STORMWATER RETENTION BASIN AND LAND DRAINAGE CHANNEL WATER LEVEL MONITORING STATIONS INVESTIGATION

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TABLE OF CONTENTS

3.0 EQUIPMENT (CONTINUED)

LIST OF APENDICIES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION AND PROJECT SCOPE

This report provides details of the preliminary assessments performed on sixteen (16) storm water retention ponds (SRB's) and drains within the City of Winnipeg. SFE Global was chosen by the City of Winnipeg's Water and Waste Department (WWD) as the successful bidder on RFP 38-2012: Storm Water Retention Basin and Land Drainage Channel Water Level Monitoring Stations Investigation. Mr. Kevin McMillan as Senior Project Manager and Mr. Nick Schellenberg as local Project Manager represented SFE Global for the duration of the project.

SFE performed site assessments on sixteen SRB's and channels from May 8th to May 10th, 2012. Photos, observations and recommendations pertaining to the assessments are contained in this report.

The intent of this project is to provide site specific recommendations and cost estimates for water level monitoring stations at various storm water retention ponds and major drains within the City of Winnipeg. Using the information obtained, and field level expertise of SFE Global staff on similar projects, preliminary designs will be developed with cooperation and consultation of appropriate City personnel from various departments. Expertise from the City will be obtained from Engineering, Instrumentation, Process Control and Information Technologies Departments.

1.1 Study Approach

During the 2011 spring flood event in Winnipeg, Manitoba, SFE Global installed over forty sanitary sewer monitors, and ten water level monitors on storm water retention ponds, land drainage channels, and the Red River to monitor water levels for emergency efforts. Several methods were utilized including radar level from bridge decks, submerged pressure level in chambers and manholes, and submerged level directly in ponds. Lessons learned from this project provided valuable information on the best possible means to meet the City of Winnipeg's monitoring needs. With regard to the current project of permanent wireless pond and channel level stations, the criteria for assessment and recommendation include:

- Reliable and Operational by City Staff
- Cost Effective Capital and Operational Costs
- Ease of Collection and Integration of Data
- Ability to withstand seasonal change or be easily removed for winter
- Aesthetically pleasing when placed in residential areas
- Ability for temporary systems to be easily relocated
- Vandalism resistant hardware

SFE field service personnel travelled to each of the sites in the study and assessed:

- Access to potential gauging locations
- General topography of the area
- Security and vandalism impacts
- Suitability for various technologies at each location
- Digital photographic log of each location

Upon completion of field assessments SFE project staff met with WWD staff on June 21st, 2012. During this meeting the first version of this report was presented and discussions were held regarding available water level monitoring options. City experts in drainage, data management and instrumentation were present and offered feedback from each of their associated areas of expertise.

The outcome of these discussions was a number of basic concepts for station configuration that City staff wanted. They included:

- Drain sites with bridges are to use ultrasonic sensors
- SRB and drain sites without bridges are to use submerged pressure sensors
- Preference is for pressure sensors to be permanently installed for all season operation
- Preference is for pressure sensors to be mounted below winter ice level to prevent damage
- Equipment kiosks are to be located on land with conduits connected to submerged sensors
- Barometric correcting sensors are not required as the City will use data from their 32 WeatherBug sites to adjust sensors for barometric changes
- The City is very interested in the Detectronics integrated data logger, 5 year battery supply and cellular communication plan

1.2 Detectronics Company and System Overview

Company Overview

Detectronic Ltd. is a UK based manufacturer of flow, level, pressure and rainfall data logging and communication equipment. The founders of the company have been active in the industry since the 1980's when they developed one of the first Doppler Radar open channel sewer flow meters.

The current focus and specialty of Detectronic is the development and supply of products featuring integrated cellular data communications. They are industry leaders in offering pre-purchased five year worldwide cellular access plans with their equipment. Past experience with this supplier has proven that this service is reliable and extremely cost effective in the water and wastewater industry.

The company currently has numerous projects and clients in the North American market. Projects currently underway include The City of Winnipeg Drainage Branch, Cole Engineering in Ontario, SFE Global in Western Canada and the Western United States.

HISTORY AND BACKGROUND

Detectronic's Specialist Measurement Technologies have evolved since the mid-1970s when members of their design team were instrumental in the development of the very first (patented) Ultrasonic Doppler Speed-Log for the Marine leisure industry. This was a Navigation instrument which measured the Velocity of a boat's hull as it passed through water and recorded the distance travelled. It was from this Technology that the first solid-state Sewer-Flow monitor was developed in conjunction with the UK Water Research centre (WRc) in the early 1980s. More recently, in late 2008, following many years of continuing research and development, working closely with the Water Industry and the UK's leading waste-water flow survey specialists, Detectronic launched its new ATEX/IECEx certified MSFM Flow Measurement System – which offers built-in GPRS Data-communication as standard throughout the product range.

Detectronic's Manufacturing and Specialist Service Facility at its Nelson premises is controlled by Quality Management Systems which ensure operational compliance with ISO 9001, ISO 60079-19, IECEx OD/14 and OD/15. This enables Detectronic to manufacture its own Products, and also to service and repair Intrinsically Safe Instrumentation from other makers - used in the Sewerage Network's potentially explosive atmosphere.

Production and repair seen at Detectronic's Manufacturing and Specialist Service Facility.

Communications and Technology Overview

The data logging and communication products evaluated in this report consist of a multichannel data logger, integrated Li-ion high capacity battery pack and GPRS cellular modem. The ultrasonic level system for under bridge use has an integrated ultrasonic level sensor. The multichannel logger for pond side use uses a third party level sensor which is powered by the Detectronic system on a 4 to 20 milliamp loop powered circuit.

The communications scheme used on all Detectronic equipment pairs a five year world wide GPRS cellular data subscription with the detecdata.com communications server. The airtime and hosting costs for the first five years are included in the data logger purchase price. Data can be fetched by a web crawling Bot from the Detectronic web server, placed in an FTP location for automated upload to SCADA systems or transferred using XML data sharing protocol.

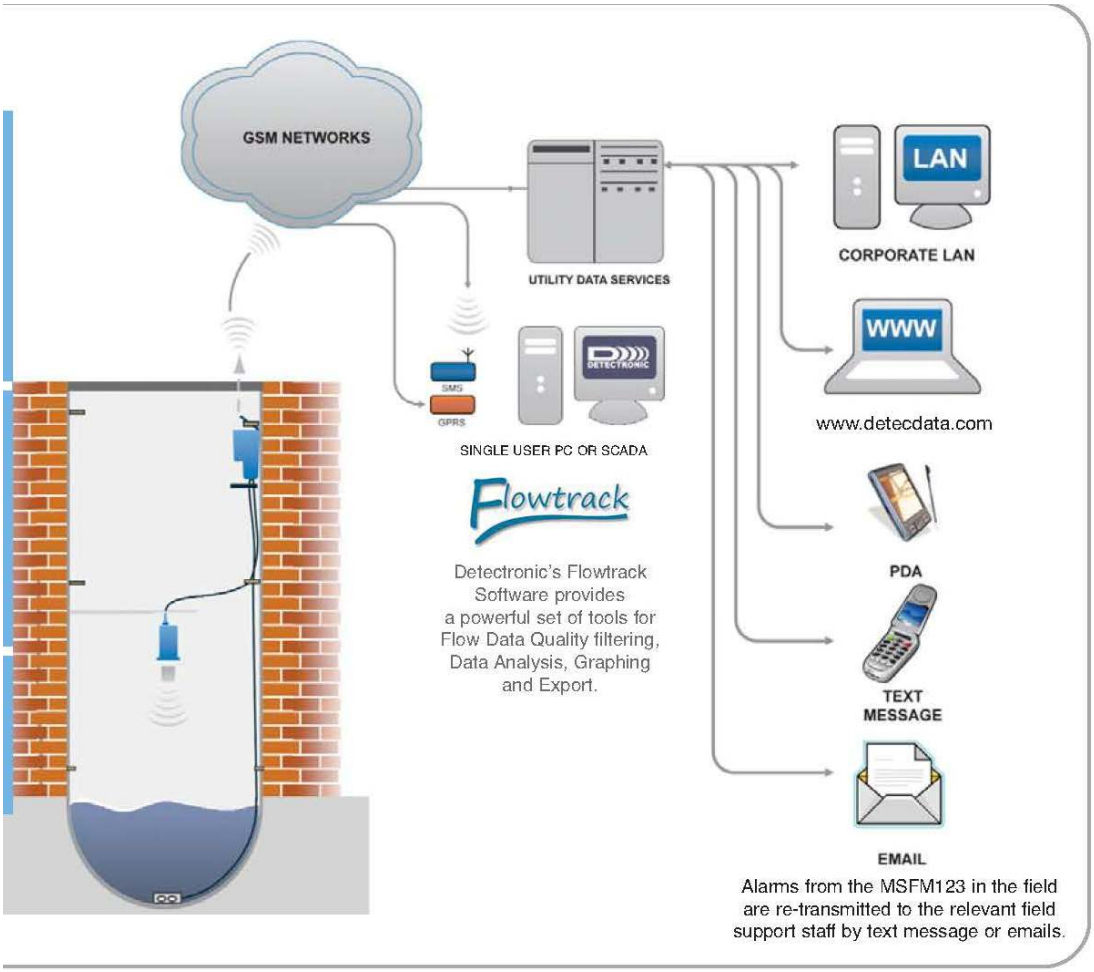


Figure 1 - Typical Detectronics Communications Scheme

Cellular Data Plan Costs

Although the hosting and cellular costs are prepaid for a five year term with purchase of hardware, there are renewal cost considerations. For an additional five year term, cellular costs are approximately $200 per year and hosting costs are an additional $80 per year. There is no anticipated escalation of these costs in future. With increased competition among cellular carriers, data costs may in fact decrease or remain stable.

Integrated System Costs

Detectronic integrated systems are sold and priced as a complete unit. For the purpose of this report, individual component prices have been estimated for the communications, data logging and power supply sections. When system costs are being presented, the Detectronic system has been combined into the integrated unit as sold. The exception to this is the cellular data and hosting costs, which have been shown separately.

Detectronic Integrated System Pricing

The following Detectronic integrated system pricing has been generated based upon location type assessed in this study, preferences conveyed by City Staff and quotations received from the supplier current to the writing of this report.

Table 1: Detectronic Cost Summary (CDN $)

	Pond Side ($)	Under Bridge ($)
Modem	Included	Included
Data Logger	2,800	3,900
Power Supply	Included	Included
Level Sensor	1,950	Included
Enclosure	1,750	1,750
Installation	4,500	4,500
Total Capital Cost	**11,000**	**10,150**
Annual Five Year Amortized Capital Cost	**2,200**	**2,030**
Annual Telemetry Cost	Included	Included
Annual Hosting Cost	Included	Included
Annual Maintenance Cost	1,600	1,600
Annual Vandalism Allowance	200	200
Total Annual Cost	**4,000**	**3,830**
TOTAL FIVE YEAR COST	**20,000**	**19,150**

Notes:

- Level sensor cost based on E&H FMX Absolute Pressure Unit.
- Detectronic units contain "flash power" supplies that provide system and sensor power for an estimated three year life. Replacement battery cost is $250 CDN.
- Installation costs include all site preparation, installation, configuration and startup troubleshooting.
- Annual telemetry and hosting costs included in the purchase of Detectronic hardware for the first five years, then subsequently renewed at $200 CDN and 80$ CDN respectively.

2.0 COMMUNICATIONS

2.1 Communications Options

It is our understanding that the ultimate end goal of the City of Winnipeg is to have reliable level data measured, collected and transmitted from monitoring sites to McPhillips Control Center. The City wishes to obtain reliable data for analysis and reporting in the most cost effective way. Although there are multiple methods to log and transmit data with varying operational costs, these end devices ultimately must communicate with the City's existing ClearSCADA reporting and alarming system. This approach would eliminate the need for software or communication protocol changes within the City's hosting system.

To satisfy this requirement the chosen communications hardware must either communicate directly with the City's cellular or spread spectrum data network, or relay data to the host system via FTP file transfers or other seamless internet protocol. The various communications options assessed in this section meet these criteria by varying means.

The viable communications options assessed for this application include:

2.1.1 RADIO TELEMETRY

Spread Spectrum Radio communication utilizes a private wireless radio frequency to transmit and receive data from the host system. In this instance the host system is the City's ClearSCADA network. Communications are real time, continuous and bidirectional.

2.1.2 BLUETREE CELLULAR TELEMETRY

The BlueTree 6x01 series of products offer flexible connectivity for industrial applications. These rugged devices connect remote terminal units (RTUs), meters, sensors and other remote devices to a central site or SCADA server. They communicate with the host system (ClearSCADA) and are offered by MTS. City protocol requires that these devices be purchased by the City communications group and supplied to contractors.

2.1.3 DETECTRONICS PREPAID CELLULAR TELEMETRY

Detectronics data loggers incorporate on-board general packet radio service (GPRS) cellular communication capabilities. Data is routed to a third party host (www.detecdata.com). Five years of cellular data service and hosting is included in the purchase price of this hardware. Automatic polling routines can be developed to regularly fetch this data and deposit into the ClearSCADA host system. Alternatively, off site hosting software may be purchased and installed on City servers to directly communicate with these systems.

2.1.4 SATELLITE TELEMETRY

Satellite telemetry uses low-Earth-orbit (LEO) satellites to provide tracking, monitoring and messaging capabilities to and from anywhere in the world. Similar to two-way paging or e-mail, the system is capable of sending and receiving two-way alphanumeric packets of data. These short, economical messages increase the efficiency of your remote operations by making critical information readily available – even from locations far beyond the geographic and economic reach of traditional systems.

2.2 Communications Costs

Costs associated with communications can be separated into capital and operational categories. Although some options such as radio telemetry have high capital costs, their monthly operational costs are lower than the monthly operational costs of the cellular and satellite options. The cost benefit analysis for decision making must carefully consider the equipment life cycle and whether the station may be moved or decommissioned during the monitoring term. Please reference Table 2: Communications Costs Per Site for details of associated costs of each communication option.

Costs included in this table and throughout this report have been obtained directly from local suppliers of equipment where applicable. Costs are estimated at the time of writing of this report and for typical configurations for each system. Some integration and installation costs have been estimated based upon the experiences of SFE Global staff and the author from previously completed similar projects.

The BlueTree Cellular Telemetry wireless sites could utilize the presently deployed data accounts supplied by City Corporate Communications. The City can reduce costs by procuring and supplying this hardware for this project.

Data transmission plans for satellite telemetry consist of a service or network access fee and a time-based data transmission fee. If there are connectivity issues, connection time can increase due to dropped calls and redials, causing higher monthly data costs.

Table 2: Communication Costs Per Site (CDN $)

	Radio ($)	BlueTree ($)	Detectronic ($)	Satellite ($)
Purchase Cost	500	775	750[1]	2,250
Infrastructure Cost	4,500[2]	2,100[3]	1,200	2,100[3]
Installation	2,750	1,750	750	1,750
Setup and Commissioning	1,750[4]	250[5]	250[5]	250[5]
Software / Programming	-	-	150[6]	250[7]
Total Capital Cost	**9,500**	**4,875**	**3,100**	**6,600**
Annual Data Cost	150	600	280[8]	900
Total Operational Cost (five years)	**750**	**3,000**	**1,400**	**4,500**
TOTAL COST (five years)	**10,250**	**7,875**	**4,500**	**11,100**

Notes:

1. Estimated cost for modem. Cost is included in data logger purchase cost.
2. Estimated average for sites to include line of sight mast, repeaters, study.
3. Includes cost of necessary solar panel, battery and charging system.
4. Includes cost to setup, configure and test radio communications.
5. Cost to program and troubleshoot modems and communications.
6. One time cost divided by 17 sites to write FTP data fetch routine for ClearSCADA.
7. Includes cost of polling software and setup divided by 17 sites.
8. Cost only incurred after first five years.

2.3 Comparison of Communications Options

Each of the communications options were compared as to the advantages and disadvantages of technology.

2.3.1 RADIO TELEMETRY

2.3.1.1 Advantages to Radio Telemetry

Cost-Effective: There is no cost for time, no roaming, and no long distance charges. In other words, there are no direct monthly communication fees but a licensing fee is paid to the regulator authority responsible for controlling the frequency bands.

Reliable, Error-Free Transmission: The data packets sent are error-checked and corrected. If the transmission was incorrect, the same packet is sent again, until confirmation of successful communication.

Secure: Encryption provides privacy of data. It can be installed on the receiver or at both ends.

Time-Sensitive: Can be constantly connected and the messages can be reviewed right after they are sent or they can be received later if required.

Fast: There is no time spent waiting for a network connection. The network is always on.

Low interference (especially compared to spread spectrum radios): Users of these VHF or UHF bands benefit by not having interference from other radios.

City Owned Equipment: There is no dependency on outside service providers.

2.3.1.2 Disadvantages to Radio Telemetry

Set-up considerations: Deploying radio communications requires a certain amount of study and planning of your needs and limitations. This typically requires an engineering firm to do a propagation study to determine the configuration for the system and if additional repeater sites are required.

Testing: The system has to be installed and tested to ensure its efficiency.

Cost of licensing: There are additional costs for licensing in the VHF and UHF bands when used for environmental monitoring.

Capital expenditures: Antenna towers and repeater sites (if required) could significantly increase the overall cost of a radio telemetry system.

Line-of-sight considerations: Wireless communications have a limitation on the amount of miles that separate a transmitter from a receiver. This concept is called "Line-of-Sight", meaning one antenna must see the other antenna without obstruction. The distance between antennas can

be up to 30 miles line-of-sight, and this distance depends on the number of antennas (repeaters) used, the type of antenna, and the terrain.

2.3.2 CELLULAR TELEMETRY

2.3.2.1 Advantages to Cellular Telemetry

Low Capital Cost: There is no need for towers, line-of-site design studies, or base station software or hardware. Data can be sent from any location with cellular signal strength with a small antenna.

Dedicated Communication: There is no interference or cross band interruption. Connectivity is generally assured and trouble free.

Low Amount of Employee Training: With packaged internet hosting plans, there is no software or hardware needed on the receiving end. An internet connection gets all data and is available to multiple users. User training is quick and straightforward.

Time-Sensitive: Can be constantly connected and the messages can be reviewed right after they are sent or they can be received later if required.

Fast: There is no time spent waiting for a network connection. The network is always on.

2.3.2.2 Disadvantages to Cellular Telemetry

Monthly Usage Fee: Although dropping through competition and deregulation, there is still a monthly usage fee for cellular service. Longer term package plans and volume discounts have reduced this cost significantly.

Service Dead Spots: Some carriers have coverage dead spots. This is getting less common, and multiple carriers can overcome this.

Carrier Dependent: Reliant on uptime of carrier network.

2.3.3 SATELLITE TELEMETRY

2.3.3.1 Advantages to Satellite Telemetry

Extensive Coverage: Since line-of-site requirement is in the atmosphere, its considerations are negligible. Data can be sent from any virtually anywhere.

Selection of Service Providers: Additional service providers have entered the marketplace. This has increased options and created a more competitive marketplace.

2.3.3.2 Disadvantages to Satellite Telemetry

Monthly Usage Fee: Although dropping through competition and deregulation, monthly usage fee for satellite service is considerably higher than cellular costs. Minimizing data transmission can help but overhead costs are still considerable.

Data Connectivity Issues: Our experience with Satellite Telemetry has had limited success. Connectivity issues and dropped calls have been a problem regardless of geographic location. Storms, dense cloud cover and heavy snowfall events can all be problematic for connectivity.

Higher Capital Cost: Satellite modems and associated hardware are considerably more expensive than comparable cellular hardware.

Higher Power Demands: Satellite modems require more current than radio or cellular hardware. This places a higher demand on battery powered locations and results in increased costs for solar panels and / or batteries.

Carrier Dependent: Reliant on uptime of carrier network.

2.4 Communications Recommendation

Communications options were evaluated on a points system based on the project selection criteria from Section 1.1. Points were awarded on each category on a scale of 1 to 10, with 1 being the least favorable scoring. Results are presented in Table 3.

Table 3: Communication Options Evaluation Matrix

	Radio	BlueTree	Detectronic	Satellite
Reliable and Operational by City Staff	8	8	7	3
Cost effective capital and operational cost	2	6	10	3
Ease of collection and integration of data	8	8	7	6
Removable for winter if necessary	n/a	n/a	n/a	n/a
Aesthetic appeal	n/a	n/a	n/a	n/a
Relocate able	3	7	9	6
Vandalism Resistance	4	7	9	6
Total Score	**25**	**36**	**42**	**24**

Based on the analysis of all communication options in Section 2.3 and the costing matrix in Table 2, our recommendation is for the City of Winnipeg's Water and Waste Department to utilize the Detectronics prepaid cellular data package. The total capital cost of the Detectronics is the least expensive option and $1775 less than the second lowest cost of the BlueTree option.

The network costs and data delivery on the Detectronics communications is 60% lower in cost than the BlueTree option. Overall, the Detectronics system is the most cost effective and practical communication option for the City of Winnipeg.

The BlueTree cellular modem is a high quality product but must be paired with a compatible data logger and external power supply. This option would satisfy corporate MTS compliance but would result in higher monthly data costs.

Radio Telemetry is a viable option for communications but the high capital cost of installation, testing and commissioning is unavoidable. These systems are widely utilized in municipal infrastructure but are more suited to multiple inputs and where the need for supervisory control exists.

The satellite telemetry option is least favorable due to capital costs that are higher than cellular and network access, and data costs much higher than cellular and certainly higher than radio access charges. This option would be more applicable if stations were in areas of poor or nonexistent cellular coverage.

3.0 EQUIPMENT

Once a data logging and communication option has been selected, various configurations of power supplies, water level sensors and data loggers can be selected depending on site specific conditions. Generally, the components to consider are not necessarily dependent on each other and can be evaluated on a modular basis. Certain communication and logger combinations will require a specific power supply. These final equipment combinations will be evaluated in Section 4.0.

3.1 Power Supply

Each combination of logger, communications and level has a unique power requirement. Ultrasonic and radar level sensors typically require a higher voltage and current than submerged level sensors. The exception to this is the Detectronic integrated ultrasonic level unit which has power conservation measures engineered into the system. Typically, satellite modems require higher amperage draws than comparable cellular and radio telemetry units.

3.1.1 POWER SUPPLY OPTIONS

The following power supply options are applicable to certain combinations of hardware:

AC Power	Permanent 120 Volt AC Power
Solar Power	Portable 12 to 24 Volt DC Solar Power
Flash Power	Portable 12 Volt DC Battery Pack

3.1.1.1 AC Power

Whenever available 120 VAC power is the best choice as it is highly reliable with low maintenance and moderate operating costs once installed. Remote monitoring sites that are not in close proximity to facilities or other sources of power will have a prohibitive initial capital cost. This option is also not practical when sites need relocation.

AC power systems would be suitable for all equipment combinations. Transformers would be utilized to provide the 12 to 24 Volts required by these systems. AC power would not be practical for locations further than fifty meters from an existing power supply due to trenching and cabling costs of installation.

3.1.1.2 Solar Power

An excellent alternative to AC power, solar power is generally reliable. There are some operational cost considerations such as battery replacement, solar panel vandalism and subsequent cost of replacement. Consideration must also be given to the intrusive aesthetic nature of solar panels in residential areas.

Solar power systems would be suitable for all equipment combinations. Chargers and transformers are readily available to generate the sixteen volts for ultrasonic and radar sensors and a fifty Watt solar panel would generate sufficient current to sustain these systems in low light conditions and winter months.

3.1.1.3 "Flash Type" Disposable Power Packs

Flash power packs are relatively small, high capacity lithium-ion battery systems. The associated data logger wakes the sensor at predefined logging intervals to take level readings. The sensor is energized for a very short period of time and a reading taken. The current overhead on the battery pack is low enough that with thirty minute logging intervals and daily data calls, the life expectancy of these packs should be three years at a minimum.

Flash power packs would be applicable to any site utilizing a submerged level sensor. Flash power packs would not be practical for ultrasonic or radar level sites due to higher voltage demands and longer sensor stabilization times. For these sites solar power or access to AC power would be preferable. The exception to this would be the Detectronics integrate ultrasonic system which has power conservation measures built into the hardware.

3.1.2 POWER SUPPLY COSTS

Table 4: Power Supply Costs per Location (CDN $)

	120 VAC ($)	Solar ($)	Flash ($)
Capital Cost including installation	2,500[1]	2,100[2]	300[3]
Annual Operational Cost	150	250[4]	83[5]
Total Five Year Cost	**3,250**	**3,350**	**715**

Notes:

1. Cost includes permits, cabling, metering, trenching and labor for a typical installation.
2. Cost includes mast, solar panels, solar controllers, batteries and installation labor.
3. Replacement cost of pack. Initial pack included in logger purchase.
4. Includes periodic battery replacement and vandalism allowance.
5. Assumes a three year battery pack life and $250 replacement cost.

3.1.3 COMPARISON OF POWER SUPPLY OPTIONS

3.1.3.1 AC Power

3.1.3.1.1 Advantages to AC Power

Highly Reliable: Generally a reliable and clean power source.

Cost Effective: Low power draw of these devices results in low operational costs.

Flexible: Elimination of need for power conservation allows real time logging and broader choice of measurement devices.

3.1.3.1.2 Disadvantages to AC Power

High Capital Cost: If power is not available local installation costs can be prohibitive. In many pond side cases, running AC power would not be practical.

3.1.3.2 Solar Power

3.1.3.2.1 Advantages to Solar Power

Portable: Panels and enclosures can be placed virtually anywhere.

Highly Reliable: Generally low maintenance and failure free.

3.1.3.2.2 Disadvantages to Solar Power

Low Sunlight Hours: During winter months and heavy overcast periods available sunlight for charging may be limited.

Aesthetically Unappealing: Solar panels and associated enclosures are not appealing in residential areas.

Vandalism Potential: Exposed panels increase likelihood of vandalism on stations.

3.1.3.3 Flash Power

3.1.3.3.1 Advantages to Flash Power

Portable: Integrated power supply can be placed anywhere.

Highly Reliable: Generally maintenance and failure free.

Cost Effective: Annual costs of replacement power packs are relatively low.

Vandalism Resistant: No exposed hardware reduces likelihood of vandalism.

3.1.3.3.2 Disadvantages to Flash Power

Non Renewable Resource: Battery packs need to be replaced when power is expended but are recyclable.

Power Draw Must be Minimized: Since packs are drawn down, power consumption must be monitored and minimized. Some hardware choices, such as third party ultrasonic sensors and radar sensors, may be restricted due to higher power draw. The exception to this is the Detectronics integrated ultrasonic level system.

3.1.4 POWER SUPPLY RECOMMENDATIONS

Based upon the parameters evaluated regarding power supplies we have scored each option according to the criteria in the following Table 5. Although some stations may require a specific power scenario depending on hardware chosen most stations would function well with the recommendation following.

Table 5: Power Supply Evaluation Matrix

	120 VAC	Solar	Flash
Capital Cost	3	4	10
Annual Operational Cost	7	4	9
Portability	5	6	10
Vandalism Resistance	8	5	9
Total Score	**23**	**19**	**38**

Based upon the matrix scoring from Table 5, the flash power supply option should be considered the best alternative for reliable, cost effective operation. If necessary for higher amperage draw remote locations the solar power could be considered. AC power could be considered only if it was available locally already but this is not likely in this project.

3.2 Sensors

3.2.1 SENSOR OPTIONS

Various sensor types and brands can be utilized to gather level data. SFE Global has successfully utilized numerous manufacturers and technology to gather reliable level data. Typically, factors such as available power supply, surface foaming of liquid, extended measurement ranges and confined areas dictate technology selection. In the following sections we will describe the available technologies, their advantages and disadvantages and their applicability to the project at hand.

3.2.1.1 Submerged Level

Submerged level sensors are installed below the water surface and measure hydrostatic pressure on a ceramic or stainless steel diaphragm in the sensor. They are extremely popular in the water and remote monitoring industries. The reason for their popularity is their high level of accuracy and relatively low current draw. For remote monitoring they can be powered up to take readings with a short excitation period and then powered down between logging intervals. This allows for a low power consumption and associated long battery life.

One potential drawback for submerged level sensors is that they must reference atmospheric pressure to correct readings for liquid level. Since atmospheric pressure is exerted on surface water relative to local barometric pressure, water level readings would fluctuate with barometric pressure. Two ways to correct for barometric pressures are through using an atmospheric reference tube or through using absolute pressure sensors.

An integral atmospheric reference tube is built into the sensor and cabling. This tube runs from the sensor through the tube to a location where local atmospheric pressure is available. This is generally a junction box or often the equipment enclosure. The vent tube must be ventilated to the atmosphere through a desiccant canister to prevent moisture from migrating down the vent tube to the sensor. These desiccant packs must be serviced regularly. This service involves changing the pack to a fresh one and discarding or in some cases regenerating the moisture laden pack. Most submerged level sensor failures involve moisture migration down the venting tube.

Absolute pressure sensors measure both water and atmospheric pressure forces on the sensor. This data is sent in raw format to the host system. At the host system a barometric pressure station feeds local data to the host. The host then cross references the absolute and barometric pressures and comes up with a corrected water level based on a correction equation. This is a reliable method of measuring level if the appropriate barometric pressure and host system is

available. The major advantage to this method is the elimination of atmospheric reference tubes, desiccants and associated maintenance and failure.

There is not an appreciable error difference in either the relative or absolute pressure sensors. Normal error for an atmosheric reference pressure sensor with six meter span is ± 2.0 cm. Normal error for an absolute pressure sensor at the same span and with accurate barometric pressure data is ± 2.3 cm.

3.2.1.1.1 Submerged Level Manufacturers

There are many manufacturers of submerged pressure sensors on the market today. SFE has hands on experience with many of them and almost all are quality products. For the purpose of this study, Endress and Hauser, Druck and KPSI will be compared.

3.2.1.1.1.1 Endress and Hauser Waterpilot FMX Series Level Transducers

Use of the FMX series level transducer in the ongoing City of Winnipeg Water and Waste Department's CSO project has proven this unit to be reliable, robust and stable. Generally, the atmospheric referenced units have been utilized, however, the Phase III stations for CSO are using the absolute pressure version of this gauge which will eliminate the need for atmospheric reference tubes or desiccant maintenance concerns.

If this technology were utilized in the Pond Level Project, the submerged level sensors in this study would have reference to the barometric pressure readings obtained from the City's network of WeatherBug Hydrometric Monitoring Stations, via ClearSCADA.

3.2.1.1.1.2 Druck Pressure Sensors

The 1730/1740 series has been developed as a general purpose, hydrostatic liquid level sensor, designed to work in low powered, arduous applications, including surface water, ground water and tank level. It is the latest generation of submersible products manufactured over the past 30 years and features high performance, micro-machined silicon technology, packaged in a fully welded 316 stainless steel assembly.

Druck 1730/1740 series

Application specific features include a Kevlar strain relieved vented cable, internal condensation protection, and an IP68 injection molded cable assembly, which guarantee sensor operation over an extended lifetime.

3.2.1.1.1.3 KPSI Pressure Sensors

Description: KPSI 300DS 0.75" diameter submersible hydrostatic level transducer is specifically designed for small bore applications and to meet the rigorous environments encountered in deep water level measurements. These transmitters provide repeatable, precision depth measurements under most adverse conditions. All MEAS KPSI Transducers utilize a highly accurate pressure sensor assembly specifically designed for hostile fluids and gases. The assembly is integrated with supporting electronics in a durable waterproof housing constructed of 316 stainless steel or titanium. The attached electrical cable is custom manufactured and includes Kevlar® members to prevent errors due to cable elongation, and a unique water block feature that self-seals in the event of accidental cuts to the cable.

KPSI 300DS

3.2.1.2 Ultrasonic Level Sensors

Ultrasonic level sensors are used for non-contact level sensing of highly viscous liquids, as well as bulk solids. They are also widely used in water treatment applications for pump control and open channel flow measurement. The sensors emit high frequency (20 kHz to 200 kHz) acoustic waves that are reflected back to and detected by the emitting transducer.

Turbulence, foam, steam, chemical mists (vapors), and changes in the concentration of the process material affect the ultrasonic sensor's response. Turbulence and foam prevent the sound wave from being properly reflected to the sensor; steam and chemical mists and vapors distort or absorb the sound wave; and variations in concentration cause changes in the amount of energy in the sound wave that is reflected back to the sensor. Stilling wells and wave guides are used to prevent errors caused by these factors. Also, since sensors are temperature compensated, station design must eliminate sensor mounting in direct sunlight areas.

There are many manufacturers of reliable, cost effective ultrasonic level sensing devices. SFE has experience with many of these instruments and have had success with Siemens and E&H models, but this is not to say there are not other appropriate choices for this application. Radar level is an option but since there are no bridge decks or distances in excess of 10 meters in the assessed sites of this project, ultrasonic level will be adequate.

3.2.1.2.1 Ultrasonic Level Sensors Manufacturers

3.2.1.2.1.1 Siemens Sitrans Probe LU

The Sitrans Probe LU is a 4-20 ma loop powered non-contacting ultrasonic level sensor. It has proven reliable in many field applications in the water and wastewater industry. Care must be taken to ensure electrical connections are sealed to prevent water ingress into the electronics. Price is competitive and local service is excellent.

Siemans +Sitrans Probe LU

3.2.1.2.1.2 Endress and Hauser Prosonic FMU-30

The Endress and Hauser (E&H) Prosonic FMU-30 is a non-contacting ultrasonic sensor for measurement of liquids and solids. As with the Siemens probe, it is a 4-20 ma loop powered sensor. Temperature compensation is built into the sensor head. Price is also competitive and local service is excellent out of Ontario.

Endress and Hauser Prosonic FMU-30

3.2.1.2.1.3 Detectronic MSFM Lite

The Detectronic MSFM Lite is an integrated data logger, battery, modem and ultrasonic level sensor. Beam angle is fifteen degrees, which is greater than the previous units, and sensor resolution is 0.5 cm, which is not as fine as the stand alone Siemens or E&H units. However, resolution and beam angle are sufficient for this project where highly accurate level data is not imperative and there is little interference on the water surface for a slightly larger ultrasonic beam spot diameter.

Detectronic MSFM Lite

3.2.2 SENSOR COSTS

The following Table 6 provides a capital cost comparison between the three submerged and ultrasonic level sensors evaluated. Performance and life cycle of all of these sensors is very comparable. Based upon past experience with all of these sensors, it is anticipated that they will provide good long term life cycle in this application. For this reason, life cycle costs have not been included.

Table 6: Sensor Costs (CDN $)

Sensor Type and Manufacturer	Cost per Sensor ($)
Submerged Sensors	
E&H FMX Absolute Pressure	1,950
Druck	1,575
KPSI	1,750
Ultrasonic Sensors	
Sitrans Probe LU	1,250
E&H Prosonic FMU-30	1,650
Detectronic MSFM Lite	1,750

As stated previously, costs of all of these sensors are relatively equal. Although the FMX Absolute Pressure sensor is slightly more expensive than the Atmospheric Reference Druck and KPSI, this cost would be easily offset with reduced maintenance, consumables and potential failures associated with atmospheric reference tubes and desiccant systems.

The Detectronic MSFM Lite sensor is a component of the integrated system. Cost has been estimated with removal of the cellular modem, power supply and data logger from the total system cost. (See Section 1.2)

3.2.3 COMPARISON OF SENSOR OPTIONS

The following section provides a comparison of advantages and disadvantages of the two primary level sensing options relevant to this project.

3.2.3.1 SUBMERGED SENSORS

3.2.3.1.1 Advantages to Submerged Sensors

Accurate: Highly accurate when configured and maintained properly.

Reliable: Reliable with proper maintenance on desiccant in atmospheric reference models. Highly reliable when absolute pressure models chosen.

Vandalism Resistant: Resistant to vandalism due to sensor being submerged under water surface.

Aesthetically Appealing: Negligible visual impact due to sensor being submerged under water surface.

3.2.3.1.2 Disadvantages to Submerged Sensors

Potential for Drifting: Some sensors have been prone to drifting due to atmospheric reference issues. This can be reduced or eliminated with absolute pressure reference models.

Freezing Damage: Can be damaged by freezing if not removed for winter months or placed below winter ice level.

3.2.3.2 Ultrasonic Sensors

The following section details advantages and disadvantages of ultrasonic level sensing technology. In certain applications, submerged level sensors are not practical and ultrasonic non-contacting sensors provide a viable alternative.

3.2.3.2.1 Advantages to Ultrasonic Sensors

Accurate: Accuracy and level stability are excellent with virtually no drift.

Highly Reliable: Generally maintenance and failure free.

Cost Effective: Multiple manufacturers have created a competitive market.

3.2.3.2.2 Disadvantages to Ultrasonic Sensors

Restricted Applications: Due to the need to have a clear space and smooth water surface, some applications such as chambers may not be possible.

Not Aesthetically Appealing: Since ultrasonic sensors require mounting above the water, stilling wells would have to be installed in ponds. Similarly, bridge sites would require external mounting hardware.

High Power Consumption: All assessed ultrasonic sensors require a minimum of 16 VDC. This would increase costs of solar panels and charging systems. The exception is the Detectronic integrated ultrasonic level system, which operates on a 12V replaceable battery pack.

Vandalism Potential: Sensor stilling wells, externally mounted sensors, and associated solar panels would increase likelihood of vandalism on stations.

3.2.4 SENSOR RECOMMENDATIONS

Based on SFE's meeting with the City on June 21st, 2012, and as discussed in Section 1, the City has decided to use submerged pressure sensors for its storm water pond locations and ultrasonic level sensors as its drainage channel locations. The following provides a recommendation of the specific type of sensor to use for each of these applications.

3.2.4.1 Submerged Sensor Recommendation

Any of the evaluated submerged level sensors would function in this application. Since the E&H FMX Absolute Pressure Sensor is available without atmospheric referencing, and the City has project experience with this brand and model, we would recommend it for this project. This feature is particularly desirable in this application to eliminate sensor desiccant maintenance and associated drift and potential failure.

3.2.4.2 Ultrasonic Sensor Recommendation

All evaluated ultrasonic sensors would also be applicable to this project. For fully Solar or AC Powered sites, we would recommend the Sitrans Probe LU for its attractive cost, reliability and excellent local support.

Since relatively accessible solar panels would be subject to vandalism and increased operating and maintenance costs for the City, we would recommend the Detectronic MSFM Lite integrated system for all under bridge applications. The integrated power supply and cellular communications would allow under bridge mounting in a small easily concealed and secured package that would be weather resistant, vandalism resistant, and low maintenance.

3.3 Data Loggers

Regardless of level sensor choice, communications choice, and power option choice, the measured level must be logged on site and transmitted to the host system. There are many options with regard to data loggers or remote terminal units (RTUs). Each has benefits and limitations such as number and type of input, power consumption, and available output and telemetry compatibility.

Through consultation with City Staff, a minimum specification has been outlined. Preliminary requirements are assumed to be, at a minimum:

- Single analog input for loop powered level sensing devices
- Additional analog inputs (2) for possible future expansion
- Power management capabilities if battery powered
- Ability to interface with an acceptable telemetry platform

Assessment of these devices has taken the criteria listed above into account. Detailed assessment has also considered additional features available by each manufacturer. These details will be specified in the following Section 3.3.1 - Data Logger Options.

3.3.1 DATA LOGGER OPTIONS

As with sensors there are many quality data loggers and RTU's available in the marketplace. We have selected three logger types for analysis. Each logger would be capable of functioning in this application but when packaged with the necessary communication, power supply and sensor peripherals there are systems that become more desirable.

The three manufactures and models of data loggers that have been compared are:

3.3.1.1 Telog Instruments R-3307

Features of the Telog R-3307 logger include:

- Capability to interface with the BlueTree Cellular modem
- Four analog and three digital channel inputs
- Low power consumption and power saving mode
- Ability to send instant alarm conditions

3.3.1.2 SCADAPack RTU

The SCADAPack100 Smart RTU is the most compact model in their product line. The SCADAPack100 offers high performance with both analog inputs and digital I/O. The product offers Modbus RTU, Modbus ASCII and DNP3 as native protocols and is remotely programmable, as a master or slave, through a choice of flexible programming languages.

SCADAPack100 Smart RTU

Features include:

- 4 analog inputs and 6 digital I/O
- One RS-232 and one configurable RS-232/485
- Optional integrated spread spectrum radio

3.3.1.3 Detectronics MSFM Multi Channel Data Logger

The Detectronics multi-channel data logger has a flash power supply and cellular modem communications integrated system. Features include:

- Two analog inputs and two digital inputs
- Integrated three year flash power supply
- Logger power saving capabilities
- Included five year cellular plan and website data access (www.detecdata.com)
- Ability to send instant alarms
- Variable data transmission capability

3.3.2 DATA LOGGER COSTS

The data loggers described in the previous section have been evaluated based upon capital cost in the following Table 7. Due to long service live expected with all of these, hardware life cycle cost has not been included in the cost comparison.

Table 7: Data Logger Costs (CDN $)

Data Logger Type	Cost per Data Logger
Telog R-3307 Multi Channel	1,500
SCADAPAK RTU	875
Detectronics MSFM Multi Channel	1,550

Notes:

- Telog 3307 price does not include modem or power supply
- SCADAPAK RTU price does not include modem or power supply
- Detectronics Multi Channel price does not include modem and flash power supply (see Section 1.2)
- Annual communication costs included in the purchase of the Detectronic unit for the first 5 years.
- Prices presented are from quotations from Canadian suppliers for a typical system
- Prices are current to December 31, 2012.

3.3.3 COMPARISON OF DATA LOGGER OPTIONS

As stated, all of the evaluated data loggers are quite capable of performing the functions necessary for this project. Some of the data loggers have attractive features when bundled with the communication and power supply options available for or integrated into these units. The three data loggers have been evaluated based upon the following relevant features in Table 8.

Familiarity by City Personnel

This criteria was evaluated because City Staff will be required to use the equipment chosen at some point. The City utilizes SCADAPack equipment so the familiarity with this equipment is high. The familiarity with the Telog or Detectronic data loggers would not be as prevalent in the City, although the drainage department does have some Detectronic equipment.

Capital Cost

Capital cost of equipment was evaluated based on the purchase of the logger only. Although all loggers have similar capital costs, they each require additional infrastructure when bundled into a system. This cost has been evaluated separately in Required Infrastructure.

Ease of Collection and Integration of Data

Integration of collected data will be required to populate the City's ClearSCADA system. This system is already in place for the SCADAPack loggers but would require development for the Detectronic and Telog loggers. Additionally the Telog system would require hosting software and hardware to relay data.

Required Infrastructure

SCADAPack loggers would require radio communication, or BlueTree cellular, and an external power source as would the Telog units. Costs of additional infrastructure required to facilitate the chosen logger have been evaluated in this section.

Table 8: Data Logger Evaluation Matrix

	Telog	SCADAPack	Detectronic
Familiarity by City Personnel	2	9	7
Capital cost	6	9	10
Ease of collection and integration of data	3	8	10
Required Infrastructure	6	4	9
Total Score	**17**	**30**	**36**

3.3.4 DATA LOGGER RECOMMENDATIONS

Based upon the scoring matrix in Table 8 we have evaluated the Detectronic Multi Channel logger highest due to the ability to integrate this unit with prepaid cellular communications and flash power. The SCADAPack logger is a good choice but must be paired with higher cost and power drawing components to fully function. The Telog data logger is an excellent product but does not have the communication and integration capabilities of the Detectronic unit.

4.0 EQUIPMENT CONFIGURATIONS

Throughout the assessment process detailed above, SFE Field Technicians and Management have:

- Performed detailed assessments of each location
- Researched various hardware vendor options
- Interviewed City engineering and instrumentation personnel
- Participated in brainstorming sessions with the above personnel
- Gathered past experience and expertise from within SFE
- Analyzed past monitoring results on City owned drainage assets

The activities above have all been taken into account to produce recommendations for the most cost effective and practical solution for the City, in our opinion. As previously stated, the criteria used to evaluate the options were:

- Reliable and Operational by City Staff
- Cost Effective Capital and Operational Costs
- Ease of Collection and Assimilation of Data
- Ability to withstand seasonal change or be easily removed for winter
- Aesthetically pleasing when placed in residential areas
- Ability for temporary systems to be easily relocated
- Vandalism resistant hardware

Assessments of communications, power, logger, and sensor options include the following components or complete systems:

4.1 Equipment Installation Types

4.1.1 INTEGRATED SYSTEMS

Depending on the data protocol required, integrated ultrasonic level, data logger and GSM (Global System for Mobile Communications) cellular communication units may be an effective option. The Detectronics MSFM-Lite unit has a five year battery life, data logger and a low cost five year data plan for communication (see Table 2). Data can be collected from the manufacturer's website at the user's convenience, from the SFE GoData site (GoData.com), or via an automated FTP transfer to the City's

Detectronic MSFM-Lite

ClearSCADA system, where it can be integrated with other City data such as CSO stations, Rainfall and River Levels.

4.1.2 IN CHAMBER OR MANHOLE LEVEL MONITORS

Depending on the logging and level monitoring equipment selected, in-chamber systems could be as simple as chamber wall mounting for all battery powered systems in IP68 rated enclosures. Integrated units would be battery powered and self contained so any further power requirements are eliminated. Enclosure units would have solar power units on masts affixed to the chamber, or AC power connected to existing station power. In any case of in-chamber mounting, all devices would have to be mounted above any anticipated high water levels.

Typical City of Winnipeg chamber

4.1.3 ABOVE GROUND PERMANENT AND TEMPORARY KIOSK ENCLOSURES

For above ground pond side, or chamber systems, a poured or pre-cast concrete pad or slab would be placed, and a water tight, secure enclosure placed to house all equipment. Submerged or ultrasonic level, power, and any communication equipment would be brought by buried conduit into these enclosures. Although not a requirement of this project, enclosures could also be constructed to enclose water quality sampling equipment.

Secure enclosure housing equipment at pond site

4.1.4 POLE MOUNTED EQUIPMENT AND SOLAR POWER SYSTEMS

In areas where solar power must be considered, a pole, enclosure and solar power panel can be utilized. Equipment enclosure and batteries, solar power and any telemetry requirements can all be incorporated into this pole. SFE has a pole design with a ground level flange system, which can be removed for decommissioning during winter months, leaving the ground section intact.

Pole mounted solar power system.

4.1.5 POND SIDE TEMPORARY OR PERMANENT INSTALLATIONS

For pond side level monitoring installation crews would trench or directional drill conduit from the equipment kiosk or pole mount, into the pond to measure the pond level with a submerged hydrostatic level transducer. This installation would be permanent and protect submerged sensors from freezing damage by installing them at 1.5 meters below normal water level and anticipated maximum ice depth.

Typical trenching seen with permanent installation.

4.2 Preliminary Equipment Configurations

From the components outlined on the previous page, various preliminary configurations and systems were evaluated. Combinations of technology were also evaluated for various applications within the study.

For all pond side applications the transducer would be mounted in a submerged weighted protective enclosure installed 1.5 meters below water surface to prevent freezing. This enclosure would be constructed of marine grade aluminum with a concrete ballast to keep the enclosure submerged and prevent movement. Cabling from the enclosure to the underwater sensor would be run in a weather tight PVC conduit to the edge of the water. Please see Figure 2 on Page 43 for a detail drawing of the sensor enclosure arrangement.

Anticipated submerged level sensor for all pond side applications would be the E&H FMX series of absolute pressure sensor. This sensor eliminates the need for desiccant and associated maintenance concerns. Absolute level would be compensated for atmospheric pressure in the City ClearSCADA system from the City's weather stations that can measure barometric pressure. The preliminary configurations that were evaluated as most favorable from this analysis included:

4.2.1 INTEGRATED ULTRASONIC LEVEL SYSTEM WITH ENCLOSURE

Although all data loggers will accept a 4-20 ma loop powered ultrasonic level transmitter, these systems would then require solar power panels that would introduce more vandalism exposure. For this reason the Detectronic MSFM-Lite integrated Ultrasonic level system referenced in Section 4.1.1 would allow flash battery powered three year operation in a vandalism resistant configuration. Since beam angle may produce a reading spot diameter at the water surface of up

Detectronic MSFM -Lite

to one meter, this technology should be limited to under bridge deck applications and not in control chambers or areas of limited space.

4.2.2 DETECTRONIC MULTI CHANNEL LOGGER WITH SUBMERGED LEVEL AND ENCLOSURE

The Detectronics Multi-Channel Logger system is a data logger, cellular unit, submerged level sensor and "flash power" supply unit. All above devices would be housed in a lockable composite enclosure to ensure weatherproof protection and vandalism prevention. The flash power option is a self-contained, disposable battery pack with an estimated three year life cycle. Battery capacity is maintained by powering up the unit for one or two seconds every fifteen minutes to take a reading. If levels are changing at a pre-determined threshold level, cellular communication intervals can be increased temporarily with alarm thresholds programmed into the logger to accommodate more readings during rainfall or flood events. After the event ceases, readings return to normal intervals to conserve battery life.

Detectronic Multi-channel Logger system

4.2.3 BLUETREE CELLULAR TELEMETRY WITH SUBMERGED LEVEL AND ENCLOSURE

The BlueTree Cellular system consists of a cellular modem, remote terminal unit, solar power panel, battery, and charging system. All above devices would be housed in a lockable composite enclosure to ensure weatherproof protection and vandalism prevention.

BlueTree Cellular system

4.2.4 RADIO TELEMETRY WITH SUBMERGED LEVEL AND ENCLOSURE

The Spread Spectrum Radio system consists of a spread spectrum radio, remote terminal unit, sufficient mast and antenna to provide line-of-sight communications, solar power panel, battery, and charging system. All above devices would be housed in a lockable composite enclosure to ensure protection from the elements and vandalism.

SCADAPack 100 Smart RTU

4.2.5 SATELLITE TELEMETRY WITH SUBMERGED LEVEL AND ENCLOSURE

The Iridium Satellite system consists of an Iridium Satellite Modem, data logger, sufficient mast and antenna to provide line-of-sight to satellites, solar power panel, battery, and charging system. All above devices would be housed in a lockable composite enclosure to ensure weatherproof protection and vandalism prevention.

Iridium Satellite modem

4.3 Preliminary Configuration Costing

Prior to defining final configurations and estimating capital and operational costs, a preliminary set of integrated systems were evaluated with regards to capital and operational costs. Defining a baseline cost for various systems would allow elimination of variables between systems. This would establish the final short list of viable technology, associated configurations and costs.

The costing comparison of all options is shown in Table 9. To make the comparison more meaningful, each configuration has been paired with the most logical choice of data logger, telemetry, level sensing, and power supply integration. The configurations and a brief description of the rationale behind the choices are:

Detectronic Integrated Data Logger and Cellular Communication

The Detectronic logger was used for the Detectronic system since its data logging, communication, and power supply are integrated. Components are enclosed in a common enclosure and pre-tested so there is no communication configuration or integration necessary.

BlueTree Cellular and SCADAPack Logger

This configuration was chosen as the City already utilizes this system, so very little data management or integration would have to be performed. No outside data transfer or hosting costs would be required.

Radio Telemetry and SCADAPack Logger

Similar to the BlueTree option above, Radio Telemetry with the SCADAPack logger would not require data hosting or intensive integration tasks from the City as this configuration is already being utilized in the City.

Satellite Telemetry and Telog R3307 Logger

A satellite modem would be integrated with the Telog data logger for communications and data logging. This system would require either offsite hosting or purchase of Teloggers listening software by the City.

Level Sensor

The level sensor chosen for all systems was the E&H Waterpilot FMX Absolute Pressure submerged level sensor. An ultrasonic sensor could also be utilized for comparison purposes, as purchase cost and basic functionality are very similar to the submerged sensor.

Power Supply

For all systems other than the Detectronic unit, a solar power panel, batteries, and charging system were included. Since the Detectronic System has an integrated flash battery, no solar power panels or associated batteries were required or priced. For all systems, a lockable weather tight steel enclosure and associated mounting mast has been included.

Operation and Maintenance

All systems have the same basic maintenance and operational overhead. There should be very little maintenance on these sites after initial setup and calibration. A day of maintenance per site annually (split into one half day - two times per year) has been included for troubleshooting or vandalism repairs.

Table 9: Total Cost Per Site of all Options (CDN $)

	Detectronic ($)	BlueTree ($)	Radio ($)	Satellite ($)
Modem	Included	775	500	2,250
Data Logger[1]	2,800	1,150	2,650	2,000
Power Supply	Included[3]	2,250	2,250	2,250
Level Sensor	1,950	1,950	1,950	1,950
Enclosure	1,750	1,750	1,750	1,750
Installation [2]	4,500	5,500[4]	7,500[4]	5,500[4]
Total Capital Cost	**11,000**	**13,375**	**16,600**	**15,700**
Annual Five Year Amortized Capital Cost	**2,200**	**2,675**	**3,320**	**3,140**
Annual Telemetry Cost	Included[5]	600	150	900
Annual Hosting Cost	Included[5]	n/a	n/a	240
Annual Maintenance Cost	1,600	1,600	1,600	1,600
Annual Vandalism Allowance	200	250	300	300
Total Annual Cost	**4,000**	**5,125**	**5,370**	**6,180**
TOTAL FIVE YEAR COST	**20,000**	**25,625**	**26,850**	**30,900**

Notes:

1. Data logger cost includes site setup and commissioning tasks.
2. Installation includes trenching, coring and any additional infrastructure including radio or satellite masts and structures.
3. Detectronic units contain "flash power" supplies that provide system and sensor power for an estimated three year life. Replacement battery cost is $250 CDN.
4. BlueTree, Radio and Satellite installation includes increased cost for solar panel installation.
5. Annual telemetry and hosting costs included in the purchase of Detectronic hardware for the first five years, then subsequently renewed at $200 CDN and 80$ CDN respectively.

4.4 Preliminary Data Management Considerations

Each system evaluated in Table 9 would have a specific data management scheme associated with it. The end goal in all configurations is integration with the City ClearSCADA system. Some configurations utilizing the SCADAPack loggers would be relatively seamless in their integration. Other options would require automated FTP file transfers or offsite hosting. Each of these configurations is detailed in the following section.

4.4.1 DETECTRONIC INTEGRATED SYSTEMS

The Detectronic system comes with a five year prepaid cellular data plan and data hosting on the Detectronic web server at www.detecdata.com. The company website is www.detectronic.org. There is also an option to host data on an FTP server for remote and automated access.

One method of data retrieval that has been successfully implemented involves automatically logging into the web server and fetching the data at predetermined intervals. This action can be performed at any time interval, as there is no additional overhead cost for higher frequency downloads. This data can then be used to populate the City's ClearSCADA data management system. There would be a minimal one time programming and development cost for setup and configuration of the fetching routine used to pass data to the City ClearSCADA system. Estimated cost would be between two and three thousand dollars. The City would be responsible for configuring data placement and configuration within their system for each individual site. This cost is not included in the estimate above.

4.4.2 BLUETREE CELLULAR AND SCADAPACK SYSTEM

The use of the BlueTree cellular system has the advantage of conforming to the City of Winnipeg's MTS carrier requirement. This advantage is offset by the additional cost of data

service through the MTS network. Approximate cost of cellular data coverage for the MTS network is $480 per year.

The data logging choice for the BlueTree modem would be the SCADAPack logger. The City has existing protocol to handle this data and integrate into ClearSCADA. Some programming and setup time would be required on the City end, with a cost of approximately $2500.

4.4.3 RADIO TELEMETRY AND SCADAPACK SYSTEM

Radio telemetry costs are generally low, depending on the frequency chosen. Some frequencies are free of FCC charges, while others carry an overhead burden. In addition to low overhead costs, a SCADAPack logger with integrated radio communication could interface directly with the City ClearSCADA.

Offsetting the lower overhead costs are the increased cost of radio infrastructure for each location. Depending on existing infrastructure near each location to repeat signals, costs to erect radio masts could be substantial.

4.4.4 SATELLITE TELEMETRY AND TELOG SYSTEM

Satellite stations would require programming to integrate with ClearSCADA depending on the data logger chosen. If utilized with the SCADAPack logger, the data stream could be easily integrated but programming and compatibility issues may be encountered in communicating the Satellite modem and SCADAPack logger.

Use of satellite technology is generally reserved for remote locations, where cellular or radio signals are limited, due to the high cost of data transmission. In general, it is not considered viable for this application.

4.5 Summary of Site Location and Type

Each site in the project was visited and assessed as to type and location. City personnel were consulted regarding this application, as some sites can be classified in multiple categories. Some drain channels have bridges and some do not. Conversely some SRBs (Storm Retention Basins) can have chambers and some do not.

The following Table 10 summarizes each location and they site type as assessed. These site types will be utilized to place recommended technology with each site as preliminary and final technology recommendations are made.

Table 10: Summary of Site Location and Type

Site Name	Common Name / Location	SRB	SRB w/Chamber	Drain	Drain with Bridge
SRB 4-5	Lakeside Meadows	✓			
SRB 4-6	Kildonan Meadows	✓			
SRB 4-7	Transcona Deep Pond	✓			
SRB 5-1	St. Boniface Industrial Park	✓			
SRB 5-21	East Mint Place	✓			
Lot 16 Drain	Brady Road Bridge			✓	✓
Lot 16 Drain	Upstream and Downstream of SRB 6-14 - Technical School	✓	✓	✓	
Lot 16 Drain	At SRB 6-36 Outlet - Automall		✓	✓	✓
Lot 16 Drain	Inlet Structure to 96" Pipe			✓	
SRB 6-6	Waverly Heights	✓			
Dugald Drain	Downstream of SRB 5-1			✓	
SRB 6-23	Inland Cement	✓			
SRB 6-29	Lee Blvd.	✓			
SRB 6-36	Waverly West	✓			

Note:

- Lot 16 Drain U/S and D/S at Technical School serviced by one station located at chamber.

4.6 Overview of General Site Locations

Two maps identified as Figure 4 and Figure 5 are located in Appendix 1 - Site Maps, Assessments and Photos. These maps outline the general locations of the specific sites chosen for this study. Sites are varied in location from industrial, commercial and residential areas. Some sites are in relatively remote areas, with fencing and secure compounds, and some are located within residential areas with ponds servicing recreational needs.

4.7 Site Configuration Drawings

Based on the assessments and evaluations performed during the study, two standard configurations have been developed. For pond sites the best equipment option would be the submerged level sensor system. The preferred system for drainage channels with bridges would be the non-contacting ultrasonic sensor system. The hardware for this option may be completely hidden below the bridge deck between girders to reduce the potential for vandalism damage.

It should be noted that regardless of the sensor chosen, the equipment can be housed in a pole mounted enclosure as per the pond side drawing. Alternatively, the equipment enclosure can be directly mounted to a bridge abutment, or other concrete structure on site. Pond side equipment could be mounted in small underground equipment enclosures, but cellular signal strength may be negatively impacted. Possible ingress of surface water, and damage to electronics, would be another potential drawback to this method.

Figure 2 outlines the general arrangement of a typical pond side installation. Equipment mast and enclosure should be located just beyond surface high water level. In this configuration the equipment enclosure is 0.6 meters above ground level so some surface water to the enclosure location would not be damaging to the equipment or installation.

Sensor cable would be run within a one inch PVC conduit to just below low water level on the pond side. From this underwater location bare sensor cable could be run to the sensor location. The sensor and underwater enclosure would be located below the water freezing level to prevent damage to the submerged level sensor. The perforated aluminum enclosure would allow water ingress and protect the sensor. Concrete ballast in the bottom of the enclosure would keep it anchored to the bottom of the pond. A lifting ring on the top of the sensor enclosure would allow technicians to trace the sensor cable from the equipment kiosk to the sensor location, and bring it to surface if service should be required.

Figure 3 details the general arrangement for under bridge applications, utilizing an integrated ultrasonic sensor unit and flash power supply. Data logger and communications equipment could be housed in an FRP (fiberglass reinforced plastic) enclosure either on the bridge girders, abutments, or, ideally, hidden

under the bridge deck. It should be noted that if integrated cellular or cellular units with integrated antennas are chosen, enclosures must be FRP and not steel to allow cellular or radio signals to pass through. Otherwise, external antennas must be utilized and thus increasing the exposure for vandalism.

The ultrasonic sensor for under bridge applications would have a 1:15 height to spot diameter ratio so a five meter height would have a 0.33 meter spot diameter on the water surface. This should not be an issue with the channels evaluated. Sensor mounting would be via an aluminum or stainless steel mounting bracket. Sensor cable runs from FRP enclosure to ultrasonic sensor would be housed within rigid conduit to reduce exposure to vandalism.

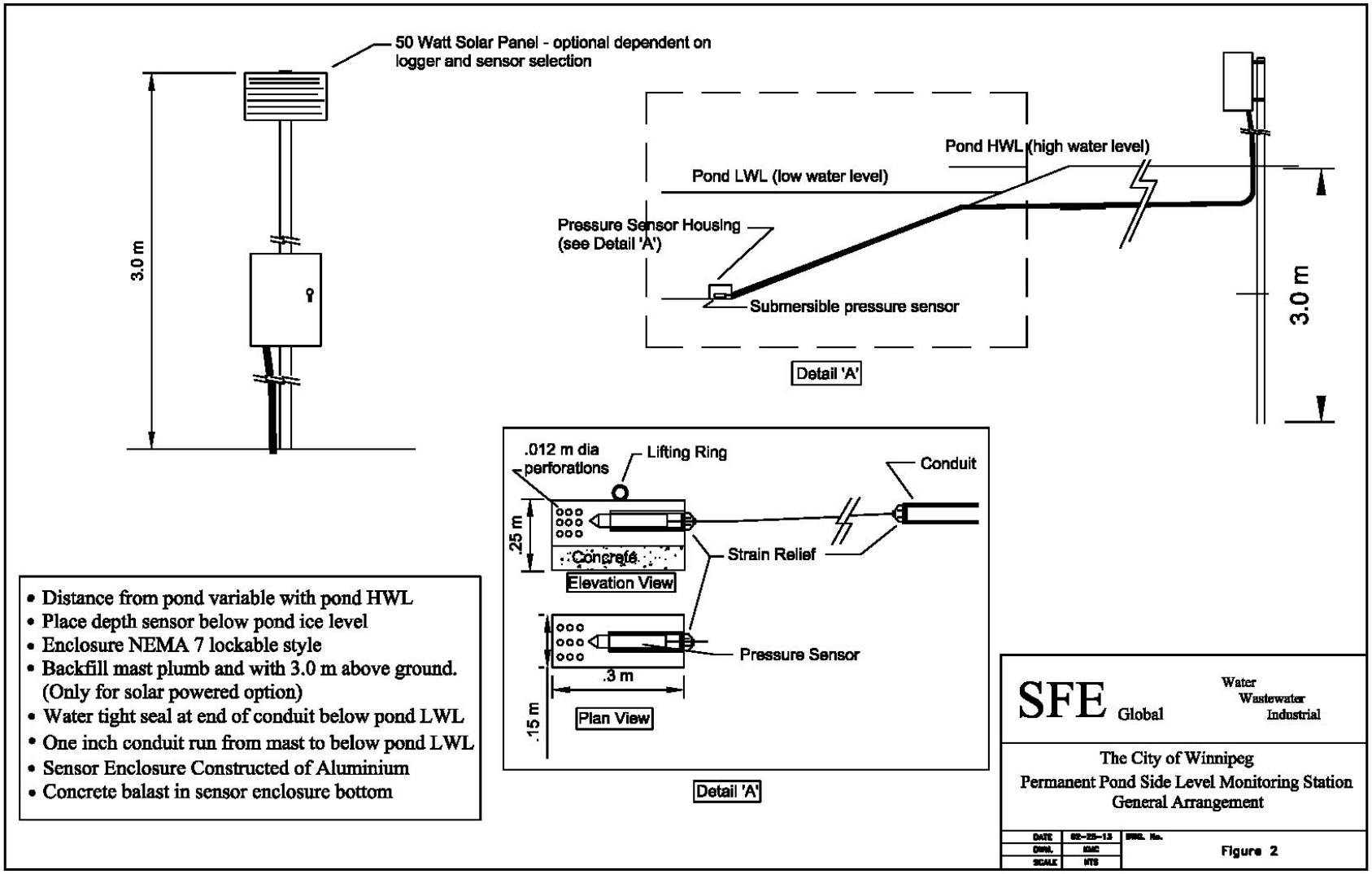
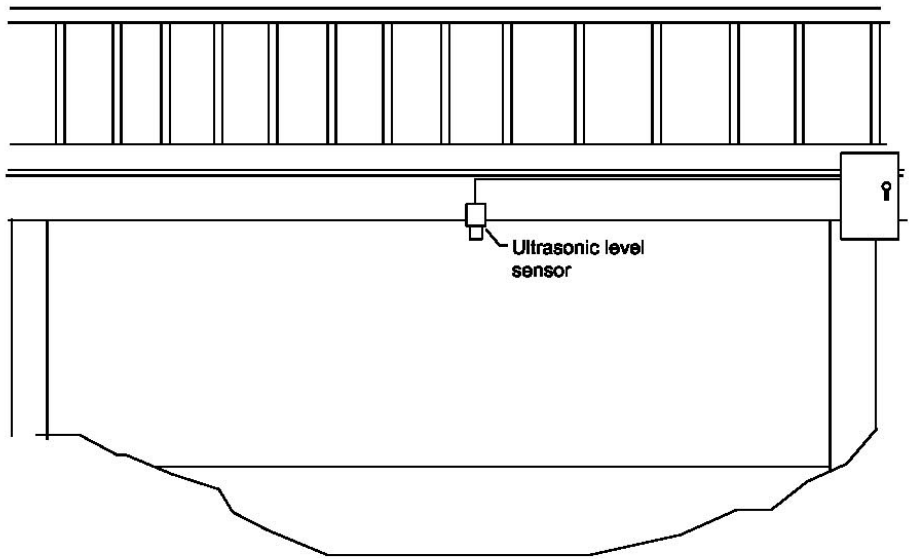

50 Watt Solar Panel - optional dependent on logger and sensor selection
3.0 m
Pond HWL (high water level)
Pond LWL (low water level)
Pressure Sensor Housing (see Detail 'A')
Submersible pressure sensor
3.0 m
Detail 'A'
.012 m dia perforations
Lifting Ring
Conduit
.25 m
Concrete
Strain Relief
Elevation View
Pressure Sensor
.3 m
.15 m
Plan View
Detail 'A'
• Distance from pond variable with pond HWL
• Place depth sensor below pond ice level
• Enclosure NEMA 7 lockable style
• Backfill mast plumb and with 3.0 m above ground. (Only for solar powered option)
• Water tight seal at end of conduit below pond LWL
• One inch conduit run from mast to below pond LWL
• Sensor Enclosure Constructed of Aluminium
• Concrete balast in sensor enclosure bottom
SFE Global
Water
Wastewater
Industrial
The City of Winnipeg
Permanent Pond Side Level Monitoring Station
General Arrangement
DATE
02-25-13
DWG. No.
DWN.
KMC
SCALE
NTS
Figure 2

Figure 2



Bridge Deck Elevation View

- Solar panel not required with flash power option
- Enclosure mount under bridge deck or on pole mount
- Enclosure NEMA 7 fiberglass lockable style
- Sonic and Enclosure may be hidden under bridge deck
- Ultrasonic level sensor maximum range 15 meters

SFE Global

Water
Wastewater
Industrial

The City of Winnipeg
Permanent Chamber or Bridge
Water Level Monitoring Station

DATE	03-25-13	DWG. No.
DWN.	RMS	Figure 3
SCALE	NTS	

Figure 3

5.0 SUMMARY / CONCLUSIONS / RECOMMENDATIONS

5.1 Summary

During the course of this study, all aspects of each type of technology were considered in detail. A study with varied site locations, communication options, and objectives has many potential configuration choices. Most technology available today is reliable, cost effective, and has applicability on each of these locations. By applying each component, then each system configuration, and finally capital and operating costs to individual scoring matrix tables, best fit systems could be determined for each specific class of sites.

During discussions with project stake holders, it was determined that installation of equipment in control chambers could create interference with City Operations activities. It was decided that it would be prudent to keep stations away from control chambers whenever possible. The City preferred that all overland ponds and ditches that could have pond side stations with submerged level transmitters be configured this way. On drainage ditch sites with bridges, it was decided that an ultrasonic system mounted under the bridge deck between girders would be the best configuration.

The final technology recommendations and cost analysis below takes into account all variables. During the construction phase, a final site assessment prior to installation would determine the exact site requirements, with regards to conduit and kiosk placement, to prevent high water level damage. Sensor mounting depth would also be determined at this time to protect against freezing. The City would then provide approval of the final station location.

5.2 Configuration Recommendations

5.2.1 RECOMMENDED SRB AND DRAIN INSTALLATION

We are recommending the use of a Detectronics multi channel data logger, integrated cellular, flash power supply and FMX Absolute Pressure submerged sensor configuration for all SRB and Drain sites. The combination of low capital cost, low operational cost, and a high level of vandalism resistance make this the most practical choice for these applications. As a pond or drain side application, there is virtually no difference between ponds and drains from a hardware perspective.

Typical City of Winnipeg retention pond

5.2.2 RECOMMENDED DRAINS WITH BRIDGES INSTALLATION

We are recommending the use of a Detectronics MSFM-Lite integrated ultrasonic level sensor configuration for all Drain with Bridge sites that cannot otherwise accommodate a submerged sensor.
The combination of low capital cost, low operational cost, and a high level of vandalism resistance make this the most practical choice for these applications.

Drain site with bridge.

5.3 Recommended Configuration Budgetary Costs

Each recommended configuration above has had capital and operational costs input into costing matrix tables to determine a total five year cost. Since some options have higher capital costs blended with lower operational costs, capital costs have been amortized over a five year period. This allows the generation of a five year total cost of supply, installation and operation.

The final selections of hardware application chosen for five year costing per site type are:

Pond Side SRB's:	Detectronic Flash Powered Integrated logger with FMX Absolute Pressure Sensor Level.
Under Bridge Drains:	Detectronic MSFM Lite Integrated logger with Flash Power and Ultrasonic Level.

Costs for maintenance have assumed one half day per site in spring and one half day per site in fall for level verification and preventative maintenance. Some locations may take more time commitment and some less, but total time commitment should average out at these levels. Vandalism repairs have not been included, but should be minimal if low impact designs are incorporated.

Finally annual Telemetry and Hosting costs have assumed the use of Detectronic's prepaid cellular program and access to automated FTP file transfers to update the City ClearSCADA system.

Table 11: Total Five Year Cost Per Type of Site (CDN $)

	Pond Side ($)	Under Bridge ($)
Modem	Included	Included
Data Logger	2,800	3,900
Power Supply[1]	Included	Included
Level Sensor[2]	1,950	Included
Enclosure	1,750	1,750
Installation[3]	4,500	4,500
Total Capital Cost	**11,000**	**10,150**
Annual Five Year Amortized Capital Cost	**2,200**	**2,030**
Annual Telemetry Cost	Included[5]	Included[5]
Annual Hosting Cost	Included[5]	Included[5]
Annual Maintenance Cost	1,600	1,600
Annual Vandalism Allowance	200	200
Total Annual Cost	**4,000**	**3,830**
TOTAL FIVE YEAR COST	**20,000**	**19,150**

Notes:

1. Detectronic units contain "flash power" supplies that provide system and sensor power for an estimated three year life. Replacement battery cost is $250 CDN.
2. Cost based on E&H FMX Absolute Pressure Unit.
3. Costs include all site preparation, installation, configuration and startup troubleshooting.
4. Annual telemetry and hosting costs included in the purchase of Detectronic hardware for the first five years, then subsequently renewed at $200 CDN and 80$ CDN respectively.

5.4 Conclusion

Throughout the evaluation of technology and application of this project it became apparent there were many viable ways to obtain and present the storm retention basin and drain level data from the City of Winnipeg's network. There are many excellent products available, and numerous combinations of them could be implemented successfully.

The top chosen technology, or combinations of technology, stood out due to accumulation of small advantages that became more substantial when evaluated as a whole. Considerations such as ease of installation, capital cost, equipment life cycle, user friendliness, and operational and maintenance costs all became factors when evaluated together.

It became apparent through discussions with City personnel that the advantages of the Detectronic System made it the highest ranking alternative. Positive considerations included:

- Low cost prepaid five year cellular communication plans
- Three year battery life with low cost of replacement
- No requirement for solar panels and associated vandalism and esthetic impact
- Ability to integrate data through automated FTP file transfers

The second alternative to the Detectronic units would be the BlueTree Cellular unit integrated with the SCADAPack data logger. This would provide a direct path to the City ClearSCADA system, but would have substantially higher cellular communication costs. For this reason, and the need to have solar power panels, we feel this alternative may not be viable.

The recommended technology from this study will provide the City with many years of reliable, cost effective monitoring of SRB's and Drains. The systems and configurations recommended will allow relatively simple relocation, should study objectives change over time.

Report End
July 2013

SFE Global
Project A12-124

Appendix 1

Site Maps

and

Site Assessments

Figure 4: Northeast Quadrant Sites

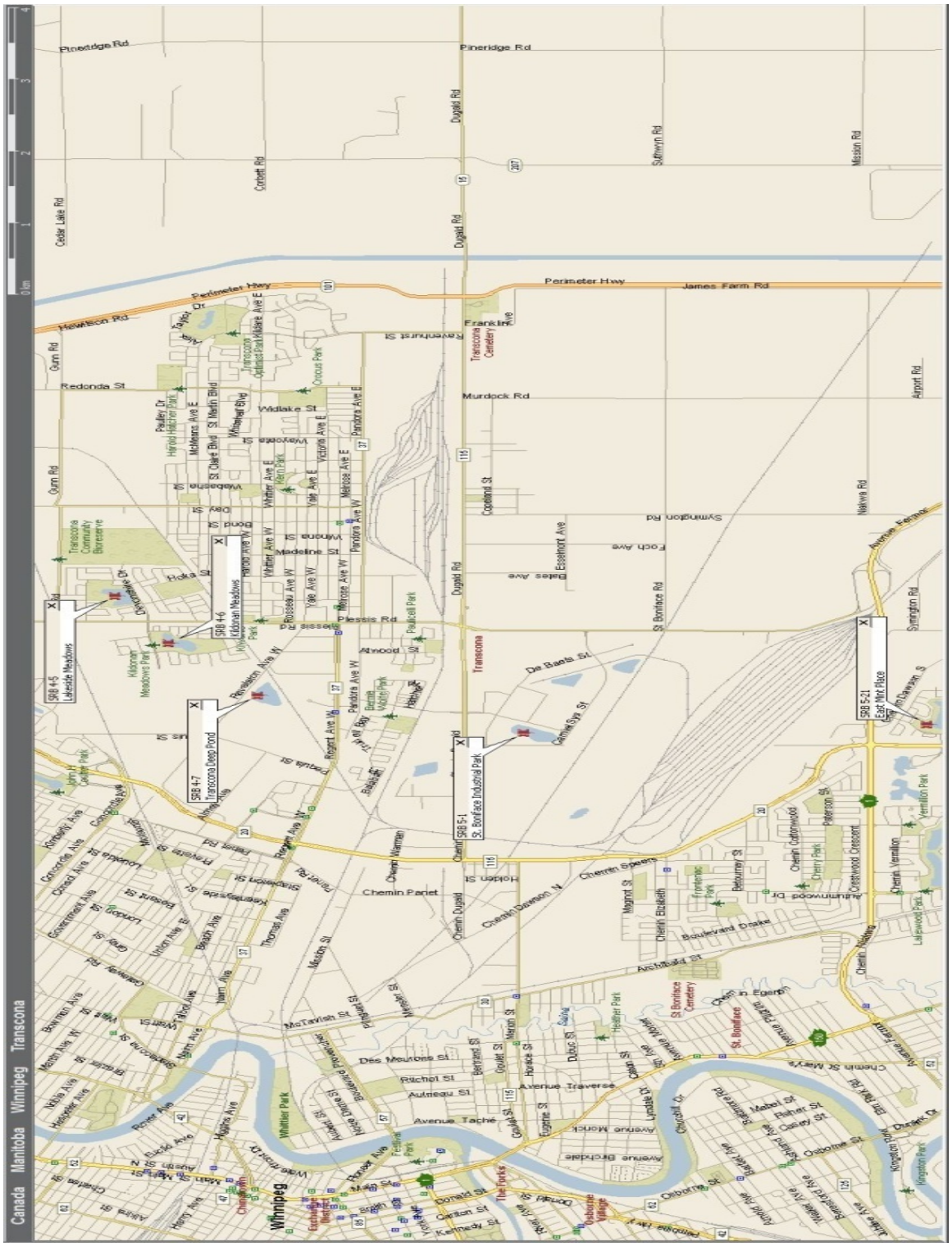


Figure 5: Southwest Quadrant Sites

Proposed Pond Level Monitoring Station
Assessment Notes
SRB 4-5

Site Name:	SRB 4-5	Common Name:	Lakeside Meadows
Site Type:	SRB	GPS Co-Ordinates:	49.910934 -97.020284
Area Type:	Residential	Area Pond Use:	Recreational

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is a residential area that will require standard procedures for dealing with pedestrians and residential areas.

Sensor and Kiosk Placement

Pond has a perimeter with trees and shore line to allow multiple potential locations for station placement. Station may be hidden in treed areas for lower impact if desired.

Trenching and Construction

Trenching and construction to be performed with reduced impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is used as a recreational area with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 4-5

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 4-5

Proposed Pond Level Monitoring Station
Assessment Notes
SRB 4-6

Site Name:	SRB 4-6	Common Name:	Kildonan Meadows
Site Type:	SRB	GPS Co-Ordinates:	49.907038 -97.02954
Area Type:	Residential	Area Pond Use:	Recreational

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is a residential area that will require standard procedures for dealing with pedestrians and residential areas.

Sensor and Kiosk Placement

Pond has a perimeter with trees and shore line to allow multiple potential locations for station placement. Station may be hidden in treed areas for lower impact if desired.

Trenching and Construction

Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is used as a recreational area with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 4-6

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 4-6

Proposed Pond Level Monitoring Station
Assessment Notes
SRB 4-7

Site Name:	SRB 4-7	Common Name:	Transcona Deep Pond
Site Type:	SRB	GPS Co-Ordinates:	49.900462 -97.039765
Area Type:	Industrial	Area Pond Use:	Industrial

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. A site key would be required, or City of Winnipeg personnel during installation and maintenance. Location is in a remote area that is gated and locked so minimal protection would be required from vandalism.

Sensor and Kiosk Placement

Kiosk could be eliminated by placing equipment within the City Pump Station. Trenching or drilling will be difficult due to slope and grade of the pond banks. Conduit run would be lengthy if equipment is mounted inside the station.

Trenching and Construction

Trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Enclosure would need to be secure, unless mounted in City Station. Installation inside the building would require smooth coring and City approval of panel location with appropriate permits.

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 4-7

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 4-7

Proposed Pond Level Monitoring Station
Assessment Notes
SRB 5-1

Site Name:	SRB 5-1	Common Name:	St. Boniface Industrial Park
Site Type:	SRB	GPS Co-Ordinates:	49.880823 -97.047196
Area Type:	Residential	Area Pond Use:	Recreational

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is a residential area that will require standard procedures for dealing with pedestrians.

Sensor and Kiosk Placement

Pond has a perimeter with trees and shore line to allow multiple potential locations for station placement. Station may be hidden in treed areas for lower impact if desired.

Trenching and Construction

Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is used as a recreational area with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 5-1

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 5-1

Proposed Pond Level Monitoring Station
Assessment Notes
SRB 5-21

Site Name:	SRB 5-21	Common Name:	East Mint Place
Site Type:	SRB	GPS Co-Ordinates:	49.851203 -97.045456
Area Type:	Residential	Area Pond Use:	Recreational

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is a residential area that will require standard procedures for dealing with pedestrians.

Sensor and Kiosk Placement

Pond has a perimeter with trees and shore line to allow multiple potential locations for station placement. Station may be hidden in treed areas for lower impact if desired.

Trenching and Construction

Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit will be difficult due to the slope of pond banks but may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is used as a recreational area with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 5-21

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 5-21

Proposed Pond Level Monitoring Station
Assessment Notes
Lot 16 Drain
Brady Road Bridge

Site Name:	Lot 16 Drain	Common Name:	Brady Road Bridge
Site Type:	Drain w/Bridge	GPS Co-Ordinates:	49.800077 -97.219462
Area Type:	Industrial / Rural	Area Pond Use:	Industrial / Rural

Assessment Notes

Accessibility

Site accessibility is limited during wet weather due to poor road conditions. Station equipment should be pre-constructed as much as possible to reduce installation trips.

Sensor and Kiosk Placement

Location of the site is in an open field. Site has very low flow so sensor should be placed in center of channel.

Trenching and Construction

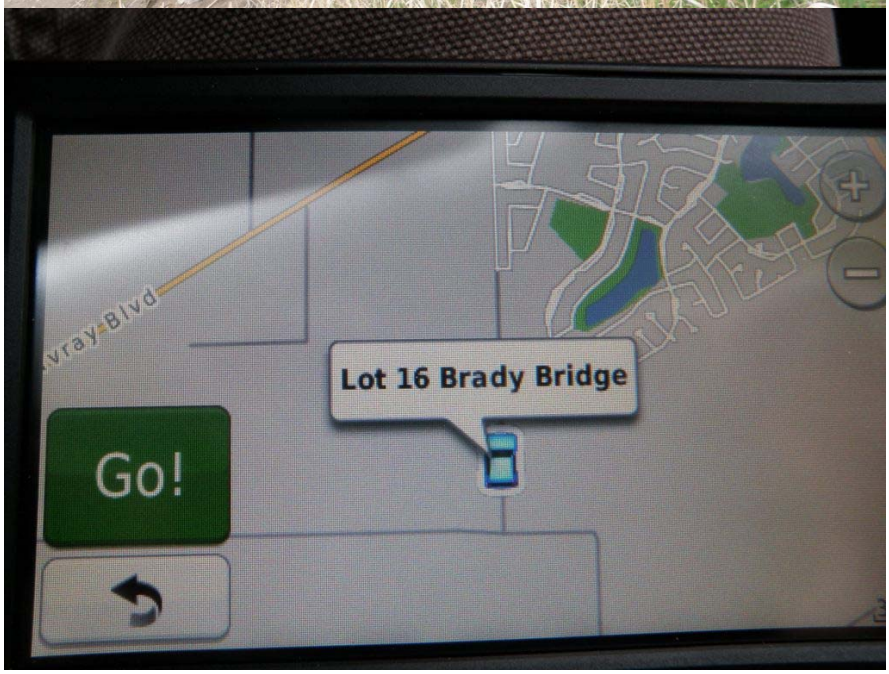
Ultrasonic sensor could be mounted below bridge deck and hidden between girders. Enclosure under deck as well with protective conduit on sensor cable runs to reduce vandalism. Appropriate high visibility signage would be required during trenching and construction.

Special Requirements or Considerations

Site is in a very remote location requiring extra protection from vandalism. Use of ultrasonic and secure enclosure and conduit will reduce any vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
Lot 16 Drain
Brady Road Bridge

Proposed Pond Level Monitoring Station
Assessment Photos
Lot 16 Drain
Brady Road Bridge



Proposed Pond Level Monitoring Station
Assessment Notes
Lot 16 Drain
Upstream and Downstream of SRB 6-14

Site Name:	Lot 16 Drain	Common Name:	SRB 6-14 - Tech School
Site Type:	SRB/Drain	GPS Co-Ordinates:	49.813248 -97.193314
Area Type:	Residential	Area Pond Use:	Recreational

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is a residential area that will require standard procedures for dealing with pedestrians.

Sensor and Kiosk Placement

Two ponds are joined by a control structure. Single kiosk can be placed on or near the chamber and have submerged sensors to each pond.

Trenching and Construction

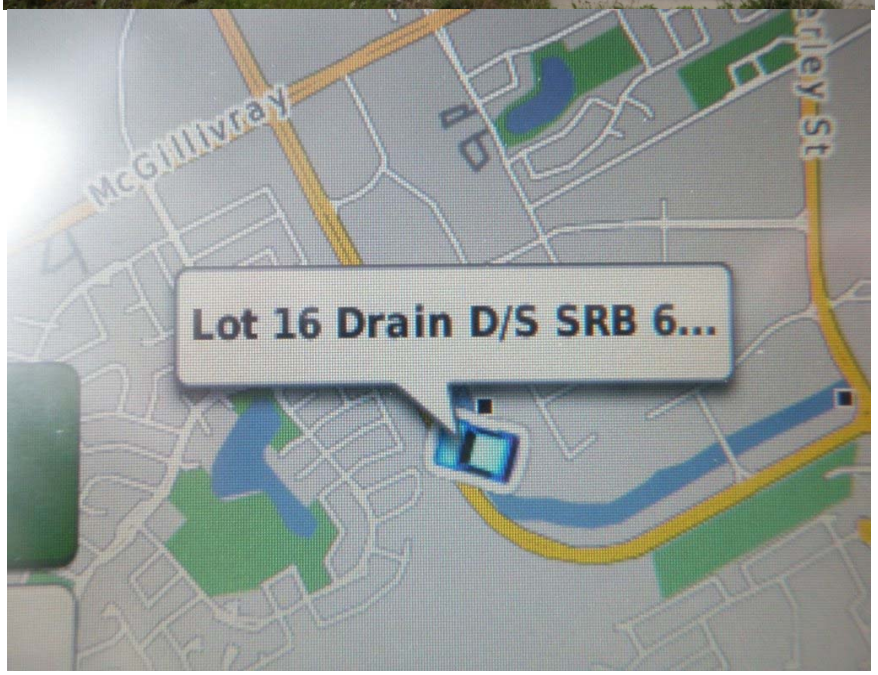
Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is near a school with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
Lot 16 Drain
Upstream and Downstream of SRB 6-14

Proposed Pond Level Monitoring Station
Assessment Photos
Lot 16 Drain
Upstream and Downstream of SRB 6-14



Proposed Pond Level Monitoring Station
Assessment Notes
Lot 16 Drain
At SRB 6-36

Site Name:	Lot 16 Drain	Common Name:	SRB 6-36
Site Type:	SRB with Chamber/Drain/Bridge	GPS Co-Ordinates:	49.812809 -97.17953
Area Type:	Urban	Area Pond Use:	Drainage

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is a residential area that will require standard procedures for dealing with pedestrians.

Sensor and Kiosk Placement

Drain has a perimeter with multiple potential locations for station placement. Station may be hidden in treed areas for lower impact if desired. Alternatively ultrasonic sensor could be mounted within culvert to prevent vandalism.

Trenching and Construction

Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is used as a recreational area with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
Lot 16 Drain
At SRB 6-36

Proposed Pond Level Monitoring Station
Assessment Photos
Lot 16 Drain
At SRB 6-36

Proposed Pond Level Monitoring Station
Assessment Notes
Lot 16 Drain
Inlet Structure to 96 Inch Pipe

Site Name:	Lot 16 Drain	Common Name:	Inlet Structure to 96 Inch Pipe
Site Type:	Drain	GPS Co-Ordinates:	49.821316 -97.15751
Area Type:	Industrial	Area Pond Use:	No specific use

Assessment Notes

Accessibility

Location is in a remote area with very poor vehicle accessibility. Added construction will be required to perform trenching and to safely operate at this location. Access restricted during wet weather due to poor road conditions.

Sensor and Kiosk Placement

Ultrasonic sensor could be mounted within manhole shown or in culvert to prevent submerged sensor freezing damage.

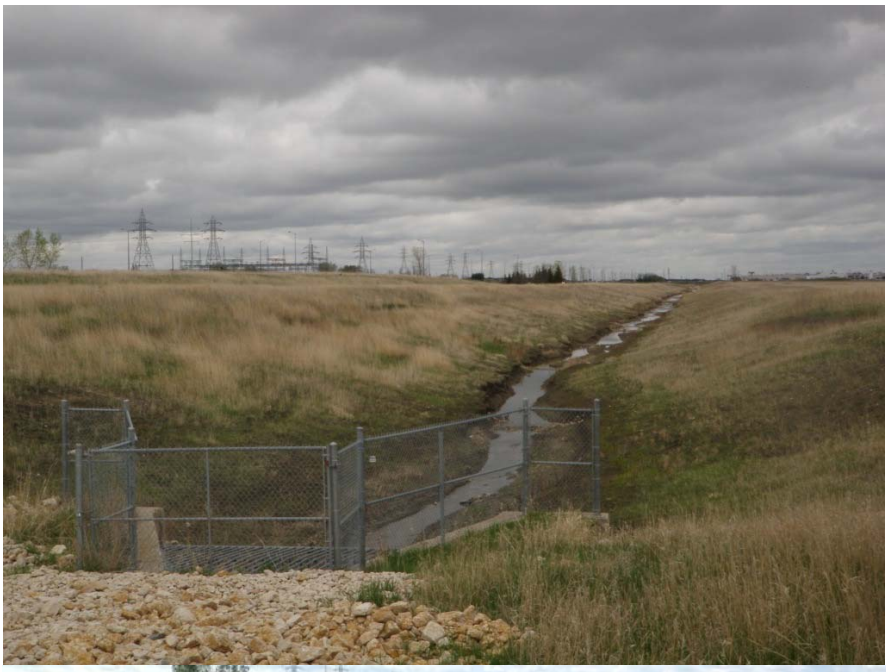
Trenching and Construction

Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is in a remote area. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
Lot 16 Drain
Inlet Structure to 96 Inch Pipe



Proposed Pond Level Monitoring Station
Assessment Photos
Lot 16 Drain
Inlet Structure to 96 Inch Pipe

Proposed Pond Level Monitoring Station
Assessment Notes
SRB 6-6

Site Name:	SRB 6-6	Common Name:	Waverly Heights
Site Type:	SRB	GPS Co-Ordinates:	49.813639 -97.167294
Area Type:	Residential	Area Pond Use:	Recreational

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is a residential area will require standard procedures for dealing with pedestrians.

Sensor and Kiosk Placement

Pond has a perimeter with trees and shore line to allow multiple potential locations for station placement. Station may be hidden in treed areas for lower impact if desired.

Trenching and Construction

Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond location is near a dog park and has heavy pedestrian traffic at times. Sensor and enclosure location and construction will have to prevent or minimize vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 6-6

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 6-6

Proposed Pond Level Monitoring Station
Assessment Notes
Dugald Drain

Site Name:	Dugald Drain	Common Name:	Downstream of SRB 5-1
Site Type:	Drain	GPS Co-Ordinates:	49.812235 -97.166648
Area Type:	Urban	Area Pond Use:	No specific use

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is an industrial area that will require standard procedures for dealing with high traffic and pedestrians.

Sensor and Kiosk Placement

No tress around location, close to bus loop, high traffic site. Ultrasonic sensor could be mounted within culvert to avoid vandalism. Kiosk installed with high visibility signage during winter season.

Trenching and Construction

Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Ditch is in an urban area with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
Dugald Drain

Proposed Pond Level Monitoring Station
Assessment Photos
Dugald Drain

Proposed Pond Level Monitoring Station
Assessment Notes
SRB 6-23

Site Name:	SRB 6-23	Common Name:	Inland Cement
Site Type:	SRB	GPS Co-Ordinates:	49.837242 -97.220426
Area Type:	Industrial	Area Pond Use:	Industrial

Assessment Notes

Accessibility

Site access is very poor with little to no accessibility. Access is unknown due to recent construction in the area. Access limited during wet weather.

Sensor and Kiosk Placement

Pond has a perimeter with trees and shore line to allow multiple potential locations for station placement. Station may be hidden in treed areas for lower impact if desired. Location is very remote but has experienced vandalism in the past, as a monitoring station was stolen/removed.

Trenching and Construction

Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 6-23

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 6-23

Proposed Pond Level Monitoring Station
Assessment Notes
SRB 6-29

Site Name:	SRB 6-29	Common Name:	Lee Blvd.
Site Type:	SRB	GPS Co-Ordinates:	49.795349 -97.166469
Area Type:	Residential	Area Pond Use:	Recreational

Assessment Notes

Accessibility

Site is easily accessed for construction and maintenance. Location is a residential area that will require standard procedures for dealing with pedestrians and residential areas.

Sensor and Kiosk Placement

Pond has a perimeter with shore line, with minimal potential locations for station placement. Station may be installed near boat launch as there is limited tress to hide site within.

Trenching and Construction

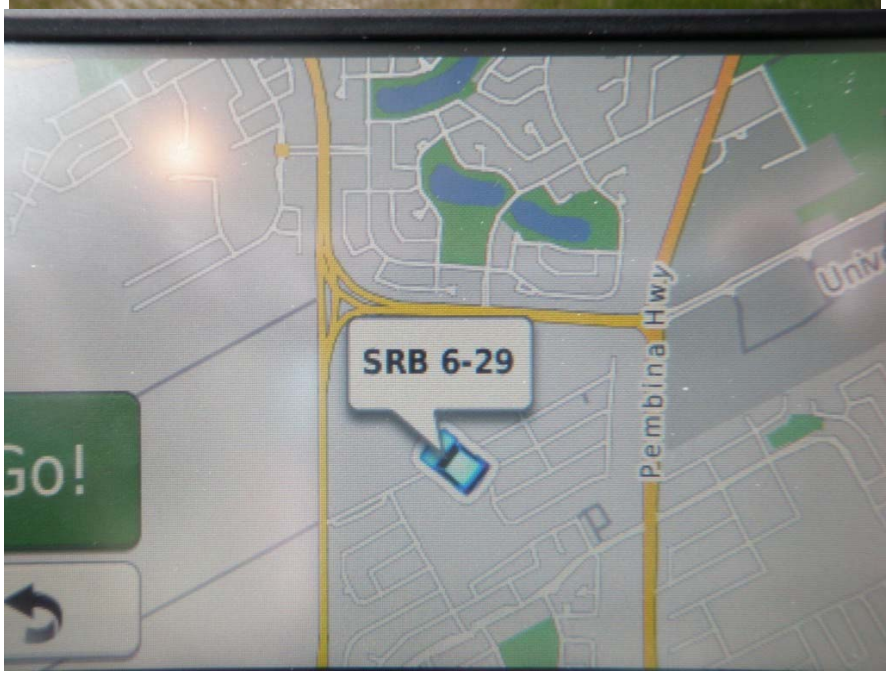
Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is used as a recreational area with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 6-29

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 6-29



Proposed Pond Level Monitoring Station
Assessment Notes
SRB 6-36

Site Name:	SRB 6-36	Common Name:	Waverly West
Site Type:	SRB	GPS Co-Ordinates:	49.808938 -97.179254
Area Type:	Residential	Area Pond Use:	Recreational

Assessment Notes

Accessibility

Site access would require City key through gated area for construction and maintenance. Location is a residential that area will require standard procedures for dealing with pedestrians.

Sensor and Kiosk Placement

Pond has a perimeter with trees and shore line to allow multiple potential locations for station placement. Station may be hidden in treed areas for lower impact if desired.

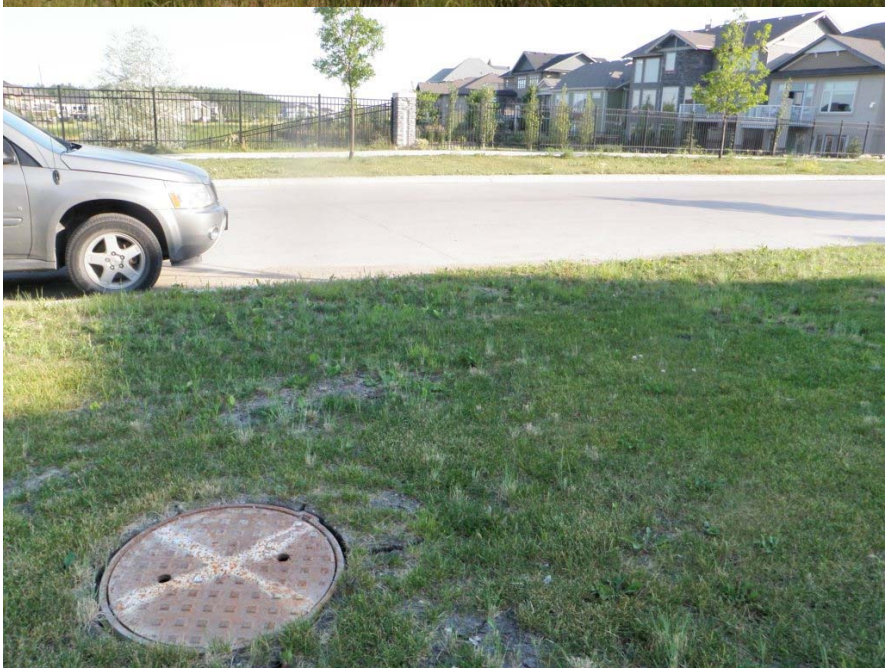
Trenching and Construction

Trenching and construction to be performed to reduce impact to residential area. Due to pets and pedestrians in area, open trenches should not be left unattended if possible. Trenching and conduit may be performed either with open cut or directional drilling.

Special Requirements or Considerations

Pond is used as a recreational area with heavy pedestrian traffic at times. Station should be located and constructed to reduce possible vandalism or tampering.

Proposed Pond Level Monitoring Station
Assessment Photos
SRB 6-36



Proposed Pond Level Monitoring Station
Assessment Photos
SRB 6-36

Appendix 2

Equipment Specifications

DETECTRONIC

MSFM-Lite Level Monitor
GPRS

ATEX MSFM Lite
GPRS Data Logger - Main Unit

ATEX MSFM Lite
Ultrasonic Sensor

Ultrasonic Level Sensor
in action

Ultrasonic Level Sensor
monitoring Storm Tank

MSFM-Lite GPRS Ultrasonic Level Monitor

Detectronic's MSFM Lite was specifically developed to satisfy the Water Industry's legislatively driven requirement to monitor Combined Sewer Storm Overflows (CSOs). It is also suitable for remote level measurement across a wide range of applications. Zone 0 Certified by both ATEX and IECEx, it is safe for use in all potentially explosive atmospheres.

It uses power saving technology developed by Detectronic to provide up to 5 years autonomy – significantly more cost-effective than traditional mains-powered systems.

The MSFM Lite's two components, the Ultrasonic Level Sensor and GPRS Data Logger are connected by a 10 metre cable. Detectronic's versatile installation kits ensure correct positioning of the Sensor directly above the measured surface, with the Main Unit being located (typically) just below the chamber cover.

Detectronic's specially developed Integral Underground Antenna ensures reliable GPRS Communication. Quad-Band operation ensures worldwide compatibility.

Features

- ✓ Non-Contact Ultrasonic Level Sensor
- ✓ 3m and 6m Operating Range
- ✓ 5 Year Battery (user replaceable)
- ✓ GPRS Remote Communication
- ✓ Simple Internet Data Delivery
- ✓ 2-Stage Level Alarms with SMS/Email Alarm Messages to Multiple Recipients
- ✓ Compatible with Telemetry/SCADA

Sensor Options:

Ultrasonic Level (0.2m dead-band).

Range 0 - 3.000m (3mm resolution) - order as ATEX-MSFM003 - 3m

Memory Type

Non-volatile, Solid-state - 128Kb, Rotating Store

Logging Capacity

80,000 Level readings, + Battery Voltage monitor

Equivalent to:

16 weeks continuous recording at 2 minute intervals

40 weeks at 5 minute intervals etc

Recording Intervals

30 seconds, 1, 2, 5, 10, 15, 20, 30 minutes, 1,2,3,4,6,8,12 hours.

GSM / GPRS Communication

Integral antenna – designed for easy underground operation. Quad Band - 850MHz, 900 MHz, 1800 MHz, 1900 MHz for worldwide operation.

The GSM and GPRS networks are used to transfer recorded Data and Alarm Messages to the host computer or to the Internet via Dedicated Data-Server

Local Communication Serial Data Port

Full duplex, asynchronous Data rate: 1200, 2400, 4800, 9600 bps

Power Supply

User replaceable Lithium primary cell - typical battery life 5+ years depending on mode of use.

Additional back up cell maintains logging and local communication when main cell is discharged.

Clock

Crystal controlled calendar clock with leap year adjustment. 100 seconds per month maximum error over operating temperature range.
Option to synchronize clock to GSM network.

Alarm Dial-Out

High/low alarms, independently programmable per measured channel. Option to upload data more frequently after an alarm

Environmental Housing - Main Enclosure

Injection-moulded PC/ABS and ACETAL.

IP68, submersible to 1m.

Internal Electronics

Totally environmentally sealed. Operating temperature: -30 C to +50 C

Connectors

Waterproof IP68 Military-specification

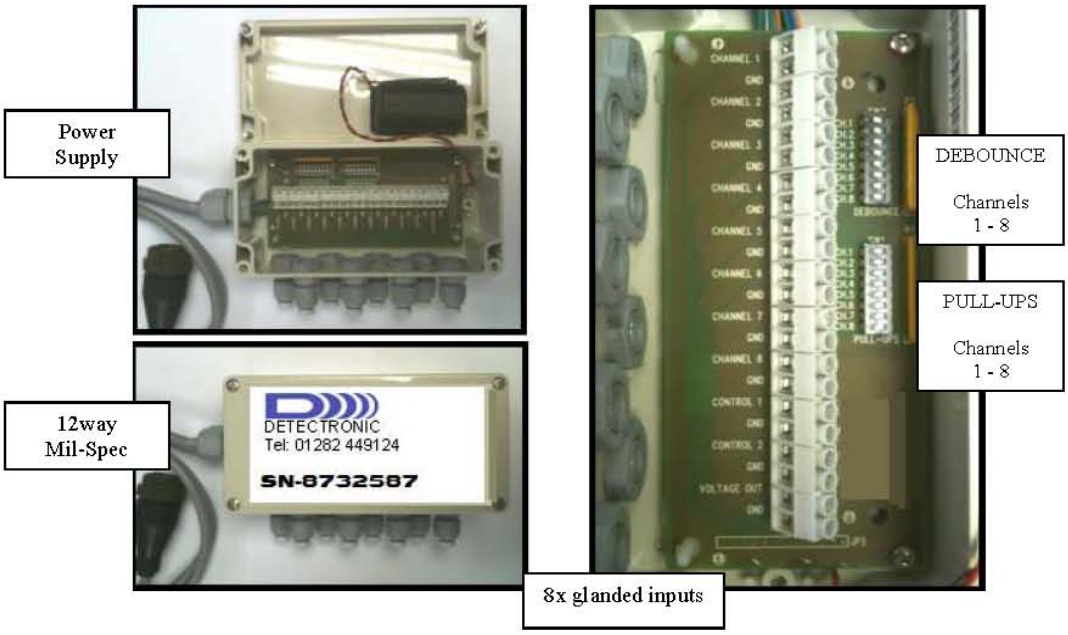
DETECTRONIC
Tel: 01282 449124 Fax: 01282 692002

IECEx CoC
Certified Service Facility
IECEx SIR S0005

Detectronic Universal 8 Channel Interface

SPRS367

- Detectronic Junction box
- Contains an internal power supply – no need to draw additional power from the data logger.
- Allows each channel (1-8) to be 'tied high' - see 8x dip switches marked PULL-UPS.
- Allows each channel (1-8) to use 'debounce' - see 8x dip switches marked DEBOUNCE.



DETECTRONIC LIMITED
1 TURNER ROAD
NELSON
LANCASHIRE
BB9 7DR
UNITED KINGDOM

Company Registration 6419526
VAT Reg: 924 5520 33

Inputs	Number of channels: 8
	Channel types: Voltage, event, state, count, frequency (independently selected on each channel)
	Input impedance: >300k
	Input protection: Protected against reverse connection and over voltage
	Voltage input: Range 0 to 2.5 volts, 0.01 volt accuracy and resolution
	Event input: Switch closure or logic pulse, date and time of event stored, resolution 1 second or 10 seconds
	State input: Switch closure or logic state. On state change, date, time and new state are stored, resolution 1 second or 10 seconds.
	Count input: Switch closures or logic pulses, maximum rate Channel 1, 4, 5, 6, 7, 8 = 10 per second, Channel 2 and 3 = 45 per second (Counted over and recorded at preset intervals). 16,000 maximum per logging interval
	Frequency input: Switch closures or logic pulses, maximum frequency 16 kHz, programmable sampling period of 1 to 250 seconds, independent of recording rate. Resolution 0.01% maximum
Outputs	2 independent digital outputs for transducer power control and alarm signaling (0 and 3 volt levels, active low, 100k output impedance)
	1 fixed output for "open collector" signal bias (3 volts, 33k output impedance)

General Specifications

GSM Modem	Quad band: 900MHz, 1800 MHz / 850MHz, 1900MHz - Integral antenna
Serial Port	Type: Full duplex, asynchronous
	Data rate: 1200, 2400, 4800, 9600 bps
Memory	Type: Solid state
	Size: 128K, allocatable between channels as required (max 64K/channel)
Clock	Type: Crystal controlled calendar clock with leap year adjustment
	Accuracy: 100 seconds per month maximum error over operating temperature range
	Synchronisation: Option to synchronise clock to GSM network
Supply	Type: Internally powered by a replaceable lithium cell (Internal back up cell maintains logging and local communications when main battery pack is discharged)
	Life: Typical battery life > 5 years depending on mode of use
Recording	Recording interval: Programmable between 1 second and 1 hour
	Data storage: Rotating store or store until full
Alarm dial-Out	High/low threshold and profile alarms
	Option to update data on alarm and more frequently thereafter
Environmental	Operating ambient temperature: -20°C to +50°C
	Protection classification: IP68 (submersion at 1m depth for > 24 hours)
Connectors	Military specification, compatible with to MIL-C-26482
Mechanical	Dimensions: 191mm x 140mm x 150mm
	Weight: 1 kg

Level | Pressure | Flow | Temperature | Liquid Analysis | Registration | Systems Components | Services | Solutions

Technical Information

Waterpilot FMX21

Hydrostatic level measurement
Reliable and robust level probe with ceramic measuring cell
Compact device for level measurement in fresh water, wastewater and saltwater, communication via HART

Application

The Waterpilot FMX21 is a pressure sensor for hydrostatic level measurement.
Endress+Hauser offers three different versions of the FMX21 sensor:

- FMX21 with a stainless steel housing, outer diameter of 22 mm (0.87 inch): Standard version suitable for drinking water applications and for use in bore holes and wells with small diameters.
- FMX21 with a stainless steel housing, outer diameter of 42 mm (1.66 inch): Heavy duty version, easy clean flush-mounted process diaphragm. Ideally suited for wastewater and sewage treatment plants.
- FMX21 with a coated housing, outer diameter of 29 mm (1.15 inch): Corrosion resistant version generally for use in saltwater, particularly for ship ballast water tanks.

Your benefits

- High resistance to overload and aggressive media
- High-precision, robust ceramic measuring cell with long-term stability
- Climate proofed sensor thanks to completely potted electronics and 2-filter pressure compensation system
- 4 to 20 mA with superimposed HART 6.0 output signal
- Simultaneous measurement of level and temperature with optionally integrated Pt100 temperature sensor
- Accuracy
  - Reference accuracy ±0.2 %
  - PLATINUM version ±0.1 %
- Automatic density compensation to increase accuracy
- Usage in drinking water: KTW, NSF, ACS
- Approvals: ATEX, FM, CSA
- Marine certificate: GL, ABS, LR, DNV
- Extensive range of accessories provides complete measuring point solutions

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