Jacques Whitford AXYS

Environmental
Engineering
Scientific
Management
Consultants

4370 Dominion Street
5th Floor
Burnaby BC
Canada V5G 4L7

Bus 604 436 3014
Fax 604 436 3752

www.jacqueswhitford.com
www.axys.net

Phase 1 Data Gaps Evaluation and Water Supply Study Plan

SUNSHINE COAST REGIONAL DISTRICT – AREA A

FINAL REPORT

Prepared for:
Sunshine Coast Regional District
Sechelt, BC

Prepared by:
Jacques Whitford AXYS Ltd.
Burnaby, BC

August 2008

PROJECT NO. 1035728.

Jacques Whitford

An Environment of Exceptional Solutions


Jacques
Whitford
AXYS

PROJECT NO.	**1035728.**
REPORT TO:	**Sunshine Coast Regional District** 1975 Field Road Sechelt, BC V0N 3A1 Attention: Steve Lee, David Crosby
FOR:	**Phase 1 Data Gaps Evaluation and Water Supply Study Plan**
ON:	**Sunshine Coast Regional District – Area A**

August 1, 2008

Jacques Whitford AXYS Ltd.
4370 Dominion Street, 5th Floor
Burnaby, British Columbia
V5G 4L7

Phone: 604.436.3014
Fax: 604.436.3752

Table of Contents

List of Tables

List of Appendices

THIS PAGE INTENTIONALLY LEFT BLANK.

1 Introduction and Objectives

Jacques Whitford AXYS Ltd. (JWA) is pleased to provide this Water Study Plan as part of the Sunshine Coast Regional District's (SCRD) Area A Integrated Water Management Program. The objective of this report is to:

- summarize existing hydrometric station data and information
- evaluate future data needs
- describe a multi-year phased approach for collecting and managing meteorological and hydrological data and other relevant geo-referenced information as part of on-going initiatives associated with the management of Area A watersheds

The phases of the plan include:

- **Phase 1** – Data Gaps Evaluation and Program Design – (described in this report with recommended schedule and cost estimates)
- **Phase 2** – Set-Up, Installation and Monitoring of Field Data Stations, and the associated Data Compilation, Management and Reporting
- **Phase 3** – Analysis and Research
- **Phase 4** – Integration of Study Results into Area A Watershed Management Plans

The development of this plan was based on a data and document review, a one-day field reconnaissance of Area A monitoring stations, and a data gaps evaluation.

2 Background

Elector Area A is located on the Lower Sunshine Coast at the northern end of the Sechelt Peninsula, bounded by the Jervis Inlet to the North, the Malaspina Strait to the West, the Caren Range and Sechelt Inlet to the East and Secret Cove to the South (Figure 1, Appendix A). The area has complex surface and groundwater hydrology with numerous lakes connected by a network of streams, creeks, aquifers and springs. The area and lakes are used by people for water supply, recreation, fishing, logging, mining and other amenities for residences, as well as providing habitat for a variety of species.

The SCRD forecasts steady growth over the next ten years for the entire Sunshine Coast and Area A is expected to see the most growth. We understand that the SCRD wishes to establish a new tax-based source of funding to support on-going initiatives associated with the management of Area A watersheds. Potential long and short term supplies of drinking water for residents in the Area A are addressed by the study described herein. The on-going initiatives include:

- the development of a meteorological and hydrological data baseline collection program in conjunction with other relevant geo-referenced land use information
- the development of an efficient and flexible means of managing, analyzing and displaying collected data and information;
- the use of this data and information to support studies concerning various water supply alternatives and other hydrologic-related evaluations of specific lake-creek systems in Area A

3 Scope of Work

This first phase of work involved the following four steps:

1. data compilation and review
2. a one-day field reconnaissance
3. a data gaps evaluation
4. the development, refinement and finalization of this draft water supply study plan

4 Physical Setting

Area A is comprised of a large region encompassing the northern portion of the Sechelt Peninsula, Nelson Island, and areas to the north draining into Jervis Inlet (Figure 1, Appendix A). The study area includes only that portion of Area A on the Sechelt Peninsula (Figure 2, Appendix A). This area is comprised of six major watersheds and a number of smaller inter-fluvial areas not considered herein. Table 1, provides a summary of the watershed and sub-watershed areas. Sakinaw Lake watershed is the largest in the area comprising 45.7% (6,899 hectares) of the total Area A study area's 15,190 hectares, and includes the following smaller sub-basins: Ruby Lake – 1,509 hectares (9.9%), Klein Lake – 644 hectares (4.2%) and Kokomo Lake – 349 hectares (2.3%) (Figure 3, Appendix A), and the combined Hotel, Garden Bay, and Mixal Lakes watershed of 788 hectares (5.2%) (Figure 4, Appendix A). Oyster Bay North is the second largest watershed – 4,646 hectares (30.6%). This watershed is distinctly different from the others, as it has very little lake area (only the small Lyons Lake in its headwaters) and is drained by larger relatively long Anderson, Kleindale and Meyers Creeks (Figure 5, Appendix A). The other important watersheds for water supply include McNeill-Harris – 1,466 hectares (9.7%, Figure 7, Appendix A), and Waugh Lake – 819 hectares (5.4%, Figure 8, Appendix A).

Currently, Area A water supply is produced from three main sources:

- the Hotel-Garden Bay Lakes system,
- McNeill Lake, and
- Waugh Lake.

Supplemental supply on an individual residential basis is provided from other sources such as Ruby Lake, Sakinaw Lake and North Lake.

Table 1: Sunshine Coast Area A Watershed Areas

Major Basin	Minor Basin	Area *			Proportion of Total Area
		Km²	*Hectares*	*Acres*	
North Lake		**4.09**	**409**	**1010**	**2.7%**
Waugh Lake		**8.19**	**819**	**2023**	**5.4%**
Sakinaw Lake		**68.99**	**6,899**	**17048**	**45.7%**
	Sakinaw Lake	36.08	3,608	8916	23.8%
	Ruby Lake	15.09	1,509	3730	9.9%
	Klein Lake	6.44	6,44	1592	4.2%
	Kokomo Lake	3.49	349	862	2.3%
	Combined Hotel, Garden Bay and Mixal Lake Sub-watershed	7.88	788	1948	5.2%
	Mixal Lake	*3.61*	*361*	*892*	*2.4%*
	Garden Bay Lake	*3.22*	*322*	*797*	*2.1%*
	Hotel Lake	*1.05*	*105*	*259*	*0.7%*
Oyster Bay North		**46.46**	**4,646**	**11481**	**30.6%**
Oyster Bay South		**9.50**	**950**	**2349**	**6.3%**
McNeil and Harris Lake		**14.66**	**1,466**	**3623**	**9.7%**
	Total Area Considered	**151.90**	**15,190**	**37534**	**100.0%**

NOTE:
* areas calculated at the mouth of each drainage

5 Document Review

A detailed review of data, documents and literature relevant to the water supply study of Area A (and to a limited extent, the Sunshine Coast in general) was conducted. Data compilation and review involved obtaining, compiling and updating data and information, if readily available, that included:

- stream-flow, lake water-level, reservoir extraction and surface water quality data;
- relevant reports and documents related to water resource studies/issues in the area (e.g. water balance studies, water quality studies, baseline studies, water license applications)
- topographic, physiographic, geologic, and related watershed boundary maps
- air photo collections
- precipitation, temperature records and other relevant climate data
- geo-referenced forestry, mining, residential development, recreation sites, and other land use activity data and information
- geo-referenced endangered species data
- geo-referenced ecological, historical, and archaeological sensitive areas data and information
- regulatory status (and other constraints to developing water supplies) in respective watersheds

Table B-1, Appendix B summarizes the relevant aspects of specific reports that were obtained and that in some manner were helpful to understand and develop the water supply study plan. A number of other reports cited in the references section and data were obtained but in general, these reports had less value in the evaluation of relevant data needs and in developing the study plan.

6 Field Reconnaissance

After the detailed review of the above-referenced documents, a field reconnaissance of the Area A watersheds was conducted, with a particular focus on the evaluation of the existing streamflow, lake level, and climate monitoring network (currently managed by DFO). Tables B-2, B-3 and B-4 (Appendix B) provide, by watershed, a summary of the status of the streamflow, lake-level and climate monitoring stations, based primarily on the field reconnaissance. The tables describe the type of equipment currently deployed (if known), the approximate elevations of each station, the period of record, equipment condition, site accessibility, apparent monitoring frequency, and any relevant comments or issues regarding potential needs or recommended changes at each site. The observations and interpretations summarized in the tables were used as a basis for the data gaps evaluation and recommended actions for future water supply study elements.

6.1 Weather Stations

There are two existing climate monitoring stations, one at the east end of Sakinaw Lake and one at the north end of Hotel Lake. Both of these stations are at relatively low elevations near sea level.

The Sakinaw Lake Weather Station is a Hobo Weather Station H-21 with sensors to measure rainfall, temperature, relative humidity, solar radiation, wind speed, and wind direction gauge. The station is located behind boathouses and partially obscured by tree branches on a somewhat loose stand which extends approximately 2.5 meters above the ground surface, (Photos 1 and 2, Appendix C). JWA recommends either moving the site away from the obstructions to a more representative site, or at a minimum, that the tree branch obstructions are cleared and maintained annually and that the station is mounted on a stronger stand in order to prevent the data sensors from being compromised during high winds.

The Hotel Lake Weather Station was viewed from a distance as it was only accessible by crossing a private residence. It appeared to be the same type of station as the Sakinaw Lake Weather Station, but without a wind speed and direction gauge. The station is located approximately 1.2 meters above water surface in a semi-protected cove, (Photo 3, Appendix C). JWA recommends that the station be moved to a more open location at a standard height above the ground surface (i.e., not over water) and be equipped with a wind speed and wind direction equipment.

6.2 Lake Level Monitoring Stations

There are five existing lake-level monitoring stations, one at each of the following locations: Ruby Lake, Sakinaw Lake, Sakinaw Dam, Garden Bay Lake and Hotel Lake.

The Ruby Lake Level Station is an Edutech Technologies Corporation (Edutech) water level sensor coupled with Onset Computer Corporation (Onset) data logger, which has been securely anchored to bedrock at the south east end of the lake. The station appears in good condition and in a good location, provided the lake level does not go lower than 0.6 m below the level observed during the reconnaissance (at the elevation of the sensor) (Photos 4 and 5, Appendix C).

The Sakinaw Lake Level Station was not located. Although we have assumed that the station is in good condition and in a good location, this would need to be verified through a field assessment.

The Sakinaw Lake Dam monitoring station had the identical housing and so appeared to be the same type of equipment as the Ruby Lake Level Station. The station appears to be in a secure location and in good condition. We are unsure, however, how the stage data has been used, and whether a stage-discharge relationship for the dam overflow has been established. The dam is located in a long narrow valley along a river-like finger that extends from the west end of Sakinaw Lake (Photos 6 and 7, Appendix C).

The continuous recording Garden Bay Lake Level gauge was not located during the assessment, but according to subsequent conversations with SCRD staff, it is located at the outlet of Garden Bay Lake (where it drains to Mixal Lake). Although we have assumed that the station is in good condition and in a good location, this would need to be verified through a field assessment.

An additional manual read staff gauge is located at the south end of Garden Bay Lake near the water supply intake. This gauge consisted of a standard white and black strip staff gauge and was in good condition, and readily accessible near the road (Photo 8, Appendix C). It is not known if, when or who collects lake-level data from this gauge.

The Hotel Lake Level Gauge could be observed from a distance as it was only accessible by crossing a private residence, but it appeared to be the same type of equipment as the Ruby Lake Level gauge. The gauge appeared to be in a secure and representative location, at the north end of Hotel Lake, and in overall good condition (Photo 9, Appendix C).

6.3 Streamflow Gauging Stations

There are three existing streamflow gauging stations at the following locations: Ruby Creek, Kokomo Creek and Mixal Creek.

The Ruby Creek gauging station is equipped an Edutech water level sensor coupled with an Onset data logger. The sensor is housed in a metal culvet that is standing between two fallen trees, each having an unknown long-term stability. There is also a manual staff gauge which is crooked and loosely attached to a log weir. The creek channel is wide and shallow at the gauge site, and appears to be just below or at lake level, with little potential for stage variation (Photos 10 and 11, Appendix C). JWA recommends that the station be moved to a more secure and representative downstream position.

Due to the remote location of the Kokomo Creek gauging station, we did not attempt to access the site during this scope of work. Although we have assumed that the station is in good condition and in a good location, this would need to be verified through a field assessment..

The Mixal Creek gauging station is equipped the same type of equipment as at the Ruby Creek gauging station. Two manual-read staff gauges are also on site, which are located to measure stage at two levels associated with weirs that have what appear to some capability to control stage (Photos 12 and 13, Appendix C).

7 Data Gaps Evaluation

Information that has been made available for the study area and that was used to develop and refine the plan for the SCRD Area A Integrated Water Supply Study is summarized in Table B-5, Appendix B. The data gaps evaluation is the first step in developing further research and analysis requirements that will eventually facilitate the integration of study results into Area A Watershed Management Plan activities.

7.1 Climate Data

The Meteorology Service of Canada (MSC) database was accessed to determine historical and/or existing climate stations within 50 km of the study area. Table 2 summarizes the available network. The site locations are as shown on Figure 9, Appendix A. In general, the available stations have short periods of record, are at relatively low elevations and are sparsely represented in the immediate study area.

Table 2: Long-Term Climate Stations Relative to Sunshine Coast Area A

Station Name	MSC Station Number	Distance To Hotel Lake (km)	Latitude	Longitude	Elevation (masl)	Period of Data Available
Pender Harbour	1046115	<1	49° 37' N	124° 1' W	64	1961-1964[1], 2001-2007
Gibsons Grower Point	1043152	47	49° 23' N	123° 32' W	34	1961-present
Gibsons WS	1043150	~50	49° 24' N	123° 30' W	62	1949-2004[1]
Lois River Dam	1044710	27			157	1931-2004
Merry Island Lightstation[2]	1045100	21	49° 28' N	123° 55' W	6.1	1942-2004
Ballenas Island	1020590	33	49° 21' N	124° 9' W	12.9	1994-2007
Sechelt 5WEST	1047179	25	49° 28' N	123° 48' W	61	1989-2004
Woodfibre	1048974	15	NA	NA	NA	1960-2006
Powell River[2]	1046390	44	NA	NA	52	1924-2004
Powell River Airport	1046391	38	NA	NA	130	1953-present
Stillwater Powerhouse	1047770	24	NA	NA	7	1931-2004

NOTES:

1. Not a full data series
2. Station meets WMO Standards for calculating temperature and precipitation climate normals
3. MSC – Metrological Service of Canada
4. NA – not available

7.2 Geo-Referenced Data

In order to compile a database for geo-referenced data JWA has obtained data from several sources including the SCRD, and websites for British Columbia government and the Department of Fisheries and Oceans. The SCRD database includes topographic, physiographic, road and trails, residential and recreation sites, as well as other environmental and land-use spatial information which can be complied, organized and effectively displayed to facilitate communication. Geologic map and fisheries resource data were readily available from BC Ministry websites, while additional forestry and mining data are likely available but could not be readily obtained during this scope of work. Further, special permission is required to access historical and archaeological site data. Although this data is likely not critical for the next Phase of the Water Supply Study Plan, it would seem prudent for the SCRD to at least determine whether any potential conflicts could arise when developing future water supply sources. Table 3 summarizes the status of available geo-reference data.

Table 3: Summary of Available Geo-Referenced Data

Data	Availability	Source	Comments	Reference Figure
Topography	Yes	SCRD		Figure 2 – 10
Geology	Yes	BC Government	No Quaternary or Soil Data	Figure 10
Watershed Boundaries	Yes	SCRD		Figure2 – 11
Road and Trail Networks	Yes	SCRD	Road names and road types not provided	Figure 2 – 8
Forestry	Yes	BC Government	Not readily available	Not obtained
Residential	Yes	SCRD		Not prepared
Recreation Sites[1]	Yes	SCRD		Figure 11
Habitat	Yes	SCRD and DFO		Figure 11
DFO Gauging Stations	Not complete	DFO	Exact locations from Site Reconnaissance	Figure 2 – 8
Historical and Archaeological Sites	Require special permission to access this information	BC Government	Coverage unknown	Not available
Growth Areas	Data available	SCRD		Not prepared
Mining	No	BC Government	Coverage unknown	Not obtained
Fisheries Resources	Yes	BC Government		Figure 11

NOTE:

1. Table B-6, Appendix B, summarizes all of the Parks in Area A.

7.3 Watershed Summaries

The following summarizes available hydrometric data for each watershed, and the recommendations JWA has made to have adequate spatial coverage to evaluate the hydrologic regime of each watershed.

7.3.1 McNeill and Harris Lake Watershed

From the data reviewed there appears to be only scant hydrology coverage for the McNeill and Harris Lake Watersheds. Based on a reference in BEL-MK (2006) to work done by J.T. Termuende in 2002, there may be some streamflow data for upper Haslam Creek. Based on the physiography and watershed boundaries, recommendations in Summit (2006) and BEL-MK (2006), potential surface water sources for growth areas, and the road network within Area A, as well as our field reconnaissance, we recommend that the following stations be considered:

- add streamflow gauging stations on Upper Haslam Creek and Lower Haslam Creek; and
- add a lake-level monitoring station on McNeill Lake

7.3.2 Sakinaw Lake Watershed

Sakinaw Lake Watershed includes a number of important recognized sub-watersheds, such as Ruby, Klein, Kokomo and the combined Hotel, Garden Bay and Mixal watersheds. There is only one climate station in all of Sakinaw and Ruby Lakes watershed (if Hotel, Garden Bay and Mixal Lakes are considered separately). As noted in Tables B-2, B-3 and B-4 (Appendix B) and on Figure 3, Appendix A, there is fair to good existing coverage of the hydrology in the lower Sakinaw and Ruby Lake Watersheds (including stations at Kokomo Creek), while Klein, Ambrose and the Penny Lake Watersheds, for example, do not have any gauging or climate stations.

Sakinaw Lake hydrology coverage consists of a lake level (at the east end of the lake), a stage recorder at the dam at west end of the lake and a climate station (also at the east end of the lake). As noted in section 6.3, JWA recommends either moving the climate station away from the obstructions or more securely mount the existing station.

Ruby Lake has one lake-level and one streamflow gauging station. As noted in section 6.3, JWA recommends relocating the stream gauge to a more secure and representative downstream location. There are no recommended changes to the lake-level station.

Based on the physiography and watershed boundaries, potential surface water sources for growth areas, and the road network within Area A, as well as our field reconnaissance, we recommend that the following new stations be considered for this watershed:

- add streamflow gauging stations on Klein Creek and Ambrose Creek
- add lake-level monitoring stations on Klein Lake and Ambrose Lake

7.3.3 Hotel, Garden Bay and Mixal Lake Watershed

Hotel, Garden Bay and Mixal Lake watershed is located in a highly developed area which puts a disproportional stress on the local water supply produced from relatively small watersheds. Due to both site accessibility and water demand, this watershed has good hydrometric monitoring coverage. In addition there have been a few water quality studies, water balance evaluations, and archaeological assessments done for this area. The watershed has one creek gauge (at the outlet of Mixal Creek), two lake level stations and one climate station located on Hotel Lake.

Based on the importance of this watershed JWA agrees that the Hotel and Garden Bay coverage density in this area should be high and recommends that a few additions and changes be made to the current network:

- add a lake-level monitoring station on Mixal Lake
- move (to a more accessible and representative ground location) and upgrade (add wind speed and direction) the Hotel Lake climate station

7.3.4 7.3.4 Waugh and North Lake Watersheds

From the data and information reviewed there does not appear to be any hydrometric coverage for Waugh and North Lake Watersheds. Waugh Lake watershed is protected (as a reserve) and is essentially undeveloped; it is also the principal water supply for Egmont. In contrast the North Lake shoreline is highly developed and is not protected, but evidently supplies water on an individual basis for shoreline residents. Based on the physiography and watershed boundaries, potential surface water sources for growth areas, and the road network within Area A, as well as our field reconnaissance, we recommend that the following new stations be considered:

- add streamflow gauging stations to Waugh and North Creeks

- add lake-level monitoring stations to Waugh and North Lakes
- add a climate station in the Waugh Lake Watershed

7.3.5 Oyster Bay Watersheds

Oyster Bay North Watershed covers a relatively large area of the study area (i.e.: 30.6%) but does not currently supply any water (except for local groundwater wells and stream diversions by individual residents), yet the watershed is relatively unique in the area in that there is only one small lake (Lyon Lake) in its headwaters. Numerous steep gradient streams (e.g., Anderson, Meyers and Kleindale Creeks) descend and join in a flat-lying area near Garden Bay Road before draining to Oyster Bay. From the data reviewed there does not appear to be any hydrometric coverage for this watershed. Based on the physiography and watershed boundaries, potential surface water sources for growth areas, and the road network within Area A, as well as our field reconnaissance, we recommend that the following stations be considered:

- add a streamflow gauging station on Anderson Creek (which is the longest stream in the watershed)
- add a climate station along the divide of the watershed (around elevation 860 masl) in the Caren Range; as noted above in section 7.1, there is no coverage of climate (specifically precipitation) for the higher elevations in the study area. It is likely that precipitation rates are more than twice the values represented by the low elevation stations at Sakinaw and Hotel Lakes. Thus, this station would be strategically placed to represent the upper elevations of a number of watersheds (McNeill, Harris, Oyster Bay, and by interpolation Sakinaw).

The Oyster Bay South Watershed is smaller, lower in overall elevation and does not appear to have any hydrometric coverage. At this time, however, due to its size and lack of major streams or lakes we do not recommend any coverage.

7.3.6 General Recommendations

Although not specifically addressed by this data gaps evaluation, we recommend that a reconnaissance level inventory of groundwater resources be conducted to:

- identify existing and potential aquifers
- identify existing groundwater well locations with estimated usage rates

This is particularly important in areas where surface water and groundwater systems have significant hydraulic connectively. Further, our document review identified only a few data sources and information regarding water quality and/or water chemistry of both existing and future water supply sources. Although we did not research water quality elements as part of this study we recommend that a water quality data gaps assessment be conducted which could form the basis for developing plans for periodic (water quality supply and analysis) monitoring on all existing and probable future water supply sources.

8 Water Supply Study Plan

8.1 Phase 2A - Data Collection Field Program

Phase 2 involves the implementation (i.e., installation, periodic monitoring, datalogger downloading and maintenance) of the data collection program. We assume that the data collection program would take place over an initial three to four year period with the intent to refine data collection strategy and needs

following the first year and then again during the initial stages of research and analysis. Although not part of this response, we recommend that the SCRD continue data collection at critical meteorological and hydrometric stations for the long-term (i.e., over 20 years).

The data collection program is based on a prioritization of watersheds that emphasizes existing and future development scenarios, watershed-specific data gaps, site representativeness, and other pertinent factors (i.e., site accessibility, cost-effectiveness, historical precedence for specific sites, etc.).

Based on our current understanding of the Sechelt Peninsula physiography and watershed boundaries, potential surface water sources for growth areas, and the road network within Area A, we recommend that monitoring stations be considered in four levels of priority as follows:

Priority 1): Maintain and upgrade existing stations (currently managed by DFO):

- maintain and/or upgrade existing streamflow gauging stations on Ruby Creek, Kokomo Creek and Mixal Creek
- maintain existing lake-level monitoring stations on Ruby Lake, Sakinaw Lake, Sakinaw Lake Dam, Garden Bay and Hotel Lake
- make repairs on Sakinaw Lake climate station, and move and/or upgrade (add wind speed and direction) on the Hotel Lake climate station

Priority 2): Level 1 station additions:

- add streamflow gauging stations on Upper Haslam Creek, Lower Haslam Creek and Waugh Creek
- add lake-level monitoring stations on McNeill Lake and Waugh Lake
- add a climate station in the Caren Range (upper McNeill Lake or Upper Oyster Bay North Watershed), and move the Sakinaw Lake climate station

Priority 3): Level 2 station additions:

- add streamflow gauging stations on Garden Bay Creek at the lake outlet and on South Mixal Creek near the Hotel Lake outlet
- add a lake-level monitoring station on Mixal Lake
- add a climate station in the Waugh Lake Watershed

Priority 4): Level 3 station additions:

- add streamflow gauging stations on Klein Creek, Anderson Creek and Ambrose Creek
- add lake-level monitoring stations on Klein Lake, North Lake and Ambrose Lake
- add a remote access telemetry station on the Caren Range climate station

The above listed stations represent important locations within the four principal Area A watersheds where supply is currently obtained; however, not all of Area A is represented. Other streamflow locations that could be considered include other streams that drain to Oyster Bay (e.g., Kleindale and Meyers Creeks), and the streams that drain to Sakinaw Lake (e.g., from Penny Lake, Vine Brook, Franks Brook). Although, some of these are less accessible, and/or are currently without significant development, the locations would represent either substantially large watershed areas where no data is currently available and/or could be important water sources in the future.

8.2 Phase 2A - Equipment and Monitoring

The streamflow monitoring stations would include some combination of continuous recording stage data loggers (e.g., like the existing EDT Technologies system or a U20-001-04 HOBO Water Level Loggers with a 0-4 m range at ± 3 mm) in conjunction with manually measured staff gauges at specific locations. Depending on channel conditions, weirs or flumes should be considered to enhance data accuracy and collection for deployment.

Periodic field visits (assumed 6 per year) would be required at each of these stations to download dataloggers, measure stage and discharge (required for developing stage-discharge rating curves) over a range of flow conditions, measure other channel geometry characteristics, and collect seasonal water quality data that would include at a minimum general field parameters (e.g., pH, dissolved oxygen, temperature, specific conductivity). Additional water quality analytes could be considered at this time but would involve laboratory analytical fees – our cost analysis below, however, assumes no sampling and analysis at this time.

The lake-level monitoring stations would include some combination of continuous automated recorders (e.g., like the existing EDT Technologies system or U20-001-04 HOBO Water Level Loggers with a 0-2 m range at ± 2 mm) in conjunction with manually measured staff gauges depending on accessibility, costs and the level of volunteer help. As with the streamflow gauging stations, general water quality data for general field parameters would be collected and additional characterization can be determined on an as-needed basis. For cost estimates purposes, however, no sampling and analysis have been included in the study plan cost estimate.

The climate stations would include a H21-001 HOBO weather station capable of recording temperature, relative humidity, solar radiation, wind speed and direction, barometric pressure, and rainfall (with tipping bucket). The higher elevation (and less accessible) Caren Range station could be installed with a telemetry transceiver, or manually downloaded on a periodic basis. We also suggest that late winter snow surveys be considered for high elevation areas (i.e., upper McNeill-Harris Lake watershed), or snowfall depths be measured at climate stations that experience significant snowfall. This would help in quantifying seasonal and annual water balances, especially for the high elevation areas of the watershed that experience significant snowfall. At this time, however, snow surveys are not included in the study plan cost estimate.

Other data stations could be considered that monitor groundwater conditions (e.g., groundwater levels, groundwater quality, etc) in areas of high groundwater well density and high surface water-groundwater connectivity. We have assumed at this time for cost estimates, however, that no additional types of data stations will be included.

8.3 Phase 2B – Compile and Manage Data and Mapping Information

Effective data collection programs (and watershed management) requires the development of an efficient, user-friendly and flexible means of managing, analyzing and displaying hydrologic and meteorologic data. We recommend utilizing SCRD-compatible spreadsheet based software (e.g., Microsoft Excel or Access) to help process, compile and organize historical and new data with the objective of facilitating the transparent storage, management, analysis and visualization of data among various workers at SCRD, UBC, Jacques Whitford and other interested parties. The data collection phase will involve rudimentary analyses of hydrologic data to develop, for example, stage-discharge relationships, hydrographs and the calculations of monthly and annual flow statistics.

The above compiled database will also require geo-referencing, such that physiographic map information, a number of other environmental and land use spatial information will need to be compiled, organized and effectively displayed to facilitate communication between researchers, field workers, managers and to Area A communities. This task identifies potential and desired map topics that are necessary to facilitate Phase 2 (Data Collection) and also provides a bases to those topics that will be become important during Phase 3 (Analysis and Research) and Phase 4 (Development of Watershed Management Plans).

8.4 Phase 3 – Analysis and Research

The specific elements and budget for this phase have yet to be determined, but it is expected to involve the following components:

- Refinement of Data Needs
- Mapping of Land Use Elements
- Water Balance Assessments
- Analyses and Modeling
- Reporting

Specific analyses and research topics are not well-defined at this time, but might include seasonal and long-term water balance studies, surface water – groundwater interactions, or lake storage – residence time evaluations of integrated watershed/lake systems. We expect that these concepts and needs would be developed during the program implementation of Phase 2, but will not be finalized until Phase 3. We anticipate that the program could support 1-2 year Masters of Science research topics that would be initiated in year 3 or 4. Dr. Moore will also play a more active role in developing specific studies while overseeing UBC graduate students as we begin to develop the agenda for Phase 3. Further, as specific research needs are understood, we expect that the on-going field data collection and mapping programs could be refined and/or modified to facilitate a specific research focus.

8.5 Phase 4 – Develop Watershed Management Plan

Towards the end of year four when a clearer understanding of data variability is achieved, an overarching Area A Watershed Management Plan can be developed. This plan will integrate critical aspects of the physical, biological and other geo-referenced data/information of individual watersheds (i.e., McNeil – Harris Lakes Watershed, Klein-Ruby-Sakinaw Lakes Watershed, etc.), and integrate existing and projected water supply demands with various supply options, while considering SCRD objectives, guidelines and milestones (e.g., optimize the lake system capacity and water supply to Area A communities while minimizing the impact on the environment and the existing communities). The plan should also identify strengths, weakness, opportunities and constraints of the integrated system in terms of supporting existing and projected future populations. Further, the plan should anticipate continued maintenance of critical aspects of the data collection program which would allow the SCRD to monitor the impact of water extraction to support current population and projected growth, and to optimize the capacities and minimize the impacts for both existing and new systems.

9 Benefit-Cost Analyses

There are four levels of costing which reflect successive additions to the monitoring network. The first level is just to upgrade existing stations (which would be handed over from DFO), while the next three levels are based on our recommended successive priority of data needs (as described in section 8.2), with the Level 1 addition being the first priority for new stations.

For each level of field monitoring during Phase 2 (from upgrading existing stations to Level 3 station addition) there are three basic tasks including:

- station set-up and equipment installation
- data collection and periodic monitoring (considered on an annual basis)
- data compilation, database management and reporting (also considered on an annual basis)

The study plan assumes that the set-up and installation of the monitoring stations will be conducted by hydrologists from the environmental and engineering consulting firm (JWA) under the supervision of Steve Wilbur, Ph.D., PGeo, while technicians from the Sunshine Coast Regional District will be trained during the beginning of the first year of equipment operation, monitoring, and downloading as well as the measurement of streamflows. A database management program will also be developed by JWA during the first year and integrated with SCRD's data collection program. We have also recommended that an annual technical data report be completed at the conclusion of each hydrologic year, which summarizes (objectives met, field issues, any site problems and conditions, tabulated summary of field measurements and station visits, table of data, figures showing hydrographs, recommendations for future – field station modifications, additions, deletions, etc). These reports will serve as the primary source for future research, modeling and analyses of Phase 3 and would be made available to concerned Area A residents.

Table 4 summarizes capital and annual recurring costs. A more detailed cost breakdown is provided Table B-7 in Appendix B. Upgrading the existing network currently managed by DFO is estimated to be approximately $10,425 for professional fees plus an additional $2,660 for equipment and expenses for a total of $13,085 (excluding GST and assuming all equipment is purchased through the SCRD). The annual recurring costs for data collection and periodic monitoring is estimated at $12,570 for primarily SCRD technicians plus an additional $2,700 for equipment and expenses, which includes an SCRD purchase for a velocity meter (i.e., Swoffer), for a total of $15,270 (excluding GST). The annual recurring costs estimates for data compilation, management and annual reporting (to be completed by JWA) is estimated to be $15,060 (excluding GST). Following this same format Table 4 summarized estimates costs for the various station addition levels for Phase 2. If all priority levels were implemented then the total estimated costs for year one would be $177,050, followed by annual recurring costs of $85,805. If some combination of priority levels were implemented then the estimated costs would fall between the Priority 1 estimate and the year one maximum total.

Table 4: Summary of Estimated Costs for Priority Levels 1-4

Program Level	Professional and SCRD Fees	Equipment, Supplies and Expenses	Totals
Priority 1 – Upgrade Existing Stations			
Installation	$10,425	$2,660	$13,085
	Annual Recurring Costs		
Data Collection & Monitoring	$12,570	$2,700	$15,270
Database Management & Reporting	$14,960	$100	$15,060
Year 1 Subtotal	**$37,955**	**$5,460**	**$43,415**
Years 2, 3 and 4 subtotals	**$27,530**	**$2,800**	**$30,330**
Priority 2 - Level 1 Station Addition			
Installation	$17,520	$10,410	$27,930
	Annual Recurring Costs		
Data Collection & Monitoring	$10,170	$200	$10,370
Database Management & Reporting	$11,140	$0	$11,140
Additional Year 1 Subtotal	**$38,830**	**$10,610**	**$49,440**
Years 2, 3 and 4 additional subtotals	**$21,310**	**$200**	**$21,510**
Priority 3 - Level 2 Station Addition			
Installation	$12,920	$7,690	$20,610
	Annual Recurring Costs		
Data Collection & Monitoring	$5,195	$200	$5,395
Database Management & Reporting	$5,620	$0	$5,620
Additional Year 1 Subtotal	**$23,735**	**$7,890**	**$31,625**
Years 2, 3 and 4 additional subtotals	**$10,815**	**$200**	**$11,015**
Level 3 Station Addition			
Installation	$19,860	$9,760	$29,620
	Annual Recurring Costs		
Data Collection & Monitoring	$11,610	$200	$11,810
Database Management & Reporting	$11,140	$0	$11,140
Additional Year 1 Subtotal	**$42,610**	**$9,960**	**$52,570**
Years 2, 3 and 4 additional subtotals	**$22,750**	**$200**	**$22,950**
Priority Levels 1-4 Year 1 Total	**$143,130**	**$33,920**	**$177,050**
Priority Levels 1-4 Year 2, 3 and 4 Total	**$82,405**	**$3,400**	**$85,805**

10 Closure

We trust this information meets your present requirements. Should you have any questions or require additional information, please contact the undersigned.

Respectfully submitted,

Jacques Whitford AXYS Ltd.

Reviewed by:

Original signed by:

Jennifer Todd, B.Sc.
Junior Hydrogeologist

Original signed by:

Stephen Wilbur, Ph.D., P.Geo.
Senior Hydrologist/Hydrogeologist

JT/SW/mp

[File Name/Path: P:_CMiC Projects\1035001_to_1036000\1035728 - SCRD WaterStudyPlan\Report\1035728 - Phase 1 Data Gaps Eval Final Report.doc]

11 References

Acroloxus Wetlands Consultancy, 2005. Garden Bay Waterworks District Conversion Plan. Report prepared November 2005.

Aqua-Tex Scientific Consulting Ltd. (Aqua-Tex), 1998. South Pender Harbour Drinking Water Supply: Preliminary Water Quality Survey – Haslam Creek.

Fisheries and Oceans Canada (DFO), 2008. FishWizard online database, http://pisces.env.gov.bc.ca/.

Bel-MK Engineering Ltd, 2005. South Pender Harbour Water District Drought Management Study. February 2005. Report prepared for the South Pender Harbour Water District in February 2005.

Bel-MK Engineering Ltd., 2006. South Pender Harbour Source to Tap Assessment Draft. Report prepared in October 2006.

Dayton and Knight Ltd.,1988. South Pender Harbour Water Supply. Report prepared for Sunshine Coast Regional District in September 1988.

Chatwin Engineering Ltd,. Undated. South Pender Harbour Water Supply System Operations and Maintenance Manual.

Edutech Technologies, Corp., 2005. Sakinaw Lake Water Study, prepared for DFO in coordination with Grant McBain

Gibson, D., 1996. South Pender Harbour Water Supply Study, prepared for the South Pender Harbour Waterworks District.

J. Termuende Hydrological., 2002. Data summary from yearly flow monitoring program: Haslam Creek, prepared for Chatwin Engineering Ltd., Nanaimo, B.C.

Kerr Wood Leidal Associates Ltd, 2005. Water Development Plan for Garden Bay Lake, report prepared for Sunshine Coast Regional District, September 2005..

McBain, G., 2004. Sakinaw Lake Water Balance Study, M.Sc. Thesis submitted to Royal Roads University, April 2004

B.C. Ministry of Environment, (2008) - various websites for sensitive fish habitat, park boundaries, First Nations lands

South Pender Harbour Waterworks District (SPHWD), 2005. Manual water level records from McNeill Lake: 1999-2005.

Summit Environmental Consultants Ltd, 2006. Final Report - Hydrologic Analysis of the Haslam Creek Watershed, September 26, 2006, letter report to Bel-MK Engineering Ltd for their Bel-MK 2006 report.

Sunshine Coast Regional District, 2007. Area "A" Water Master Plan Draft.

Sunshine Coast Regional District, 2008. Geo-referenced map data: topography, water bodies (lakes, streams, marine waters), road network, place names, park boundaries

Westland Resource Group, 1992. Sunshine Coast Regional District Electoral Area "A" Lakes Study, report prepared for Sunshine Coast Regional District in April 1992.