allows the CR1000 to work with "off the shelf" Modbus software packages.

COMMUNICATIONS

Compatible telecommunication options include ethernet, phone modems (land-line and cellular), radios, short haul modems, GOES satellite transmitters, and multidrop modems. Real-time and historical data can be displayed on-site using a PDA (requires PConnect 3.1), the CR1000KD keyboard/display, or a PC.

The PC connects to the CR1000 via an RS-232 cable, or if optional isolation is required, via the CS I/O port and SC32B interface. Users can transport programs/data to a PC via CompactFlash® cards. The CFM100 module is used to store the programs/data on the card; a SanDisk® ImageMate® card reader is used to download the programs/data to the PC.

DIAGRAM OF POSSIBLE COMMUNICATION METHODS



APPENDIX D

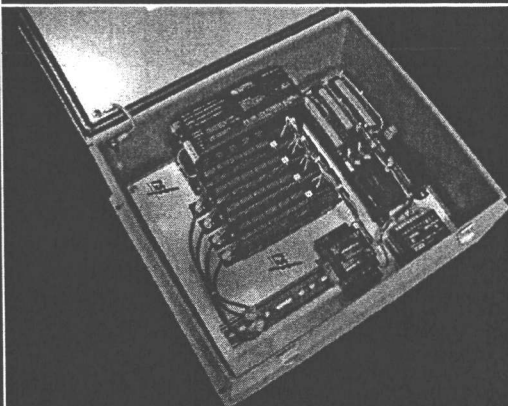
RTU / TELEMETRY PRODUCT INFORMATION

The CR1000 Datalogger is a multi-channel data logger designed for reliable, remote monitoring under demanding geotechnical conditions. It provides sensor measurement, timekeeping, data reduction, data/program storage and control functions. Data values are stored in tables with a time stamp and record number. The CR1000 is capable of monitoring all types of sensors including vibrating wire, servo-accelerometer, linear potentiometer, strain gauge, thermistor, electrolevel, etc.

The standard CR1000 datalogger includes 2 Mbytes of memory for data and program storage. Data and programs are stored either in a nonvolatile Flash memory or RAM. A lithium battery backs up the RAM and real-time clock. The CR1000 also suspends execution when primary power (BPALK, PS100) drops below 9.6 V, reducing the possibility of inaccurate measurements. The CR1000 can be augmented with peripherals to form a data acquisition system; many CR1000 systems can be networked to form a local or regional monitoring network.

Battery-backed SRAM memory, and clock, ensure that data, programs, and accurate time is maintained while the CR1000 is disconnected from its main power source.

Multiplexers, such as the RST Flexi-Mux, can increase the number of sensors that can be measured by the CR1000 by sequentially connecting each sensor to the datalogger. Several multiplexers can be controlled by a single CR1000.



FEATURES

2 Mbytes standard memory; 4 Mbytes optional memory.

Program execution rate of up to 100Hz.

CS I/O and RS-232 serial ports.

13-bit analog to digital conversions.

16-bit H8S Hitachi Microcontroller with 32-bit internal CPU architecture.

Temperature compensated real-time clock.

Background system calibration for accurate measurements over time and temperature changes.

Data values stored in tables with a time stamp and record number.

Battery-backed SRAM memory, and clock, ensure that data, programs, and accurate time is maintained while the CR1000 is disconnected from its main power source.

FUNCTIONS

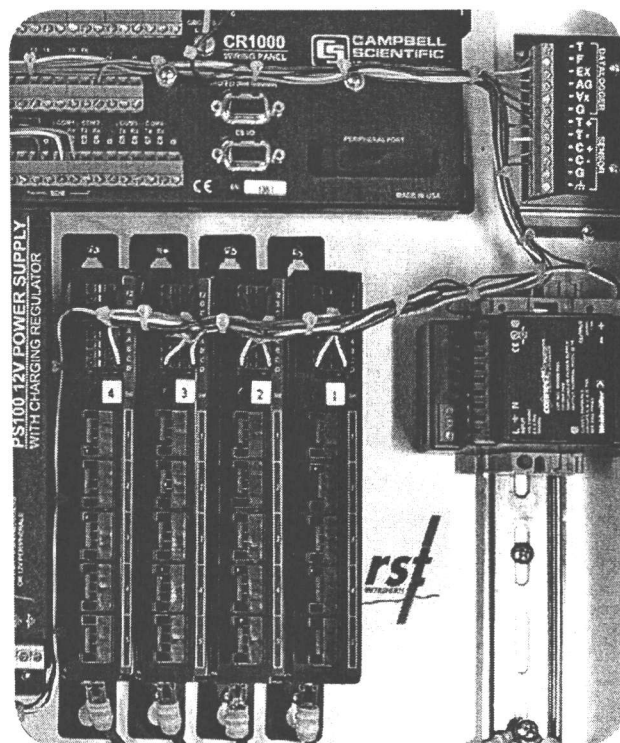
Remote datalogging of various types of geotechnical instrumentation used in dams, tunnels, bridges, mines, and natural slopes.

Alarm triggering when movement reaches a preset critical rate or levels reach a present value.

Real time data logging and analysis.

ORDERING INFORMATION

Part Number	CR1000
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Specifications may change without notice. ELB0028A

rst
INSTRUMENTS

RST Instruments Ltd.
200 - 2050 Hartley Ave., Coquitlam, BC Canada V3K 6W5
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Toll Free (USA & Canada): 1-800-665-5599
Email: info@rstinstruments.com
www.rstinstruments.com

The RST Instruments
Management System
is certified to
ISO 9001:2000



COMMUNICATION PROTOCOLS

The CR1000 supports three communication protocols: traditional, PAKBUS®, and Modbus. The traditional communication protocol is connection-based.

The PAKBUS® communication protocol improves upon traditional communications for datalogger networks. PAKBUS® networks have the distributed routing intelligence to continually evaluate links. Continually evaluating links optimizes delivery times and, in case of delivery failure, allows automatic switch over to a configured backup route.

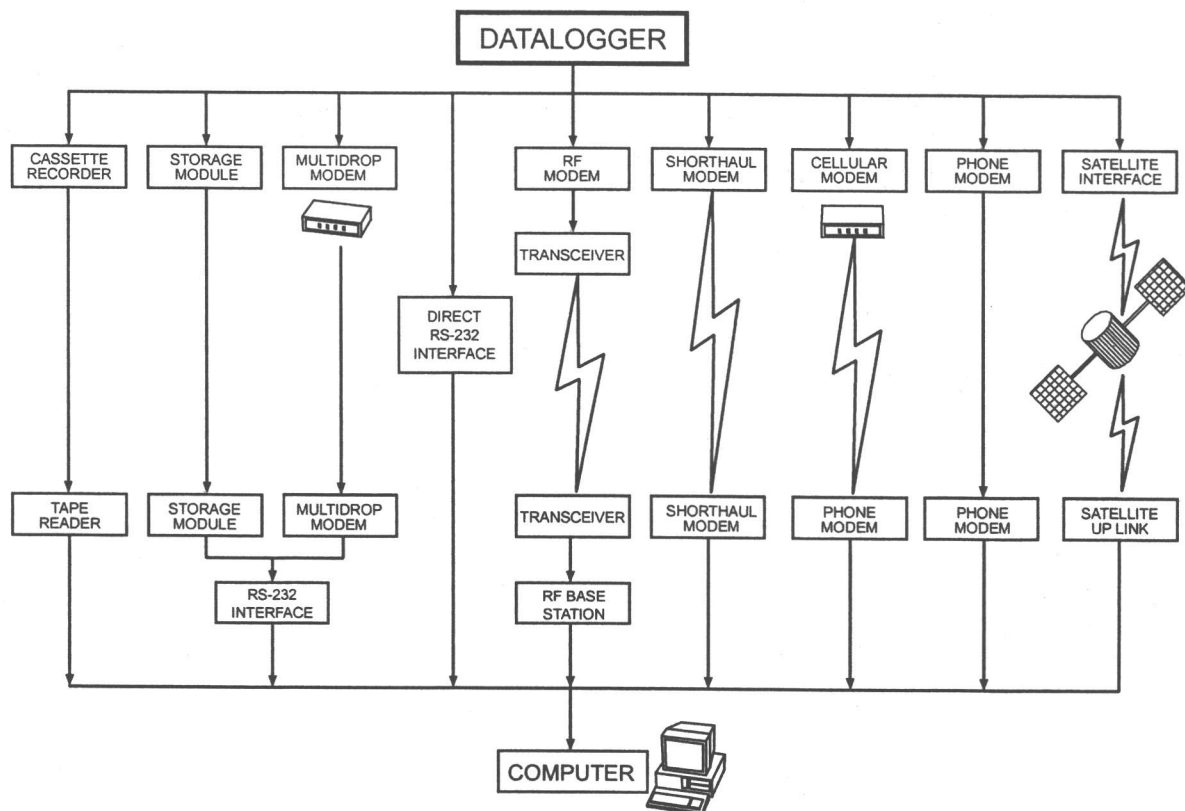
The Modbus protocol allows the CR1000 to work with "off the shelf" Modbus software packages.

COMMUNICATIONS

Compatible telecommunication options include ethernet, phone modems (land-line and cellular), radios, short haul modems, GOES satellite transmitters, and multidrop modems. Real-time and historical data can be displayed on-site using a PDA (requires PConnect 3.1), the CR1000KD keyboard/display, or a PC.

The PC connects to the CR1000 via an RS-232 cable, or if optional isolation is required, via the CS I/O port and SC32B interface. Users can transport programs/data to a PC via CompactFlash® cards. The CFM100 module is used to store the programs/data on the card; a SanDisk® ImageMate® card reader is used to download the programs/data to the PC.

DIAGRAM OF POSSIBLE COMMUNICATION METHODS



Specifications may change without notice. ELB0028A

rst
INSTRUMENTS

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GEOMATION'S VISION

Geomation will be the acknowledged global leader in field data acquisition and control, dedicated to our founding purpose of helping customers overcome the barriers inherent in taking physical measurements in harsh and remote environments. We will help our customers reduce the long-term cost of field automation by designing, developing, manufacturing, marketing and servicing products that are rugged, reliable and easy to use.

Geomation places high value on building lasting and trusting relationships with its customers, employees and industry partners. We will work with customers to find sensible, cost-effective solutions to their field instrumentation problems, and strive to attract and retain talented, professional employees who desire to excel by contributing to Geomation's vision and values.

Geomation

Denver, CO, U.S.A.

Tel: 720.746.0100

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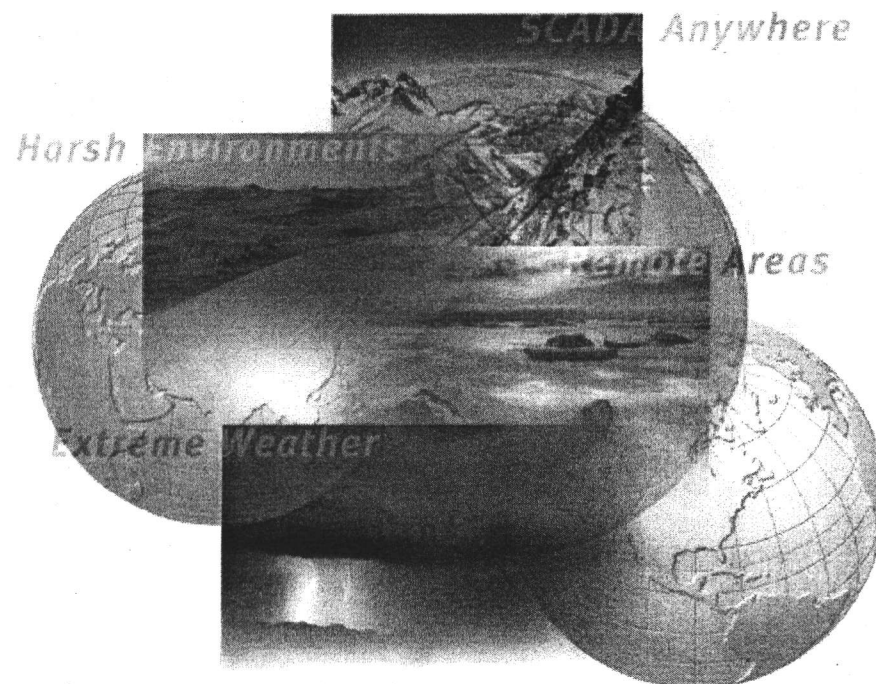
info@geomation.com

P/N 16-200-00

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OutDAQ™ RTUs—3300 & 3310

Remote Terminal Units for the Field



Geomation
Measurement and Control Systems

The OutDAQ™ Generation
Built for the Outback

WHY GEOMATION?

Geomation was founded in 1982 to satisfy the need for improved methods of obtaining timely physical measurements from the field. To help make dams safer, Geomation developed the System 2300, the first networked system designed specifically to overcome the barriers inherent in collecting data automatically from multiple instruments deployed within and around dams. Beginning with the largest Federal dam owners in the United States in 1987, Geomation customers now include many U.S. and foreign government agencies, water and power utility companies, energy producers and transporters, and natural resource ministries in various regions of the world.

Today Geomation is expanding beyond its proven System 2300 products with the addition of a more versatile platform—the OutDAQ™ Generation—that uses industry standard communication protocols and is more cost effective and reliable for dispersed outdoor installations. The OutDAQ Generation is suited to a wide range of applications—wherever environmental factors pose challenges to the automated collection and monitoring of physical data.

OutDAQ RTUs offer you flexible solutions for remote automated data acquisition and control. You can purchase a complete SCADA system, including installation and commissioning by Geomation or one of our Authorized Distributors; or you can buy just the components you need to extend the functionality of an existing system. Integrated assemblies are also available to make installation in the field quick and simple. Whether acquired as a total system solution or as individual components or assemblies, OutDAQ RTUs are fully backed by Geomation service and technical support, so you'll always know where to go for answers and satisfaction.

At Home in the Field

Most automated measurement systems for field instrumentation were originally designed for the plant, factory or laboratory. They weren't meant to withstand conditions in the field. Harsh, remote areas such as those around dams, industrial facilities and natural resource monitoring sites present serious obstacles to the reliable, long-term collection and transmission of physical measurements. The environmental, power distribution and communication linkage barriers are precisely what Geomation products were built to overcome. We take the worry off your shoulders by providing a dependable, easy-to-install and easy-to-use system that meets your field automation needs.

OutDAQ RTUs—3300 & 3310

Eight Reasons to Seek a Geomation Solution

Whether you are monitoring temperature, pressure, flow, level, displacement or environmental parameters, for any kind of outdoor application from the Arctic Circle to the Sahara Desert, you can connect Geomation RTUs directly to your instruments and get a rugged, reliable data collection and monitoring system designed and built for the places no one else wants to go. Embankment dams, tunnels, mines, open excavations, instrumented slopes, waterways—these are just a few of the situations that call for a Geomation solution. If you are challenged by any of the following conditions related to taking physical measurements in the field, Geomation RTUs may be right for you.

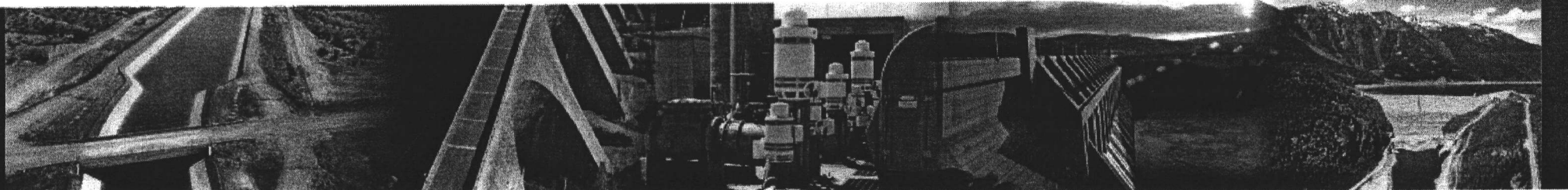
1. **Deployment in an Extreme Environment.** You have instruments deployed outdoors in areas that are difficult to access and subject to harsh environmental conditions.
2. **Susceptibility to Damage.** Your instruments are exposed to the elements, especially lightning, which can cause equipment failures that disrupt the gathering of data. Instruments and measurement equipment are also subject to temperature extremes, moisture and vandalism.
3. **Dispersed Outdoor Measurement Points.** Your instruments are scattered over a wide area, and data has to traverse obstacles or difficult terrain to get where it's needed.
4. **Varied Instrument Mix.** You have instruments measuring pressure, level, flow, displacement—from multiple vendors using different sensing technologies—but you require a consistent method of gathering and sending data.
5. **Low Power Requirement.** You're concerned about getting power to field measurement equipment and devices, either due to the cost involved or to the susceptibility to damage resulting from power cables, which conduct transients into sensitive equipment.

6. **Flexible Communication Links.** You don't want any limitations on the way data is linked from the field to your central monitoring point, but you don't want to make major investments in general-purpose communications facilities.
7. **Industry Standard Protocols.** You want a system that operates with industry standard communication protocols, so you can use widely supported software. You can even change software or mix RTU hardware if required.
8. **Installation and Maintenance.** You need a system that is easy to install and that can be easily maintained by your staff without need for specialized technical assistance.

What's Unique About Geomation RTUs?

An OutDAQ RTU combines the ruggedness of a truck with the sophistication of a race car. It's built with state-of-the-art electronics and embedded Linux operating system, yet it's practically indestructible. You can install and configure the system yourself, and maintain it with your own people; or if you don't want the bother, Geomation or one of our Authorized Distributors can install it for you. And you don't have to haul a lot of power into the field to keep it running—small solar panels and batteries do the job. The RTU talks an interface protocol that off-the-shelf software used all over the globe can understand. It's built for long life in the outback, and Geomation stands behind it with training and technical support.

Left to right:
Hayden-Rhodes Aqueduct—
Central Arizona Project, USA
Daniel Johnson Dam—
Hydro Quebec, Canada
Pumping Plant—
Central Valley Project, USA
Chief Joseph Dam—
US Army Corps of Engineers, USA
Mica Dam—
BC Hydro, Canada



OutDAQ refers to Geomation's Generation of harmonized products to make field automation much easier than it has been in the past. OutDAQ is a product platform consisting of a set of system building blocks—RTUs, communication link devices and repeaters, power systems, field packaging and accessories—engineered for ready deployment in almost any outdoor situation. OutDAQ eliminates the significant costs related to site preparation work, instrumentation shelters, and the provision of larger power sources and elaborate communications facilities.

OutDAQ Generation products are designed for high reliability in harsh environments. All remote system building blocks are designed for ultra-low power battery operation using wide temperature range electronics. In addition, the OutPAK™ and i/oXPAK™ engineered field enclosures for RTUs and distributed I/O, respectively, reduce system design specification and installation costs, and eliminate environmental hazards in outdoor installations.

The OutDAQ RTUs

The RTUs and associated I/O Assemblies are the cornerstones in the OutDAQ Generation of harmonized system components. There are two RTU models:

- 1) The very low power 3300 RTU with serial communication port for Geomation ultra-low power communication link devices
- 2) The 3310 RTU, which adds an Ethernet communication port for direct connection to computer LANs

Beyond the Industrial RTU

OutDAQ RTUs allow a new installation, or the extension of existing SCADA, into remote areas without the operating constraints imposed by industrial RTUs.

The Model 3300 is designed to operate over a much wider temperature range and at less than 1/100th of the power consumption of typical RTUs considered to be low power. This means that you can install 3300s outdoors from arctic to tropical regions powered by small, inexpensive alternate power sources.

I/O Assemblies are available to support typical industrial applications. In addition, OutDAQ RTUs support I/O Assemblies for specialized environmental, water measurement, geotechnical and structural applications.

Industry-Standard Interfacing

The OutDAQ RTUs support industry standard, open architecture Modbus communication protocols. They can be used with any off-the-shelf data acquisition or SCADA/HMI software packages with Modbus communication drivers. The open standards communication support also allows RTUs to be interfaced not only with off-the-shelf host computer software, but also with the remote PLCs and RTUs of existing SCADA or DCS systems.

Geomation also supports the OPC Foundation industry standard for interoperability among third party software server and client packages. Customers may use the client software package that best suits their application or industry, without custom interfacing.

Remote I/O Architecture

OutDAQ RTUs employ a unique I/O architecture designed to reduce installation costs, provide maximum measurement integrity, and mitigate susceptibility to damage from lightning and power switching transients.

Each I/O Assembly (I/O Module + Base) is designed for connection to a single instrument, or to multiple sensors related to a certain instrument type. Each I/O Assembly provides screw terminals for field wiring connections, as well as multi-stage transient protection and isolation.

The microprocessor-controlled I/O Module performs the required signal conditioning, analog-to-digital conversion, measurement function conversions, and galvanic isolation.

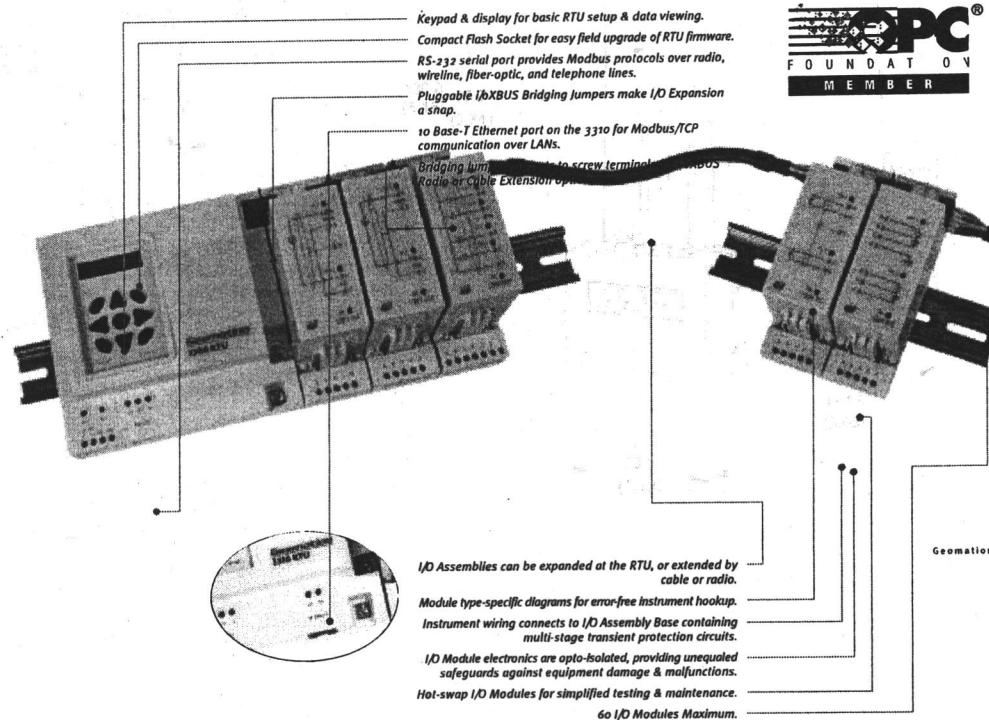
Isolation is assured between separate instrument connections and the i/oXBUS (I/O Extension Bus). Therefore the RTU itself is isolated from all I/O. In the unlikely event that a failure would occur from a violent transient, damage is limited to one I/O Module, without affecting the rest of the system.

Since I/O Modules are designed to be hot-swapped, with auto-configuration for a replacement Module, the most likely required field repairs can be done without special technical training.

I/O Assemblies

The following is a list of I/O Assemblies available at the time of printing. Ask for Product Data on OutDAQ I/O Assemblies for detailed specifications, as well as a list of currently available I/O Assemblies.

1201 mA	Current Input Assembly (for 4-20mA Transmitters)
1202 TC	Thermocouple Input Assembly, 2-Channel
1203 MMR	Multi-Mode Resistance Input Assembly, 2-Channel
1204 STAT	Status Input Assembly, 5-Channel
1205 PC	Pulse Counter Input Assembly, 2-Channel
1211 VWT	Vibrating Wire & Thermistor Input Assembly
1221 RO	Relay Output Assembly (Form C), 2-Channel
1241 SDI	Interface Assembly for SDI-12 Sensors
1242 RS232	Interface Assembly for RS-232 Instruments
1243 RS485	Interface Assembly for RS-485 Instruments



CONNECTING BETWEEN OFFICES & REMOTE SITES

Data Transport

The type of Wide Area Network (WAN) facility appropriate for remote instrumentation systems depends primarily on three things:

- 1) Whether a communication terminal connection is available at remote project locations
- 2) The communications protocols supported by the instrumentation system
- 3) The monitoring objectives

To transport data from remote project locations to distant offices, some form of Wide Area Network (WAN) connection is required. WANs are communication facilities for transporting voice and data over large geographic regions. WANs use microwave, satellite, dedicated internet connections (via Virtual Private Networks-VPNs), and the Public Telephone Network.

Communication facilities between operations offices and remote project sites are sometimes owned and maintained by the customer. These customer-owned facilities can be used for instrumentation data transport.

If real-time monitoring is needed, then an always-on connection is required. If periodic data logging is adequate, then an intermittent connection may suffice.

Enterprise Networks

Real-time data from field instrumentation can be served to Division, Corporate, or Headquarters Offices via enterprise computer networks. This type of operation implies a client/server architecture, which is supported by host software packages compatible with the Geomation OutDAQ RTUs.

Web access to real-time data is also available, providing even more options for access to field data from anywhere.

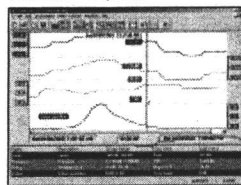
Host Software

Host software normally runs on the computer at the Project Site, the Project Office, or at the District or Regional Office.

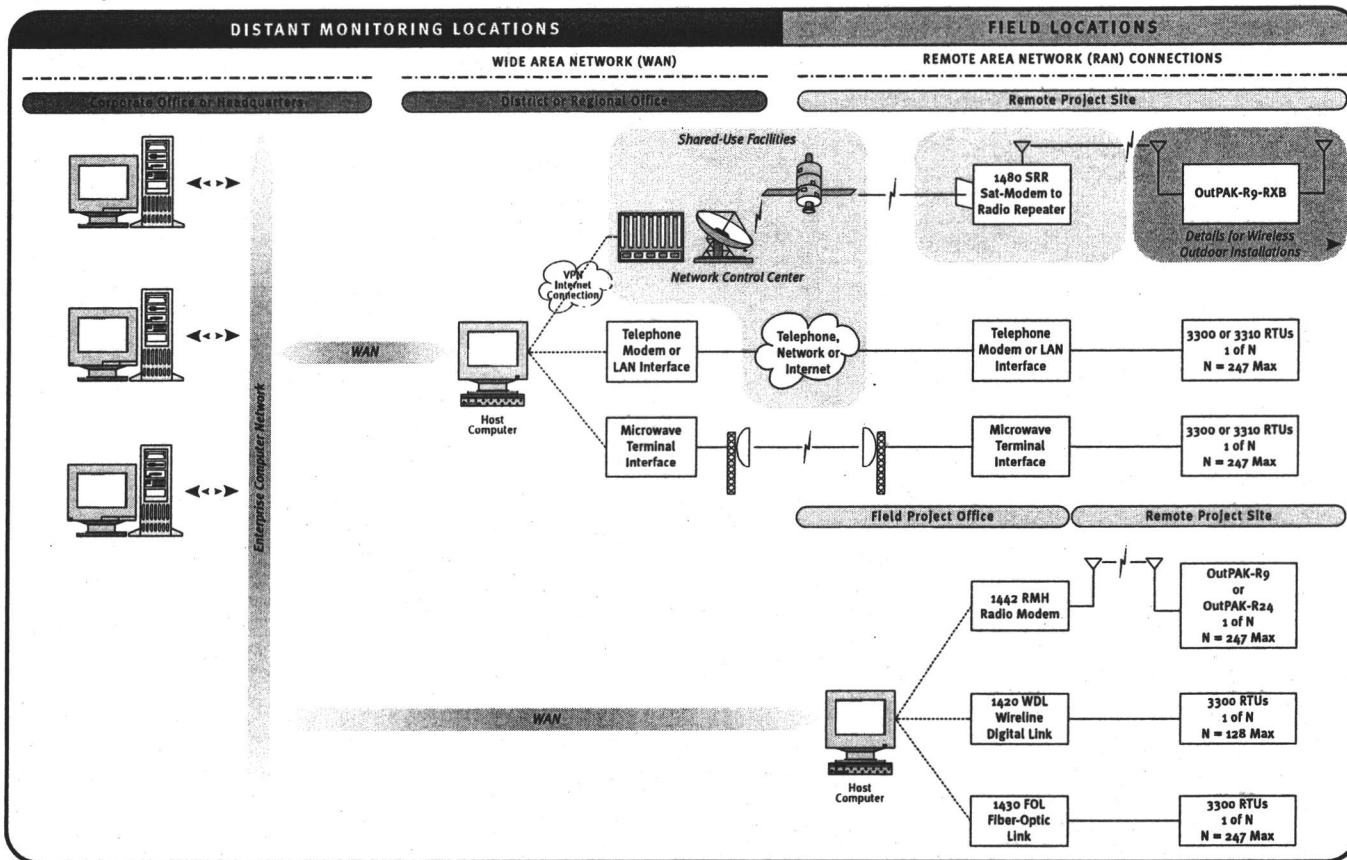
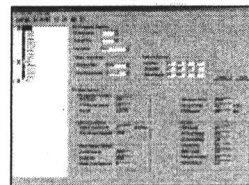
OutDAQ RTUs are compatible with many off-the-shelf historian, trending, and SCADA/HMI software packages through industry-standard Modbus communication drivers. Geomation re-sells and supports selected software packages, such as the trending software shown here.

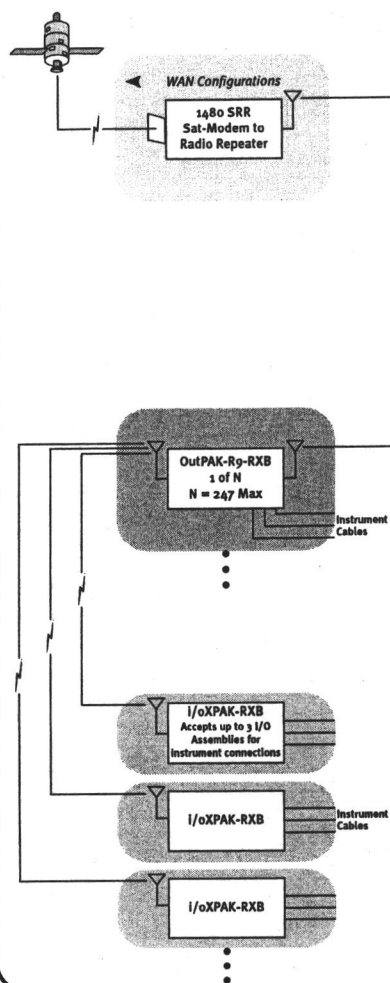
Trendlink™ is a registered trademark of Canary Labs, Martinsburg, PA.

Trendlink™ Software

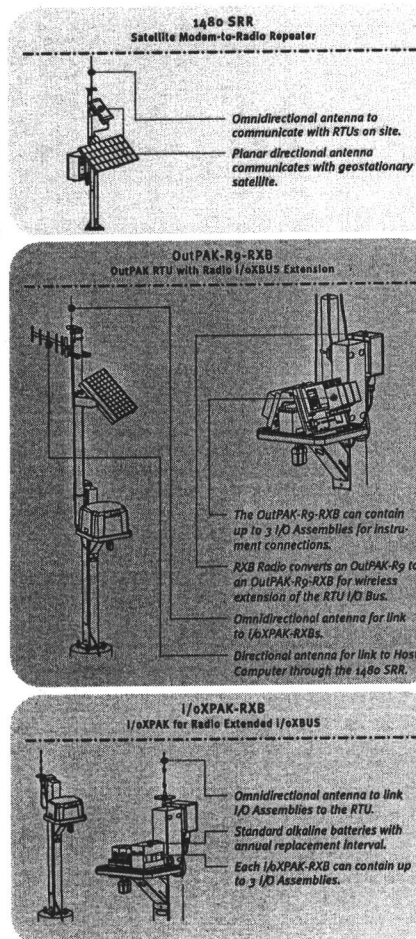


OutDAQ RTU Configuration Software



REMOTE AREA NETWORK
(RAN) CONNECTION

INSTALLATION-READY FIELD PACKAGES

2-Tiered Radio Communication for
Outdoor Environments

The example illustrations show RTU features enabling a remote outdoor installation with no communication or power facilities on site. The OutPAK RTU Assemblies communicate with the host computer through a Satellite-to-Radio Repeater, and the simpler i/oXPAKs communicate with one or more OutPAK RTUs over a separate wireless channel. The result is a cost-efficient method of making wireless field connections to all instruments of virtually any type and quantity, in any location.

The satellite link is not required if OutPAKs can be radio linked directly to the host computer.

Outdoors Anywhere

The VSAT (Very Small Aperture Terminal) satellite communication service offered by Geomation in North America allows access to any site, no matter how remote. Outside North America, other satellite data services may be available. On-site VSAT eliminates the need for easements and other restrictions associated with mountaintop radio communication repeaters. Data communication is also free of disruptions from earthquakes and other natural disasters.

A bridge to license-free spread spectrum radio is implemented with the 1480 SRR Satellite-to-Radio Repeater, to communicate with one or more RTUs across the project site.

Wireless connections between all equipment provide protection from lightning transients, reduce installation and maintenance costs, and allow incremental system expansion without the need to plan for uncommitted or unknown measurement points.

The OutDAQ RTUs, with Adaptive Advanced Power Management, support battery powered wireless communication strategies for field instrumentation that are unmatched in the industry.

Satellite-to-Radio Repeater

The illustrations show communication between the host computer and the remote site via a VSAT L-Band Satellite Modem, and then repeating data packets through a Radio Modem Link to 3300 RTUs.

The 1480 Satellite-to-Radio Repeater is solar powered and designed for unitized, stand-alone installation with no external connections. Therefore, it can be installed at any location on the project site, considering optimum radio paths, accessibility and security.

Transparent Communication

The communication configuration provides an "always-on" end-to-end wireless connection from the host computer to RTUs installed at various locations around one or more project sites.

The point-to-multipoint online connection allows conventional polling of RTUs by the host computer, with a standard serial Modbus software driver. A connection or dialing protocol is not required. The efficient Modbus RTU Protocol and optimized Modbus register structures supported by OutDAQ RTUs minimize satellite data service charges.

Instrument Connections

Field instruments connect directly to I/O Assemblies. A primary system design objective is to keep the cable connections between I/O Assemblies and electrical sensors as short as possible, and to totally eliminate horizontal cable runs in excess of 2-3 meters.

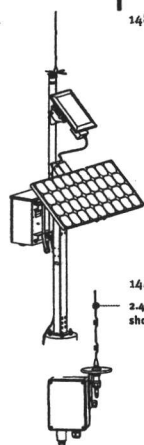
The degree to which this design objective is implemented determines the level of protection from lightning transients provided for electrical sensors.

OutDAQ Integrated System Components

System sub-assemblies are complete, and ready for field installation. Geomation engineered packages are easy to understand, making both system design and installation easy and risk-free.

Geomation provides construction reference drawings to assure proper site preparation work by sub-contractors.

INTEGRATED FIELD ASSEMBLIES & SYSTEM SPECIFICATIONS



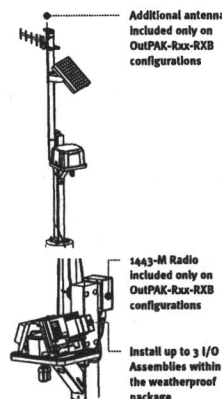
1480 SSR

Host Computer Interface Options

- 1442-01 RMH Radio Modem Kit, OutDAQ Host 900MHz FHSS
- 1442-02 RMH Radio Modem Kit, OutDAQ Host 2.4GHz FHSS

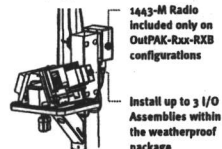
The 1442 RMH may be connected directly to a serial COM port of the host PC, providing a wireless interface to radio linked RTUs, as shown between the Field Project Office and the Remote Project Site on page 5. The 1442-01 is for license-free operation in North America, Australia, and Israel. The 1442-02 is for license-free operation worldwide.

If the distance between the PC and the RMH is greater than ~15m (50ft), then the 1442-03 PCI Power & Communication Isolator option should be used, allowing extension up to 1000m. Directional antenna options and longer antenna feed cables are also available. However, the antenna feed cable should not exceed 10m. For antenna extensions, use the 1448 AJ10 Coaxial Antenna Jumper, 10m.



1442 RMH
2.4 GHz antenna shown (1442-02)

Additional antenna included only on OutPAK-Rxx-RXB configurations



1443-M Radio included only on OutPAK-Rxx-RXB configurations

Install up to 3 I/O Assemblies within the weatherproof package

OutPAK RTU Configurations

With the purchase of Geomation OutPAK integrated field assemblies, you will not be delayed during field installation due to missing parts or incompatible components.

- OutPAK-R9 OutPAK RTU, Solar Powered 900MHz Host Link
- OutPAK-R24 OutPAK RTU, Solar Powered 2.4GHz Host Link

The OutPAK-R9 and OutPAK-R24 are complete kits ready for field installation. The two models differ only by the RF components, either 900MHz or 2.4GHz, determined primarily by the country of installation as noted above under Host Computer Interface Options.

The assemblies include the following: 3300 RTU, 1901 Secure Field Enclosure, 1905 Stanchion, 1907 Solar Panel/Antenna Mast Kit, 1121 Online Battery Charger, 1131 Rechargeable Battery, 1151 Solar Panel, 1440 (or 1441) Radio Modem Link, 1440-DA (or 1441-DA) Antenna, all interconnect cables, grounding cable, anchor bolts and anchor bolt template.

Each OutPAK RTU can house up to 3 I/O Assemblies within the weatherproof package. The interior air is equalized with atmospheric pressure changes through a

The RMH is designed for mounting to a pole or a vertical surface. The included antenna bracket is detachable from the RMH mounting bracket for relocating the antenna to avoid path obstructions.

- 1480 SRR Satellite Modem-to-Radio Repeater 900MHz FHSS

The 1480 SRR provides a repeating bridge between an L-band Satellite Modem and a Geomation 1440 RML spread spectrum radio. The SRR integrates WAN data communication with any remote site in North America, and RAN Project Site communication by radio. See illustrations on pages 5 & 6.

The solar powered package is completely self-contained with no external connections. It includes the Stanchion with the same pedestal or caisson mounting provisions as OutPAK RTUs and the i/oXPAKs.

desiccant cartridge. The dry atmospheric reference allows the termination of true gauge pressure transducer cables within the enclosure with no additional treatment of cable vent tubes. Additional I/O Assemblies can be connected to an OutPAK RTU by cable extension with i/oXPAK-CXBs.

- OutPAK-R9-RXB OutPAK RTU, Solar Powered 900MHz Host Link, Radio i/oXBUS Extension
- OutPAK-R24-RXB OutPAK RTU, Solar Powered 2.4GHz Host Link, Radio i/oXBUS Extension

The OutPAK-R9-RXB and OutPAK-R24-RXB are identical to the previously listed assemblies, except that they also include the 1443-M Radio Kit with surge suppressor, RF cable, and omni-directional antenna for wireless extension of the RTU I/O Bus. The i/oXBUS radio link always operates in the internationally approved 2.4GHz ISM (Industrial-Scientific-Medical) band.

The RXB configuration of the OutPAK RTUs provides for wireless extension of I/O Assemblies from the RTU with i/oXPAK-RXBs. The wireless I/O architecture minimizes installation cost for distributed instrument points, and virtually eliminates system component damage from lightning transients.

i/oXPAK™ Configurations

The distributed I/O features, along with Adaptive Advanced Power Management, are key beneficial aspects of the OutDAQ Architecture. The remote I/O features of OutDAQ RTUs provide substantial advances in reducing installed system cost and complexity, while greatly enhancing system reliability.

The i/oXPAK is Geomation's I/O Extension Package, allowing I/O Assemblies controlled by an RTU to be located close to distributed instruments. There are two types of these packages, the i/oXPAK-RXB for radio linkage to OutPAK-Rxx-RXB RTUs, and i/oXPAK-CXB for bussed cable connection to OutPAK-Rxx RTUs.

i/oXPAK-RXB for Radio Extended I/OXBUS Installations

The i/oXPAK-RXB is a complete assembly, ready for mounting to an existing structure or a concrete caisson. The assembly includes the following: 1902-R Secure Field Enclosure, 1905 Stanchion, 1140 Alkaline Battery Pack, 1443-S Radio with surge suppressor, 1441-OA Antenna, power & signal interconnect cabling, grounding cable, anchor bolts, and anchor bolt template.

Each i/oXPAK-RXB can house up to 3 I/O Assemblies within the weatherproof

package. The interior air is equalized with atmospheric pressure changes through a desiccant cartridge. The dry atmospheric reference allows the termination of true gauge pressure transducer cables within the enclosure with no additional treatment of the cable vent tubes.

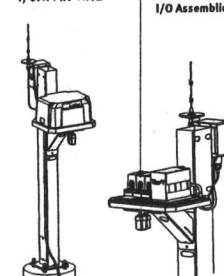
The package is completely self-contained, with the only external connections being those from the instrument cable(s). The radio and I/O Assemblies have extremely low power consumption. Alkaline batteries available at retail outlets are replaced on yearly intervals for logging frequencies required in most environmental monitoring applications.

i/oXPAK-CXB for Cable Extended I/OXBUS Installations

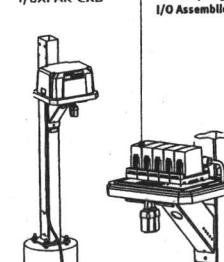
The i/oXPAK-CXB uses common packaging and mounting components with the RXB version. However, it does not include the alkaline battery pack or the radio components. It can house up to 5 I/O Assemblies within the weatherproof package, and it has the same dry atmospheric equalization features as the RXB version.

The i/oXPAK-CXB derives its power as well as communications from the RTU through the i/oXBUS Cable, Geomation P/N 64-010-00 or 64-010-01.

i/oXPAK-RXB



i/oXPAK-CXB



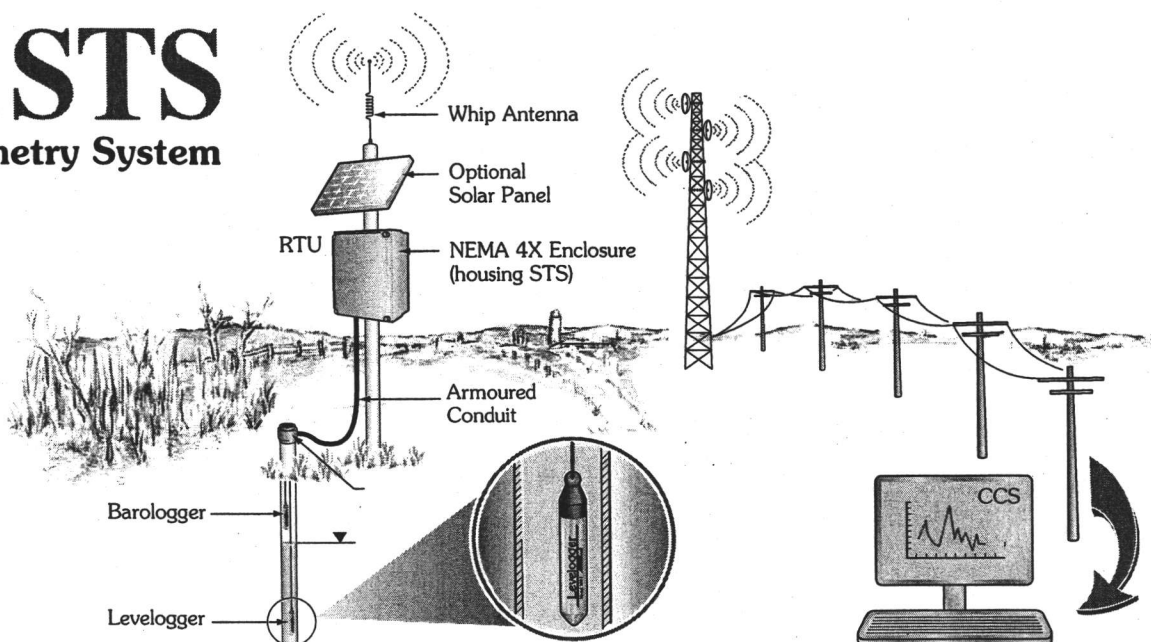
Other Options & Accessories

- 1442-03 PCI Power & Communication Isolator for 1442 RMH
- 1448 AJ10 Coaxial Antenna Jumper, 10m
- 3105 RTU Configuration Software (Included with every RTU)
- 3110 Windows Logging Software for 3300/3310 RTUs
- 1487 Backhaul Connection Setup for Satellite Network Control Center (North America only)

Use of the satellite data service requires the customer to establish and maintain an online connection between the host computer and the Satellite Network Control Center located in Reston, VA. The most cost-effective approach is to maintain an Internet-based VPN connection as illustrated on page 5. The monthly charge for satellite data service is dependent on data traffic. Geomation application engineers are available to provide assistance in estimating the monthly data service charges.

General System-Level Specifications

- 8 Maximum No. of RTUs Per Host Network: 247
 - 8 Maximum No. of I/O Assemblies per RTU: 60 (for combined local expansion at the RTU, cable extension, or radio extension)
 - 8 Range on the Radio Modbus Link (with standard antennas shown): ~5km (3mi) unobstructed range
 - 8 Range on the Radio i/oXBUS Link (with standard antennas shown): ~1.6km (1mi) unobstructed range
 - 8 Maximum Extent for the Cable i/oXBUS: 1200m (3950ft) using Geomation 64-010-00 or 64-010-01 i/oXBUS Cable
- (See Product Data Sheets for detailed specifications on individual system components.)



Solinst Telemetry System

The STS enables 2-way communication and control between a central computer based station and field located Levelloggers, Barologgers and Rain Loggers. Communication may utilize cellular GSM, CDMA, AMPS, landline telephone or radio.

STS Systems are designed to allow the user to save time and money by automated remote collection and self-management of data. The STS is so easy to operate and understand that it can be completely set up by the user.

The STS and its software are suitable for both small and large systems. The Central Computer System (CCS) can run up to six modems and each modem can run up to 100 Remote Telemetry Units (RTUs). The System can also be operated on a laptop. Password protection for three levels of access authority, as well as high and low water level alarm warnings are available.

Long-Term Cost Savings

Financial savings provided by the STS come primarily from time saved through automated data collection, and logistic cost savings through the reduction of travel related expenses to access each site for data collection. In many cases, as the costing graph at right depicts, a complete telemetry system can pay for itself over a manually monitored system in 2-3 years. When cost savings can be realized in such a short amortization period, the financial arguments to telemeter long-term or high logistical cost data collection projects become very strong. In addition, the peace-of-mind value of having advance alarm notification and much more frequent access to data.

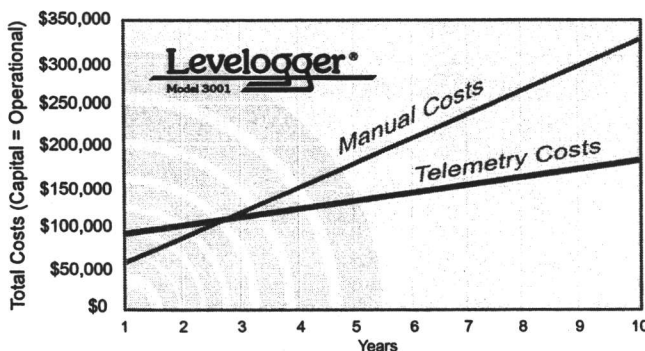
Advantages

- Long term cost savings
- Time saved by eliminating manual data collection
- Frequent and scheduled access to detailed data
- No need to travel to remote field locations
- Self-management gives additional savings and data security
- Simple software and easy network management

Applications

- Remote water level monitoring
- Long-term drought monitoring
- Oversight of water taking
- Golf course & mine water management
- Longer term pump tests
- Flood water management
- Long-term aquifer management
- Well data to PLC/SCADA systems

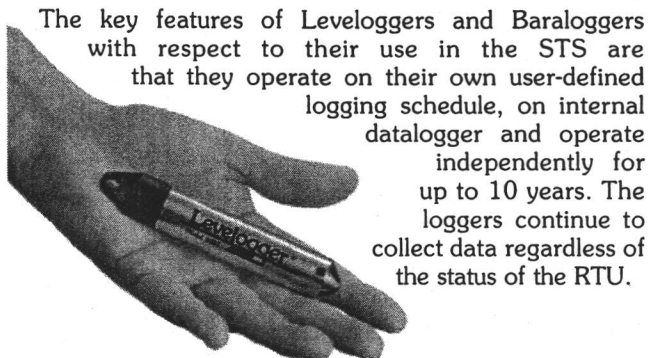
Telemetry Costs vs Manual Monitoring Costs



Based on 25 Levelloggers, 5 Barologgers, 25 RTUs.
Monthly manual download or semi-annual telemetry visit.
Hourly rate \$50 (inclusive of all expenses).

Levelloggers & Barologgers have a datalogger, 10-year battery, pressure transducer and temperature sensor, all housed in a very small, minimal maintenance, 7/8" x 4.9" (22x125mm) stainless steel housing. The sealed design offers protection against power surges such as nearby pumps or lightning, and greatly simplifies maintenance.

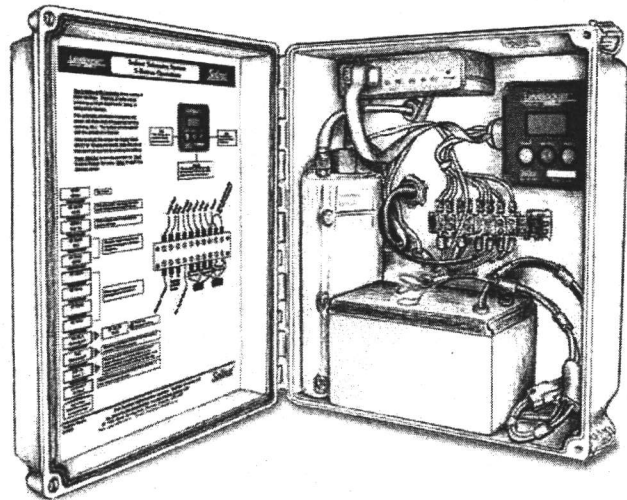
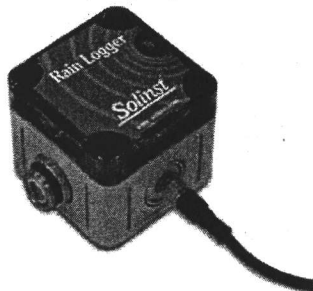
Levelloggers are connected to the surface with direct read cable for rapid downloading of data and/or reprogramming, without removal from the water. No vented cable or desiccants are needed. The inexpensive Barologger is available to provide the most accurate and easy method of barometric compensation.



The key features of Levelloggers and Barologgers with respect to their use in the STS are that they operate on their own user-defined logging schedule, on internal datalogger and operate independently for up to 10 years. The loggers continue to collect data regardless of the status of the RTU.

Levelloggers are available in a variety of ranges. The simple Levellogger Software allows measurements at chosen time intervals as small as 0.5, uses non-volatile flash memory, and does not overwrite data. Logarithmic, linear and event-based sampling regimes are easily programmed. The software allows immediate viewing of temperature and barometric compensated data in chart or graph form and you may easily export to other programs. The STS can also be used with the LTC Levelloggers for level, temperature and conductivity measurements.

The Rain Logger is designed for use with Solinst Levellogger software and almost any conventional tipping-bucket rain gauge with a reed switch output. The Rain Logger counts rain bucket tips in micrometers (μm), then expresses readings in mm/period. The linear sampling rate can be set anywhere between 10-90 minutes. The Rain Logger provides readings for total rainfall for the sample period and maximum intensity based on rainfall in the sample period.



Remote Field Equipment

The STS is designed for use with Levelloggers and the Solinst Rain Logger. The loggers are attached to the wellhead using direct read cables and to the RTUs with armoured cable. A 3-Button Controller, battery, modem, transceiver and terminal panel are all protected within a Nema4 box with a connected antenna. The telemetry controller has a display screen and three buttons to allow viewing of latest readings, RTU time, date and battery level also powering up of the RTU for initial setup, testing and data collection. A low-gain whip antenna is standard, however, hi-gain antennas and solar panels may be used for battery charging.



Computer Controls

The STS provides three levels of user access to the remote RTU. The primary access level is via the STS Administrator Software running on the Central Computer System. The Administrator Software controls the telemetry network, to add/remove/edit RTUs, program RTU settings, "ON" times, polling events and alarm condition settings. Most importantly the Administrator Software runs the automated collection of telemetered data. A secondary user software package referred to as the Observer is a password access program that provides users the ability to obtain the last readings or download all the logged data since the last polling event by that observer. It does not allow alteration of any of the RTU or telemetry system settings.

STS Telemetry Case Study

The Ontario Ministry of the Environment and Energy required water well monitoring and telemetry equipment, installation services and a central data management system, to be part of the establishment of a Provincial Groundwater Monitoring Network (PGMN).

Under the contract Solinst supplied the Well Monitoring and Telemetry Equipment along with training and technical support for the equipment. Golder Associates managed of the project, installing the equipment and supplying the Central Data Management System.

The contract called for the supply of up to 380 Remote Telemetry Units, utilizing Levelloggers and Barologgers to measure water level, temperature and barometric pressure. These units were installed in 38 Conservation Authorities across the Province of Ontario, Canada.

As of September, 2003, 239 Solinst Telemetry Units, 365 Levelloggers and 28 Barologgers were The Central Data Management System has been in operational mode since July 2001.

Approximately 400 wells across Ontario are being studied. Continuous monitoring helps the government track long-term drought conditions and obtain vital province-wide baseline groundwater information. Telemetry takes the most important function of this project, the data collection, away from the possibility of human error. The Ministry saves valuable time that would have been spent on field visits and accomplishes its monitoring goal while saving taxpayers' money.

Setting up an STS System

The STS has easy to use Windows based software with which the user chooses times and selections using pull-down menus. No code writing or knowledge of traditional programming is required. The STS is designed to communicate with one to three loggers per location. This allows any combination of 3: Levelloggers, Barologgers and Rain Loggers for each STS. The loggers are pre-programmed using Levellogger Software with required monitoring regimes and deployed at the remote site using direct read cables.

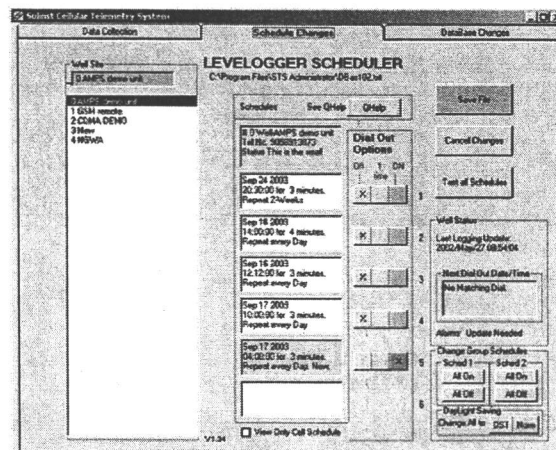
Modem communication is then established with the Central Computer System (CCS). The dialing schedules are downloaded to the RTU and subsequently communications are established at the chosen scheduled times for receiving data from each Levellogger.

To maintain a low power usage, the RTU is typically programmed by the Administrator Software to turn ON only for short periods, several times per day or week. These ON times are the schedules. The user will select which ON times are to be used as actual data polling events. For instance, the user may program an RTU to power up for 4 minutes, 2 times/day, for use by Observers, or for re-scheduling, etc., but will only poll for data once per week.

Data Management

Data retrieved from the each logger is placed in individual .lev files on the computer, appending the newest data onto the existing file. This data can be viewed with the standard Levellogger Software or exported directly into other spreadsheets or databases.

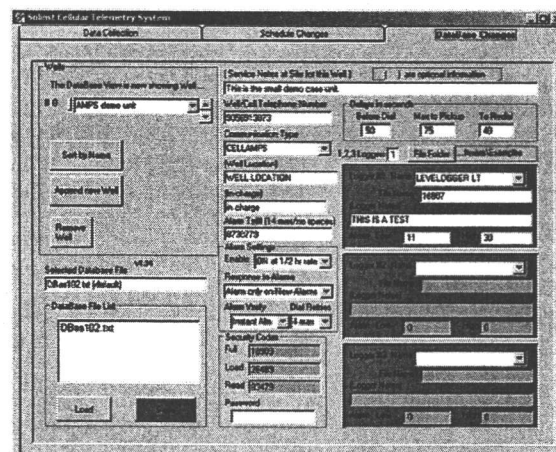
The Observer Software allows a secondary user group access to the data in the RTU, without allowing them to alter schedules, which are controlled only by the Administrator.



Setting up Dialing Schedules

The software has a simple system for identifying each individual logger, and allows easy set-up of automatic dialing and polling schedules. It also allows manual dial ups during scheduled "ON" times. A built-in automatic checking system avoids schedule conflicts, using a map of schedule times.

As a precautionary measure, the CCS clock time and the dialing schedule information is downloaded to the RTU at each communication with the CCS. This allows schedules to be changed and avoids possible imbalances in the schedules.



Power

The STS 12V DC design uses low power electronics and no power while in standby mode. This enables operation for periods up to 1 year before battery recharge is required depending on frequency of access. Solar panels, for continuous trickle charging, or 110V power supply are an optional extra, if more frequent access is required. Leveloggers have a 10-year Lithium battery.

Alarms

The STS allows a high and a low water level alarm point to be established individually for each Levelogger. When an alarm status occurs the RTU will call out to the modem of a separate computer. The user can configure how often the alarm status will be checked; how long the condition has to last before the STS dials out; and options for how often it dials out if not getting a connection. These avoid repeated or continuous alarm calls caused by the water level swinging in and out of alarm status.

Communication Types

STS Systems are available for use with cellular systems, using GSM or CDMA digital, AMPS analog, as well as landline telephone and spread spectrum radio connections on mixed applications.

Levelogger Data Input to SCADA Systems

Solinst has developed Modbus RTU and SDI12 protocol converters to allow the latest reading from the logged Levelogger data to be input to any SCADA PLC unit with a serial port. The connection can be direct to the SCADA PLC or Solinst can supply radio links through a Remote Radio Unit sending the converted signal to a Radio Receiver which connects to the SCADA. The logged water level data stored in each Levelogger can also be accessed by traditional Levelogger methods, if more detailed data is desired, or in case of system failure. (See 3001 and 9100 data sheets.)

Specifications	Direct Line	Radio	GSM & CDMA Digital Cellular	AMPS Analog Cellular
Advantages	<ul style="list-style-type: none"> • Less expensive • No cellular charges • Reliable telephone system • If AC power available, system can be ON at all times. 	<ul style="list-style-type: none"> • No airtime or long distance fees • Strong 1 Watt power • You control the network 	<ul style="list-style-type: none"> • Less expensive airtime • Smaller size & smaller battery 	<ul style="list-style-type: none"> • Widest cellular coverage in parts of North America • Powerful 3 Watt transceiver • Data transmission is faster than with digital
Disadvantages	<ul style="list-style-type: none"> • Restricted to locations near existing phone lines • More prone to lightning and electrical surges 	<ul style="list-style-type: none"> • RTU>CCS range limited by trees, buildings, etc. - in restricted conditions 3250 ft (1Km) - in unrestricted area, with Yagi antenna 63,000 ft (20 Km) 	<ul style="list-style-type: none"> • Less geographic coverage than AMPS in some areas 	<ul style="list-style-type: none"> • AMPS network is being retired to digital networks
Modem	FCC approved AC/DC integral	FCC approved DC, FCC part 15 Rss-210, spread spectrum	FCC, IC, CE approved	FCC and IC approved
Power	12V/12AH sealed lead acid battery	12V/12AH sealed lead acid battery	12V/1.3AH sealed lead acid battery or smaller	12V/12AH sealed lead acid battery
Operational Sales Limits	-30 to 60°C, 0-99% relative humidity	-30 to +55°C, 0-99% relative humidity	-30 to +55°C, 0-99% relative humidity	-30 to 60°C, 0-99% relative humidity
Auto Answer	1200-19200 DTE rate. MNP 10 EC Modem Hayes AT Command Set with 400 byte buffer in modem control	9600 baud	2400-9600 DTE rate	1200-19200 DTE rate MNP10 EC Modem Hayes AT Command Set with 400 byte buffer in modem control
Antenna	None	External Whip	External mini-whip	External ground-planned 3dB whip, loaded coil whip optional
Nema 4X Enclosures	12" x 10" x 6" etc.	7.5" x 3.5" x 3.5" etc.	7.5"x3.5"x3.5" (19mm x 9mm x 9mm)	12" x 10" x 6" (305mm x 245mm x 152mm)
Optional Equipment /Accessories			Central Computer System Requirements	
Trickle Charge Accessories <ul style="list-style-type: none"> • 4 Watt Solar Panel - suitable for one call per day access • 20 Watt Solar Panel, suitable for hourly access • AC/DC power - suitable for access anytime. Battery Charger <ul style="list-style-type: none"> • 10AH or 1.5AH style, depending on system Protective Enclosure <ul style="list-style-type: none"> • Nema 1 armoured steel box to enclose wellhead manifold, STS Nema 4X box & antenna, allowing easy access for manual readings 			Computer <ul style="list-style-type: none"> • PC Pentium 400 or better, (1GHz or more) • Laptop with sufficient screen size and modem port is suitable for up to a maximum of 100 RTUs. Software <ul style="list-style-type: none"> • Solinst Levelogger Software • Administrator Software • Observer Software: for secondary users with limited access optional 	

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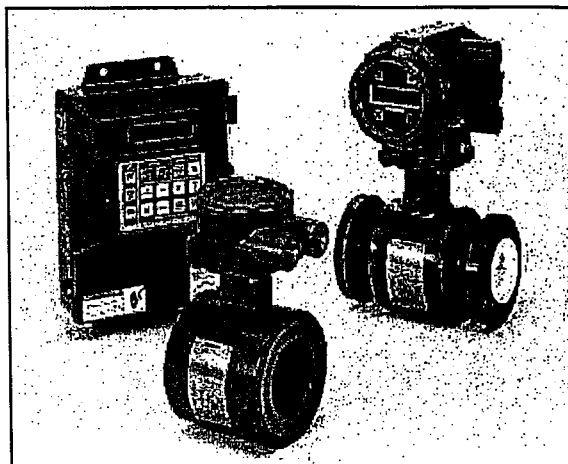
APPENDIX E

MAGNETIC FLOW METER PRODUCT INFORMATION

Rosemount 8700 Series Magnetic Flowmeter Systems

THE 8700 SERIES...

- Rosemount 8712D Transmitter - Easiest to use local operator interface and works with any manufacturer's flowtubes
- Rosemount 8712H/8707 High-Signal System - Pulsed dc solutions for the most demanding flow measurement applications
- Rosemount 8705 - Fully welded flowtube for maximum protection (standard ISO lay length)
- Rosemount 8711 - Economical, compact, and light weight flowtube, provided with alignment rings for easy installation
- Rosemount 8732/8742 Transmitter - Integral-mount design eliminates wiring error, backlit display for easy viewing, and explosion-proof housing for hazardous environments
- Rosemount 8742 Transmitter - Utilizing advanced diagnostics (high process noise detection, grounding/wiring diagnostic, and electrode signal fault) increase magmeter performance



Content

Specifications	page 4
Product Certifications	page 19
Dimensional Drawings	page 28
Magnetic Flowmeter Sizing	page 36
Material Selection	page 38
Ordering Information	page 39
Rosemount 8712 D/H and 8732C Configuration Data Sheet	page 53
Rosemount 8742C Configuration Data Sheet	page 55

ROSEMOUNT

www.rosemount.com



EMERSON
Process Management

Rosemount 8700 Series System Overview

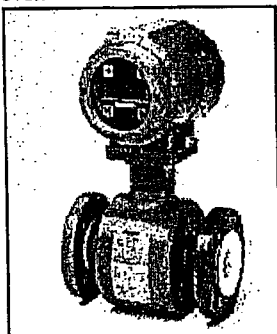
Rosemount 8712D/H

The remote mount Rosemount 8712 transmitter features an easy to use operator interface. The intuitive 15 actuator keypad provides instant access to the most commonly used functions, and the 2 line by 20 character display provide clear indication. Together they provide fast, intuitive, and easy configuration.

The 8712D transmitters operate with all Rosemount magnetic flow meters and the D and U versions provide universal functionality allowing them to operate other manufacturer's flow tubes. The 8712H high signal transmitter provides unprecedented performance in high process noise applications.

Rosemount 8732C

The integral mount Rosemount 8732C transmitter has an explosion proof housing and full RFI/EMI protection that is ideal for harsh environment installations where moisture and contaminant in filtration are possible. With an optional backlit 2 line by 16 character local operator interface, the transmitter can be configured by optical switches to simplify adjustments in hazardous environments without removing the cover.



Rosemount 8714D

The Rosemount 8714D Calibration Standard attaches to a 8712D, 8732, or 8742C transmitter's flowtube connections to ensure traceability to NIST standards and long-term accuracy of the flowmeter system. The 8714D is not compatible with 8712H high-signal transmitter.

Flanged Flowtubes

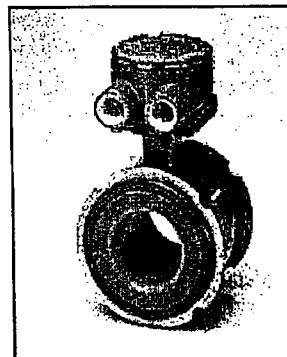
All flanged Rosemount flowtubes are fabricated from stainless and carbon steel and welded to provide a hermetic seal that protects against moisture and other contaminants. Sizes range from 1/2 inch (15 mm) to 36 inch (900 mm). The sealed housing ensures maximum flowtube reliability by protecting all internal components and wiring from the most hostile environments.

Sanitary Options

The adapter flanges on the 3-A-compliant 8705 are designed to attach to a magnetic flowtube of smaller diameter than the process piping to ensure a crevice-free interface. The adapters provided are polished internally and externally. A more robust sanitary wafer flowtube offering, the Rosemount 8721, has been released (document number 00813-0100-4901).

Wafer Flowtubes

The flangeless design of the 8711 wafer flowtube makes it an economical, compact, and lightweight alternative to flanged magnetic flowmeters. Alignment rings, provided with every Rosemount 8711 flowtube, center the flowtube in the process line and makes the installation easier.



High-Signal Magmeter System ⁽¹⁾

The Rosemount 8707 High-Signal Flowtube, used in conjunction with the 8712H High-Signal Transmitter, forms the Rosemount High-Signal Magnetic Flowmeter System. This system provides stable flow measurement in the most difficult high-noise applications while maintaining the benefits of dc technology. The increased signal strength of the Rosemount® high-signal system is made possible through a combination of flowtube coil design that incorporates the most advance materials and an extremely efficient and innovative coil drive circuit. The increased signal strength of the Rosemount high-signal system, coupled with advanced signal processing and superior filtering techniques, provides the solution to demanding flow measurement applications.

(1) The high-signal magmeter system is not available in Europe.

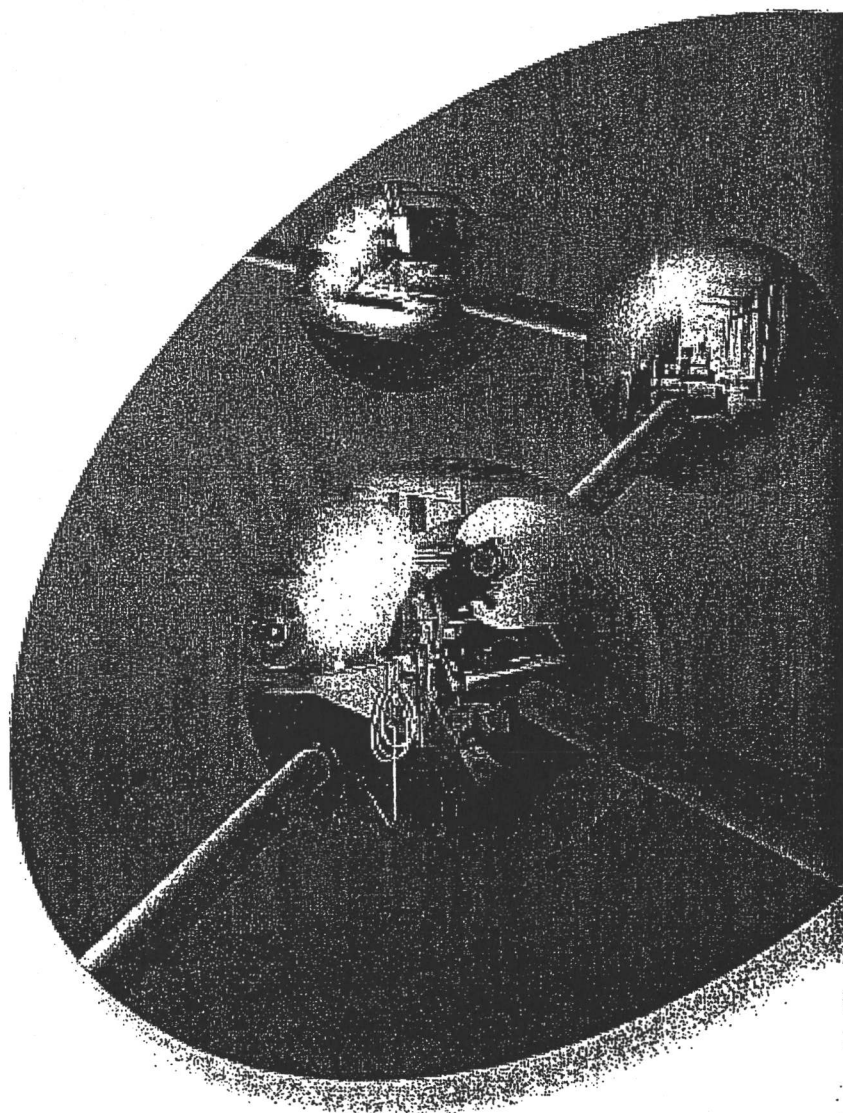
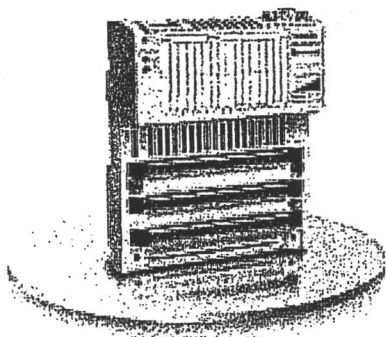
APPENDIX F

PROGRAMMABLE LOGIC CONTROLLER (PLC)
AND
VARIABLE FREQUENCY DRIVE (VFD)
PRODUCT INFORMATION

PLC

Distributed I/O and control
Modicon Momentum

Flexible system for
distributed I/O and control



Controller and IP20 monobloc I/O for distributed control architecture

a brand of
Schneider
Electric



Telemecanique



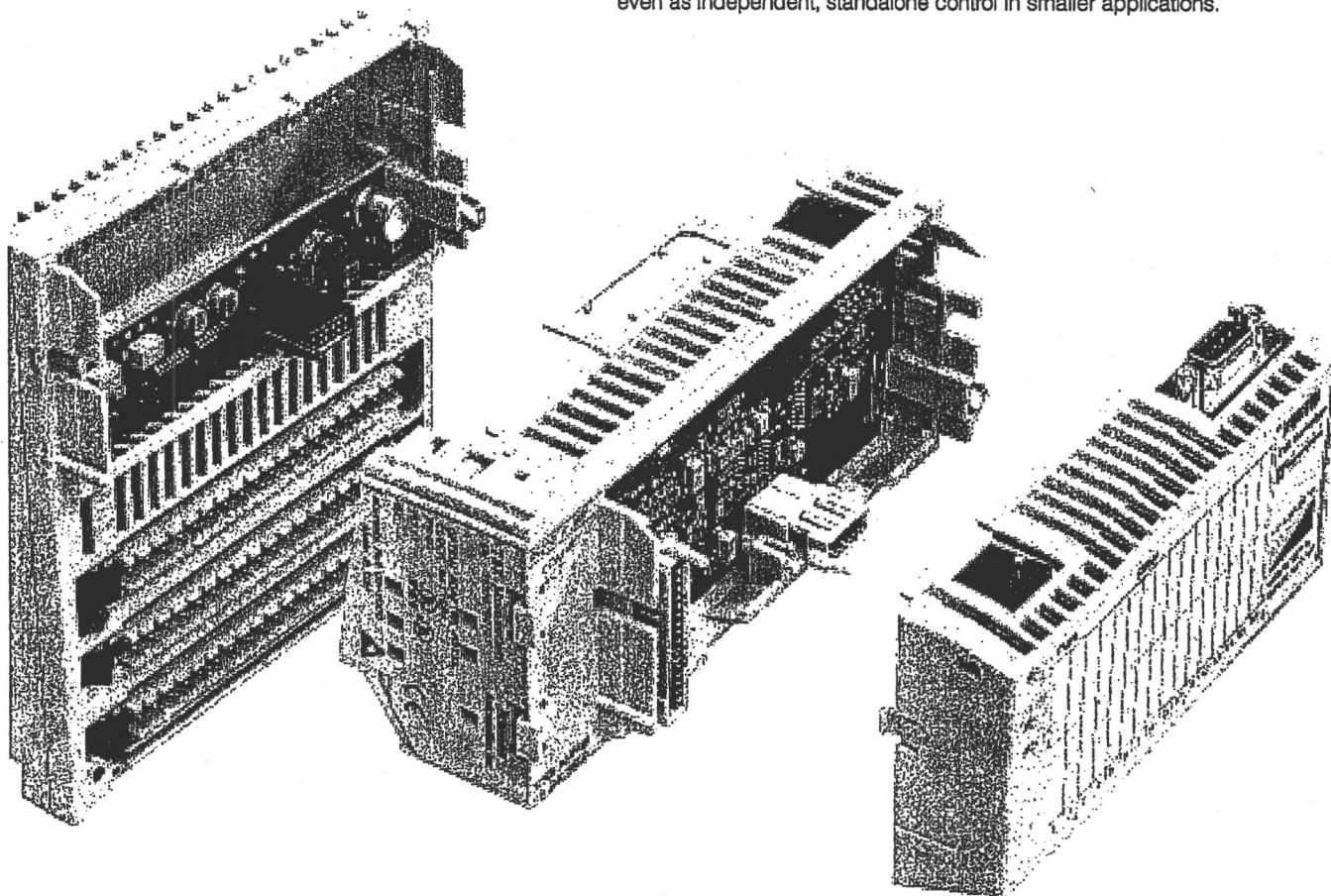
Simply Smart!

Leveraging
ingenuity
and intelligence
for **ease of use.**

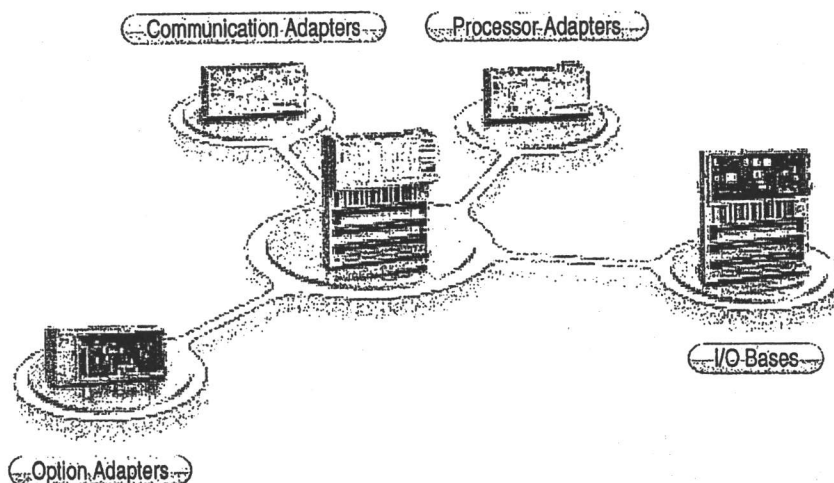
Modicon Momentum

A proven, flexible solu

Modicon Momentum is a range of proven control system and I/O components — I/O modules, control processors, network adapters and option adapters — that has been solving a wide range of customer applications for many years. The key to its success? Momentum easily adapts to your needs, whether simply as an I/O solution, as part of a distributed control solution, or even as independent, standalone control in smaller applications.



um
tion.



Benefits

Compact size

Reduced wiring

Flexible architectures

**Easy maintenance
and diagnostics**

Flexible system design

The Momentum system includes four fundamental components that easily snap together in various combinations to form versatile control systems or sub-systems.

I/O bases

The I/O base provides the foundation for the rest of the Momentum system and serves as the mounting base for communication adapters, processors or option adapters — which all snap onto the I/O module. In addition to providing I/O capability, the base also includes the power supply for I/O module circuits and adapters.

Communication adapters

The Momentum system offers a wide selection of communication adapters that snap onto any of the I/O modules, creating a truly open I/O system that can be easily adapted to many popular fieldbus networks. Communication adapters are available for Ethernet, Modbus Plus, Fipio, INTERBUS, Profibus DP, and DeviceNet.

Processor adapters

There are currently 10 Momentum processor adapters available, ranging from those for local control of a single I/O module, to models with a built-in distributed communication port, Modbus TCP/IP-Ethernet communication and embedded web pages, capable of servicing up to 8192 points of I/O.

Option adapters

Option Adapters provide additional networking capabilities to the processors, as well as a time-of-day clock and battery back up. The Option Adapter also snaps onto the I/O base, with a Processor Adapter mounted on top.

VARIABLE FREQUENCY DRIVE

VLT® 2800 Series Overview



VLT 2800 Series drives are available in Protected Chassis (IP20) up to 10 HP and NEMA 1 for 15-25 HP as standard.

- 0.5 to 2 HP, 230 VAC, 1Ø
- 0.5 to 5 HP, 230 VAC, 3Ø
- 0.75 to 25 HP, 460 VAC, 3Ø

VLT® 2800 Benefits for Water and Wastewater Applications

- Optimizes process control of flow, level and pressure
- Enables use of standard pumps with integral AC motors and can be installed into existing plants using standard AC motors
- Programmable for constant or variable torque operation: constant torque operation for maximum motor torque throughout speed range; variable torque operation optimized for maximum efficiency
- Eliminates control valves and problematic pressure storage tanks
- Lower energy consumption
- Less pump noise
- Reduced maintenance
- Eliminates current in-rushes on the AC line
- No motor derating as with conventional PWM drives
- Designed to communicate with programmable logic controllers as well as machine operators
- I/O selector switches, pushbuttons and indicator lights for manual devices

VLT® 2800 Feature Highlights

Optimized Enclosures

- Optimized for size — ideal for panels
- Small size doesn't compromise performance
- Horizontal or vertical mounting with no side clearance

Designed for Performance

- Designed for 0.5 to 25 HP applications; constant or variable torque operation
- Cold plate technology provides efficient thermal transfer the panel backplate
- Wide AC line voltage range; 230 VAC 1Ø and 3Ø, and 460 VAC 3Ø
- No derating for 230 VAC 1Ø or 3Ø; a 1 HP unit is 1 HP on either 1Ø or 3Ø power
- Starting torque of 160% for 1 minute (constant torque)
- High starting torque = 180% for 0.5 sec.
- Standard protection features include: phase-to-phase short; phase-to-ground short; input and output protection
- Unlimited switching between drive and motor (with optional output coils)
- Fast response time
- Built-in DC link inductors reduce harmonics

VLT® 2800 Series Overview

Enhanced Software

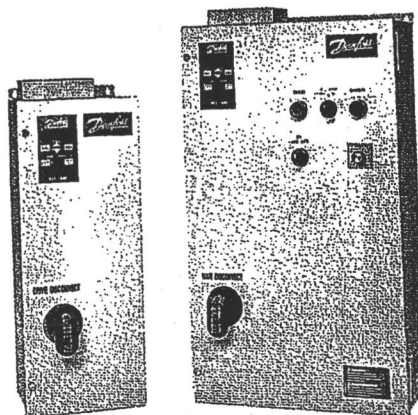
- Quick Menu has 11 primary parameters for quick start-up
- Electronic Thermal Relay provides motor overload protection
- Built-in PID controller
- Hand-Off-Auto functionality
- AMT (Automatic Motor Tuning) parameter optimizes system performance
- TAS (Temperature Adaptive System) provides optimum operation over extended temperature range

Versatile Interfaces

- Access to all programming parameters via standard LED keypad
- Alarm, Warning and On LEDs indicate drive status
- Built-in RS-485 is fully-equipped for serial communication – up to 31 drives can be connected to one serial bus
- Window-based programming, system monitoring, control or diagnostics with VLT Dialog software
- Galvanically-isolated I/O

International Approvals

- UL
- cUL
- CE



VLT® 2800

Engineered Panel Solutions (See Section E for complete information)

The Engineered Panel Solutions program for the VLT 2800 family provides increased functionality. These enclosures are available in NEMA 1, 3R, 4/4X, 12 and offer a variety of control configurations.

Options (Factory built-in) (pages B 19)

Enclosures

- Protected Chassis (IP20)
(0.5-10 HP)
- NEMA 1 (IP20) (15-25 HP)

Hardware

- Standard
- Standard with Brake

RFI Filter

- Class 1 Group A
- Class 1 Group B

Fieldbus Options

- Profibus DP/FMS
- DeviceNet

Accessories (See Section F)

- NEMA 1 kit
- Motor Coils (chassis)
- LCP-2 (Local Control Panel)
for remote panel mounting
of 4-line alpha-numeric
display with upload/
download capabilities
- RFI Filter (Class 1 Group B)
- VLT Dialog Software
- Harmonic Traps
- Line Reactors
- LC Filters

Danfoss

New VLT® 2800 features:

Dry run detection and Enhanced sleep mode

The new features improve pump operation significantly and result in improved energy savings as well as pump protection in case of dry run situations.

Cost saving as additional dry run detection equipment is not necessary.

Dry run detection

This new feature protects the pump in case the well runs dry, by shutting down before damaging the pump.

Important features are:

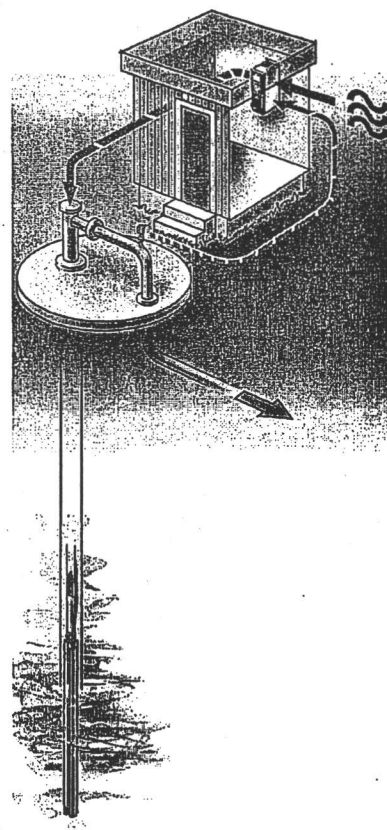
- Automatic or manual restart after shut down
- Programmable restart delay up to 1 hour.
- Shut down at low or no flow
- Operates in either open or closed loop

Enhanced sleep mode

When using pumps with flat pump curves or when the suction pressure varies, this feature provides excellent control for shutting down the pump at low flow, thus saving energy.

Important features are:

- Automatic restart after shut down based on pressure
- Boost function to increase pressure for a period after shut down
- Operates in closed loop





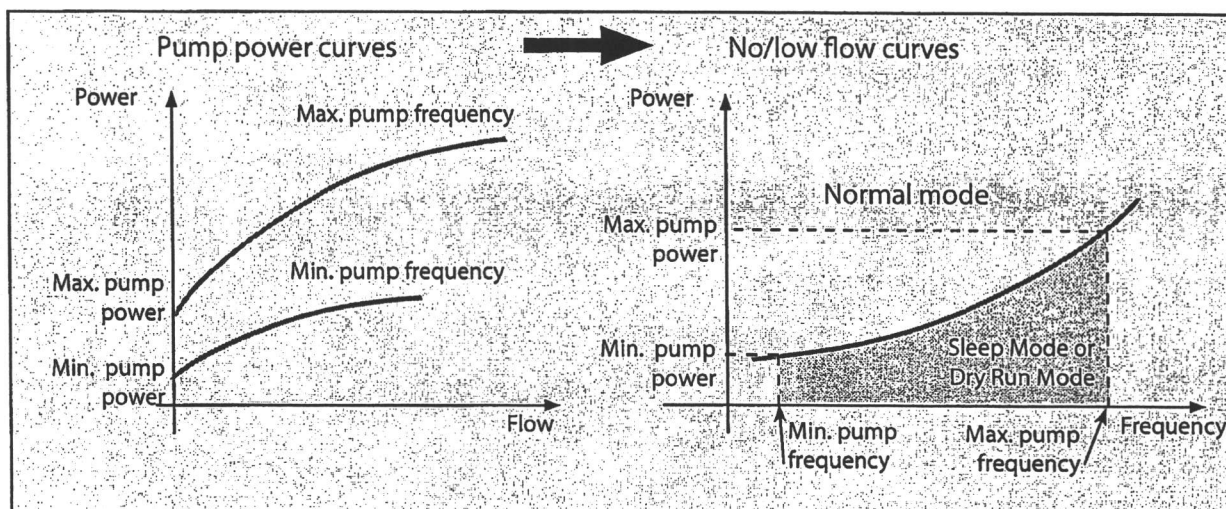
Working principle

Both features are based on drive power and frequency monitoring. Two working points for power and frequency at no or

low flow, enables the drive to generate the no/low flow power curve.

At power values below the

curve the drive will be forced to either trip due to dry run or enter sleep mode – depending on the actual drive configuration.

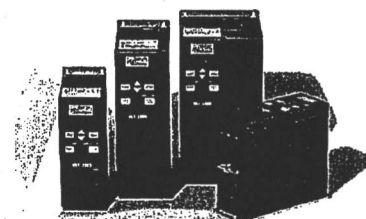


Commissioning is easily done

- Enter the power consumption for no/low flow at minimum and maximum frequency (two working points).
- The drive generates the no/low flow power curve
- Use the power compensation factor for moving the curve and fine tuning of the system.

Other dedicated VLT® 2800 features

- Pipe Fill mode to prevent water hammering
- Choose constant or variable torque operation
- Initial ramp to fast acceleration of submersible pumps



VLT® 2800
Power range 0.37 - 18.5 kW



Sangiuliano, Tony (MTO)

From: Sangiuliano, Tony (MTO)
Sent: June 22, 2006 8:18 AM
To: Mendoza, Felipe (MTO)
Cc: 'Cunningham, Mike'
Subject: RE: Innovation Report pdf

Felipe:

We have reviewed Golder's response letter and confirm that our comments have been appropriately addressed. We have no further comments. Please have Golder's submit a hard copy of the report to our office.

Please call to coordinate the presentation meeting for this project.

Tony

-----Original Message-----

From: Cunningham, Mike [mailto:Mike_Cunningham@golder.com]
Sent: June 21, 2006 1:53 PM
To: Mendoza, Felipe (MTO); Sangiuliano, Tony (MTO)
Cc: Cunningham, Mike
Subject: FW: Innovation Report pdf

Felipe, Tony,

The Innovation Report has been loaded to the following ftp site (see link below). And I've also attached a pdf of the response letter. Hope this helps. Thanks,

Mike Cunningham, P.Eng.
Associate

Golder Associates Ltd.
32 Steacie Drive
Kanata, Ontario K2K 2A9
Tel: (613) 592-9600
Fax: (613) 592-9601
email mcunningham@golder.com

Visit our website at www.golder.com

-----Original Message-----

From: McConnell, James
Sent: Wednesday, June 21, 2006 10:09 AM
To: Cunningham, Mike
Subject: Innovation Report pdf

Mike, the report is over 7Mb, I've uploaded it to the FTP site below.

James McConnell
ACAD Technician
Geographics Information Services Group

Golder Associates Ltd.
32 Steacie Drive
Kanata, Ontario
K2K 2A9

MEMORANDUM



To: F. Mendoza
Sr. Contract Controls Officer
Contracts, Ottawa

29 March 2006

From: Pavements and Foundations Section
Room 223, Bldg "C".

Tel: (416) 235-5267
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Re: Draft Report Review
Innovation – Groundwater Monitoring and Control
Groundwater Pumping and Recharge System
Lynwood Subdivision
GWP 759-93-00

We have completed our evaluation of the Draft Innovation Report for the Groundwater Monitoring and Control Alternatives for the Pumping and Recharge system at the Lynwood subdivision dated March 2006 and prepared by Golder Associates. Our office received the report on March 24, 2006.

Our evaluation is based on verifying that the report satisfies the Terms of Reference for completeness. The Consultant is responsible for the accuracy of the information and adequacy of the technical aspects of the recommendations. Any deficiency identified in this memorandum is intended to alert the Consultant but shall not relieve the Consultant of any responsibility for their work. The Ministry assumes no responsibility or liability for these aspects of the report.

Review comments are provided in this memorandum. The Consultant should be instructed to address the comments provided and submit their responses prior to finalizing the report. Once the report is finalized, it is recommended that the Consultant make a formal presentation to the Ministry at the Ottawa Area Office on Tremblay Road as per the requirements of the Terms of Reference. This presentation shall include discussion on the rationale and process used to compile the report, discussion on the report content and a detailed discussion of the groundwater monitoring and control alternatives.

The Geocres No. assigned to this project is 31G-204

3 EXISTING RECHARGE SYSTEM

3.1 System Overview

- Third paragraph – second last sentence – editorial comment – “which are no longer part of the system *or* indicated on Figure 2...” Should this be “*as*”.

3.2 System Components

- C. Pumps – Can the pump capacity be included in the report in IGPM?

4.0 UPGRADE OBJECTIVES

- Would language pertaining to “improving the efficiency and effectiveness of groundwater monitoring and control” be applicable in this section?

5.0 MONITORING, CONTROL AND ALARM ALTERNATIVES

5.1 General

- The report recommends a “direct telephone line” to service the proposed upgrades identified in the report. What are the costs to trench the cable onto the site and identified in the last paragraph on page 9?

5.2 Groundwater Level Monitoring Options

- Has trenchless technology been considered to facilitate the installation of underground cable associated with the piezometer monitoring?
- Clarification is needed on the frequency of monitoring as identified in the 5th paragraph on page 12. Are daily water level measurements required?
- Clarification is needed on the recommendation for the buried cable for the monitoring of piezometer 90-26 as compared to the remote monitoring recommended for the other three piezometers. What are the risks and consequences of remote monitoring the piezometer 90-26?

5.3 System Monitoring Options

- Clarification is needed on the recommendation for monitoring the water levels at the recharge wells. What are the risks of the water levels being at a level that will frequently trigger a high water level alarm?
- What are the estimated costs of installing the high/low water level remote monitoring at the recharge wells?
- Is it recommended that the high/low water level remote monitoring be conducted at each recharge well?
- Clarification is needed on the magnetic flow meter. The report identifies that with a magnetic flow meter, a confined space entry associated with the flow meter chamber is eliminated. Where will the flow meter be installed ?

5.4 System Control Options

- Pg 15 – 1st paragraph – spelling – “property” – should this be “properly”?
- Pg. 15 – 3rd paragraph – editorial – “It not considered..” – should this be “It is not