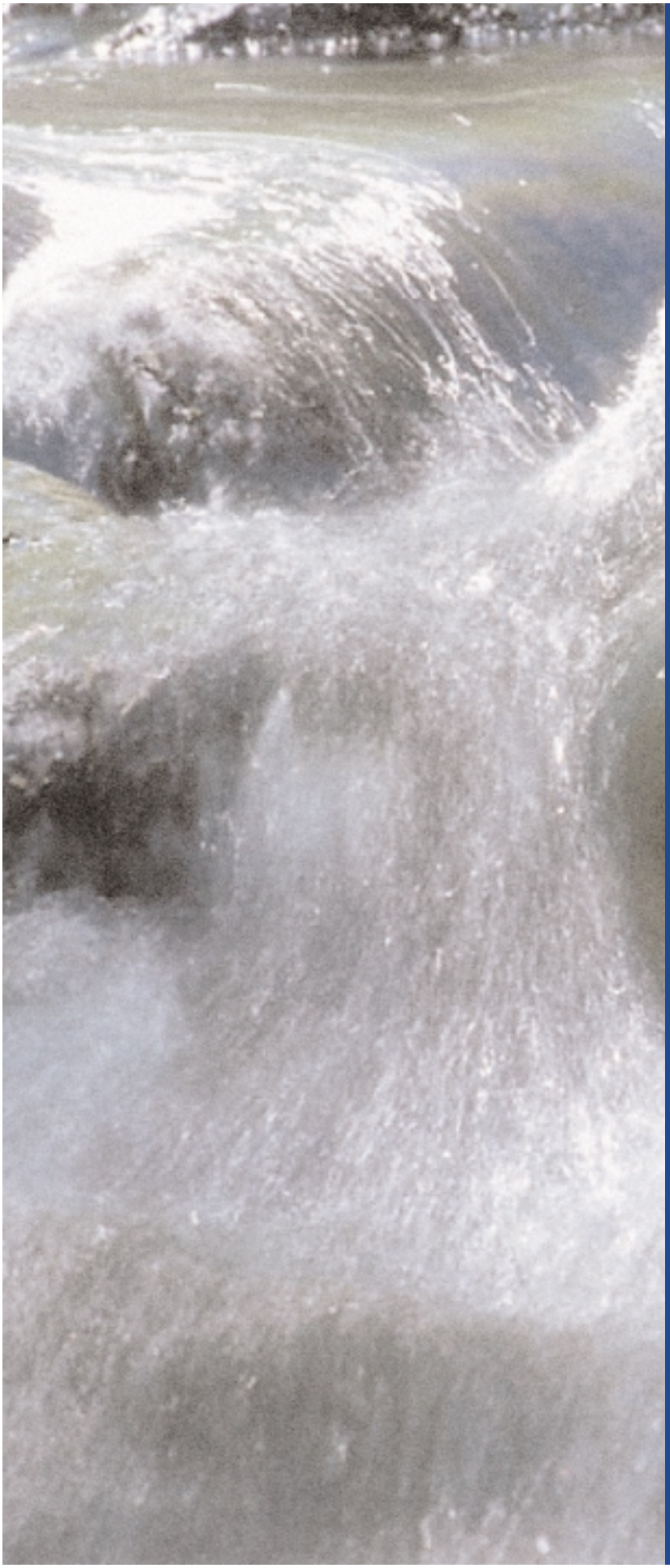

Water Quantity Monitoring in British Columbia:

A Business Review of the BC Hydrometric Programs

BRITISH COLUMBIA
Ministry of Sustainable Resource Management

April 2003

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Ministry of Sustainable Resource Management

Resource Information Department

Hydrometric Business Review

April 2003

Foreword

The business review of the hydrometric program in British Columbia is one of the most important initiatives the Ministry of Sustainable Resource Management (MSRM) has undertaken. The water quantity data gathered and published through this program provides immense benefits to the economic development, public safety and resource sustainability of the province. Yet, the importance of this program is poorly understood by many of the organizations that benefit from the data or are responsible for program funding.

The users and beneficiaries of the program are varied and dispersed. Besides the several major beneficiaries, the user community is comprised of hundreds of companies, consulting firms, government agencies, municipal and First Nations governments, universities and research institutes and other associations and organizations. The dispersed nature of this community makes it difficult for program support to be voiced. The operation and management of the program is also fragmented between the Water Survey of Canada, Ministry of Sustainable Resource Management and many companies and organizations independently gathering data.

The program already provides substantial benefits for the very modest amounts of funding expended. However, the program is clearly capturing only a fraction of the potential benefits obtainable. Too many users too often report that the program doesn't meet their needs, with serious consequences for ongoing resource investment decisions, design of water-related structures, and sustainable resource management. Almost all users feel the program is substantially under-funded. Many consider the program to be "broken." Importantly, many user groups have expressed interest in playing a role in "fixing" the program and exploring alternate ways to fund needed improvements and expansion.

As the broadly experienced consultants constituting the business review team, we have seldom seen a program where such a substantial amount of economic benefits and public good can result from a relatively modest investment in program infrastructure. To meet its enormous potential, the program requires strong leadership and appropriately increased funding. Implementing the recommendations in this report will lead to a program that provides a solid foundation for economic growth and the sustainability of BC's water resources. We urge the provincial government to provide the leadership the user community requires to work together for the well-being of this important program and the development of our province.

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Victoria and Vancouver, BC

26 March 2003

Marine Bombs and Other Phenomena

In his book *Bush Telegraph and Other Stories*, Stephen Hume writes about the impact the water created by "marine bombs" has on the climate, people and economy of British Columbia.

> The storm that lashed Vancouver and the coast was what meteorologists call a marine bomb…
>
> Here on the Northwest Coast our storms are a matter of billions—not in cost…. These maritime disturbances… are also the great atmospheric engines on which our whole provincial economy is based. They pay for our schools and hospitals and highways and municipal elections…
>
> Winter storms are what fill the rivers that generate hundreds of millions in hydro electric exports each year. They replenish the reservoirs that provide the cheap power that drives and gives competitive advantage to our manufacturing industries…
>
> British Columbia has almost 10 percent of the entire world's fresh water supply because of these storm systems. And without their ability to soak the ground so thoroughly, we'd have few of the fast growing forests that grace the province with fully half of Canada's softwood inventory. Our winter storms can be said to create 300,000 direct jobs for the economy…
>
> All these resources which derive from the great storm cycles of the north Pacific have one thing in common: the potential to bless British Columbia with an endless renewable foundation to economic life. They also have values that cannot be entered into the accountant's ledger.

Water is the "great" resource of British Columbia. Maximizing the benefit of water, and minimizing its occasional harm, requires knowledge of the resource. This report is about the hydrometric data that provides the essential foundation for that knowledge.

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Executive Summary

This executive summary of the BC hydrometric program business review explains the purpose of the review and how it was conducted; provides an overview of the uses and benefits of water quantity data and how they meet the business needs of users; indicates the economic value of the hydrometric system; explains our diagnosis that the current state of the hydrometric program is "broken" and summarizes our prescriptions for the renewal that will enable the hydrometric program to maximize its benefit to the people and economy of British Columbia.

Business Review Purpose and Modus Operandi

This business review of the BC hydrometric program was conducted by the Resource Information Department of the Ministry of Sustainable Resource Management (MSRM) to determine the most appropriate program required to serve the critical business needs of the user community. The business review assessed the ability of the existing network to provide the data needed by users to make important business decisions. The process also acted to inform the user community of the challenges faced in maintaining the network and assessed how that community can participate in obtaining and paying for their data requirements. Institutional and organizational options for the management of the program were also assessed.

The business review used focused consultations with users and service providers selected for having their fingers on the pulse of their sector. These were people who provided high-grade information and commentary on water quantity-related business needs and the essential underlying data requirements. Over 50 water management professionals were consulted at a workshop sponsoured by the BC Branch of the Canadian Water Resources Association (CWRA). This workshop provided additional insight into the various sectors through the eyes of the engineers contracted to provide sector clients with water management services.

The business review was guided by a high level steering committee of government (provincial and federal) and private sector executives. Ministry technical personnel were part of the project flow (management) committee. They provided direction and perspective without hampering the independence of the project manager and technical consultants and their focus on the needs of the user community.

The Uses and Benefits of Water Quantity Information and Data

Water in British Columbia is a critical resource for the well-being of the population and for economic activity in such sectors as energy, forestry, fisheries, agriculture and tourism. Stream flow and water level information is used every day by companies, business organizations, all levels of government, first nations and non-governmental organizations to make critical and important decisions related to economic development, public safety and resource protection. For these decisions to be meaningful and effective, comprehensive, accurate and up-to-date water quantity data must be collected through networks of monitoring stations.

The management of water in the province is challenging. As well as having the most complex terrain profile in Canada, British Columbia is one of the most climatologically diverse areas in the world and the streamflow variability reflects this terrain and climate diversity. The spatial and temporal distribution of the water resources is extremely complex with seasonal and year-to-year variations and climatic cycles that can last for decades. The potential for long-term climate change adds yet another level of complexity. A thorough understanding of the distribution of water provided by a comprehensive hydrometric program is critical for effective development and management of provincial water resources.

Three types of benefits have been quantified in this study: design-related benefits, flood warning and avoidance benefits, and sustainable resource management benefits. Design-related benefits stem from the use of hydrometric data to optimize the design of various types of hydraulic structures – bridges, culverts, pipeline crossings, dams, reservoirs, hydroelectric plants, dykes, other flood protection works, irrigation and drainage schemes, plus the various water-related structures of the mining industry. Flood warning and avoidance benefits are generated through the use of hydrometric data to either reduce flood damages through flood warnings, or to avoid flood damages completely through temporarily increasing dyke crests by sandbagging. Sustainable resource management benefits relate to the use of hydrometric data for the day-to-day operations of the resource sector in its efforts to achieve sustainable resource management objectives and requirements.

Meeting the Business Needs of the Users

The formal collection and dissemination of water quantity data is done by the Water Survey of Canada (WSC) through the BC/Canada Agreement. The WSC operates an "integrated" program that includes a network of 461 stations. Most of the WSC operated stations serve the needs of a large number of organizations sharing the use of common data. Where WSC stations provide data to single non-government users, the users pay for the installation and operation of the stations.

The limited coverage of the BC/Canada Agreement network has resulted in a large amount of additional data being collected by numerous organizations and consulting firms. This large number of stations and independent measurements is not part of an "integrated" network and the data are not made available to the broad user community. Also, as the data are not collected using verifiable quality control standards, they cannot be shared effectively. A large potential value of these data is being lost to the user community.

It appears that sectors such as water supply, agriculture and sewage disposal are reasonably well-served by the hydrometric network. The major economic sectors of forestry, transportation, small hydro, mining, and oil and gas are the least well-served. These sectors require short- and long-term regional data, often on small streams throughout the province. The flood warning systems on the major rivers serve the larger downstream communities in the province quite well. Other communities are less well-served

Many of the benefits of the hydrometric network for all sectors relate to cost savings in design and construction and reduced operating costs. Where data are inadequate, there is

increased uncertainty in the design process and conservative decisions are made to compensate for the risk. These decisions are made not only by project designers and operators but also by regulators. This sometimes leads to less water being allocated for the project than is available; in other instances approvals may be delayed or, in the extreme, denied due to this uncertainty.

In the case of the small hydro and mining sectors, investors require low risk regarding available water supplies for power generation, mill operation and waste disposal. Streamflow records are key to demonstrating project feasibility and the absence of adequate data can lead to reduced investment in the province.

Economic Value of the Hydrometric System

The literature on the economics of hydrometric networks indicates that substantial benefits accrue to the economies in which the networks operate. The literature also strongly suggests that government owners and managers of hydrometric systems throughout the world have limited those systems to scales far below what would be optimal for the overall economies that they serve. Networks that are sized at sub-optimal scales fail to capture substantial amounts of potential hydrometric benefits. As is made evident in this report, the situation in BC is no different.

The total of the annual benefits generated by the existing hydrometric program is about $84 million. However, the current inadequacy of the network is estimated to result in at least $82 million annually in capital and operating inefficiencies and losses throughout the resource sector of the province. These losses could be avoided through appropriate expansion of the network. The expansion required to obtain these additional savings is substantial, probably involving well in excess of a doubling of the network, and possibly in excess of a tripling of network size.

The cost of operating and maintaining the present network of 461 stations is about $4.5 million annually. The estimated benefit/cost ratio of the current network is therefore 19:1. Every dollar spent continuing to support the present network returns more than nineteen dollars in benefits. It is also clear that expansion of the network is in the best economic interests of the province, and would promote Provincial goals of economic growth and sustainable resource development. Even if a tripling of network size was required to capture all of the benefits that the existing network fails to garner, it is likely that such an expansion would have a benefit/cost ratio of as high as 9 to 1. Less ambitious expansions, including the proposed provincial standards program for the capture and dissemination of hydrometric data from non-WSC stations, would have appropriately higher benefit/cost ratios.

Assessment and Diagnosis: The State of Program Delivery

British Columbia does not have an effective well-managed hydrometric program. Existing hydrometric operations suffer from a lack of focused, committed executive level leadership and vocal, supportive champions. Potential champions in the user community have difficulty being heard by the "service" providers due to the lack of an effective forum and consultation mechanism.

A hydrometric network of data collection stations, data bases and reporting mechanisms are the technical or system part of a hydrometric program. To operate effectively, the integrity of the "whole" system (collection, storage, retrieval, analysis and reporting) must be maintained if it is to provide the data needed for business decisions. The system or process integrity of the BC/Canada Agreement Network is complete. However, the number of stations existing core funding will support is far below the optimum required to meet the needs of the broad user community. The size and effectiveness of the "whole" program has been compromised in recent years through such things as budget and staff reductions and a general shift in emphasis towards information systems and away from gathering important data. If core base-budget funding is not secured to replace the existing shortfall, the BC/Canada network will be cut to approximately 300 stations from the present 461. This will result in the loss of operations capacity that could not be rebuilt for at least five years and a financial liability of a million dollars for the decommissioning of discontinued stations.

There is no integrated hydrometric system for the capture, storage, and dissemination of the data collected outside the BC/Canada Agreement Network. Considerable funds have been spent in the development of the Ministry of Sustainable Resource Management's WIDM (Water Information Data Management) data base and the development of a set of provincial (RIC) standards. However, little water quantity data can be captured by WIDM due to the lack of a standards management system. An empty data base does not serve user community needs. Funding the development and operation of a standards management system would significantly enhance and complement the BC/Canada Agreement network. If resources are not found the work on standards development to date will be largely wasted.

Prescription: Towards an Effective Client-focused Program

Implementation of the following recommendations is critical for the renewal of the hydrometric program. Renewal is essential if the hydrometric program is to provide the water quantity data foundation required to support and sustain public safety initiatives, robust economic development and sustainable resource management.

- **One: Provide the Leadership to Move Forward**

  Leadership is the biggest challenge facing the program. Strong, dedicated leadership is essential to implement the changes required to turn existing hydrometric operations into an effective comprehensive program. The government service delivery organizations need executive-level leadership to consolidate and enhance their funding and to enable staff to focus on meeting user needs. Leadership is also required to pull together the large diverse user community and encourage it to support the program in proven and innovative ways. MSRM is in the pivotal position to provide this leadership and the ministry must reaffirm its commitment to the hydrometric program and to providing quality hydrometric data for the user community in British Columbia.

- **Two: Promote the Program**

  To meet its potential, the program has to move from its historical roots as a strictly technical operation to being a dynamic business oriented organization that promotes

and markets its services and benefits the user community. Promoting and marketing the program will create a more global awareness of its benefits and facilitate the development of alternate funding mechanisms.

• Three: Improve the BC/Canada Agreement Network

Immediate action to consolidate funding for the existing base network is critical. Constant funding uncertainty is a root cause of the problems facing the program and leads to sub-optimal decisions on network size and configuration. The BC government must take the lead in developing the funding mechanisms and partnerships required to support the BC/Canada Agreement Network at its existing size and plan for its expansion. This includes encouraging the federal government to increase its commitment to the economic development, public safety and resource protection of British Columbia by increasing its support for the network.

• Four: Implement a BC Standards Management System

MSRM should implement a standards management system for the collection, storage and dissemination of the significant volume of data being collected through the informal "disintegrated" network.

The amount of benefit provided by assisting the collection of accurate data and making that data available through BC government data bases would be magnitudes greater than the modest amount of funding required. While this review did not allow for the detailed costing of the staff and resources required to manage a BC standards management system, a rough estimate of the amount required is $250,000 to $300,000 per annum.

• Five: Lead the Development of Suitable Funding Mechanisms

The future well-being of the hydrometric program requires the user community to increase funding contributions to the program. Leading the development and implementation of suitable funding mechanisms for government and business sector participants is an important role of the hydrometric program. Mechanisms should include consideration of base budgets, license and permit fee surcharges and cost-sharing partnerships.

• Six: Move Toward a New Institutional Structure

There is a need to develop a suitable institutional arrangement to coordinate the diverse user and service delivery community in collectively managing and supporting the renewal and development of the hydrometric program. There is a need for a common organizational focal point where all players can come together for the overall well-being of the program and the essential business needs. Unless representatives of the major users and service providers work together, the state of the hydrometric program will continue to deteriorate.

The first step is the creation of a management board that will develop a step-by-step renewal plan for the hydrometric program. The management board will take the lead in promoting the hydrometric program renewal and building the partnerships that will provide the program's long-term funding. To succeed, the management board will require a small focused secretariat.

• Seven: Move Forward: Keep the Momentum Going

This business review was conducted from the perspective of the user community and the data they require to make important business decisions. Meeting client needs is what makes a program viable. During consultations, several business sector leaders expressed their desire to meet with senior government officials to discuss their data needs and their thoughts on program renewal.

It is extremely important that a meeting take place to begin the public-private collaboration that will begin the hydrometric program renewal. It is recommended that a meeting be scheduled as early as possible in the new fiscal year.

Succeed by Doing What is Necessary

The hydrometric program's key infrastructural importance in the province is much greater than most senior government and business officials appreciate. The program provides quality data that is the foundation for a vast array of economic development, public safety and resource protection business decisions. This lack of appreciation has led to neglect that, in turn, has created a program on the brink of collapse.

The action required to renew the BC Hydrometric Program is relatively straightforward and the funding required is minimal in relation to the vast benefit the program provides users. However, the program will not renew itself. Leadership, focus, the dedication of the required resources and commitment to follow-through are essential to build the program the province needs.

Now is the opportunity for the Ministry of Sustainable Resource Management to lead the renewal of the hydrometric program. The ministry is urged to take up the challenge.

"It is no use saying 'We are doing our best'

You have got to succeed at doing what is necessary."

Winston Churchill (1874 – 1965)

Introduction: the Hydrometric Business Review and Program

Business Review Purpose, Objectives and Modus Operandi

This business review of the BC hydrometric program was conducted by the Resource Information Department of the Ministry of Sustainable Resource Management (MSRM) to determine the most effective program and network required to serve the critical business needs of the user community.

Providing the right data to make water-related decisions is a costly, but essential, service. The annual cost of operating the BC network's current level of 460 stations is approximately $4.5 million. Future funding levels are unstable and funding reductions are a real possibility. In light of funding and budget realities, a business review of the hydrometric program is critical for determining the impact potential cuts would have on the users of hydrometric data and their public safety, economic development and resource protection needs.

The objectives of the business review were to inventory and assess:

- the core business decisions that key clients, potential clients and constituents must make that require water quantity information
- the hydrologic/hydrometric information and data needed to make those decisions
- the need for standards, quality assurance and audit practices
- options for program management and delivery including provincial government roles and other institutional options
- financial management and funding options and constraints including negotiated cost recovery based on data needs and operational realities

How the Business Review was Conducted

The business review assessed the ability of the network to provide the data needed by users to make important business decisions. The process also acted to inform the user community of the challenges faced in maintaining the network and assessed how that community can participate in obtaining and paying for their data requirements. Institutional and organizational options for the management of the network and network data were also assessed.

The authors have attempted to tell, in a clear and concise report, the definitive story about the need for hydrometric stations and data by all users and potential users. The business review used focused consultations with users and service providers selected for having their fingers on the pulse of their sector. These were people who provided high-grade information and commentary on water quantity-related business needs.

Over 50 water management professionals were consulted at a workshop sponsored by the BC Chapter of the Canadian Water Resources Association (CWRA). The CWRA workshop *"Who needs it? Who cares? A Business Review of the BC Hydrometric*

Program" provided the opportunity for participants to contribute to this important subject. Participants were able to discuss and comment on the hydrometric program from the perspective of their business needs and those of their clients.

The business review was guided by a high level steering committee of government (provincial and federal) and private sector executives. Ministry technical personnel were part of the project flow (management) committee. They provided direction and perspective without hampering the independence of the project manager and technical consultants and their focus on the needs of the user community.

The Need for Water Quantity Information and Data

Water in British Columbia is a critical resource for the well-being of the population and for economic activity in such sectors as energy, forestry, fisheries, agriculture and tourism. Stream flow and water level information is used every day by companies, business organizations, all levels of government, first nations and non-governmental organizations to make critical and important decisions related to economic development, public safety and resource protection. For these decisions to be meaningful and effective, comprehensive, accurate and up-to-date water quantity data must be collected through networks of monitoring stations.

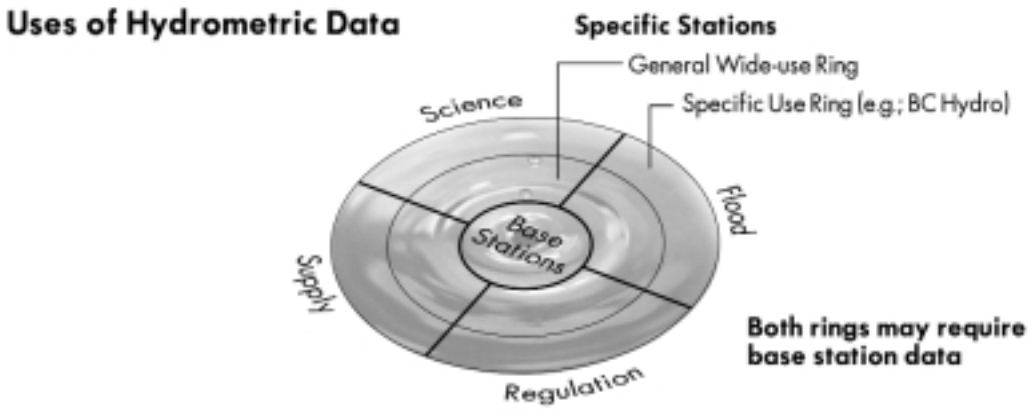
The management of water in the province is challenging. As well as having the most complex terrain profile in Canada, British Columbia is one of the most climatologically diverse areas in the world ranging from near-desert in the Southern Okanagan to temperate rainforest in coastal areas. Streamflow variability reflects this terrain and climate diversity. The spatial and temporal distribution of the water resources is extremely complex with seasonal and year-to-year variations and climatic cycles that can last for decades. The potential for long-term climate change adds yet another level of complexity. A thorough understanding of the distribution of water provided by a comprehensive hydrometric program is critical for effective management of provincial water resources.

Hydrometric data are used by a variety of organizations in the following ways:

- **to characterize water resources:** including the magnitude of floods, droughts and the seasonal distribution of flows. A long length of flow record is required to characterize the year-to-year variability and the potential magnitude and duration of extremes.
- **for statistical analysis:** to determine design floods and droughts, calibration of watershed models to simulate reservoir operations, design of stream and river crossings for roads, railways and pipelines and design of stormwater management. The data are critical for design and operation of water supply and sewage treatment plants. Hydrometric data are also used for the design of water supply, flood control and waste management for mine development.
- **to optimize hydropower planning and operations:** hydropower generation is a critical component of the economy of the province. BC Hydro uses hydrometric data to optimize operations and for planning new facilities. Independent power producers use hydrometric data to determine whether small hydro sites are economically feasible.

- **for flood warning and flood control works design:** flood control is important for public safety in our mountainous province. Hydrometric data are used for design of flood control works and for flood warning systems.
- **for regulatory purposes:** regulatory agencies are major users of hydrometric data. The information is required for licence reviews, licence approvals, compliance monitoring and fisheries management.

Where hydrometric data are inadequate, the tendency of designers, operators and regulators is to make conservative decisions to compensate for the uncertainty and reduce the risk. As will be shown in this report, this leads to reduced project investment, project delays and increased costs for construction and operation.



The uses of hydrometric data can be grouped into four broad categories: scientific knowledge, flood protection, regulation and water supply. A minimum number of stations are required to provide a base amount of data that are essential to all uses. A large number of general wide-use stations provide data to a vast number of users and there are some stations that are used specifically by one user. While financial support for the latter stations can be collected from the user, it is difficult and expensive to try to allocate the cost of the general use and base stations. Funding these stations, arguably, is the responsibility of government.

Meeting the Need: Hydrometric Networks and Data in BC

The formal collection and dissemination of water quantity data is done through the BC/Canada Agreement network of stations operating as an "integrated" program. Due to the limited coverage of the integrated network, there is also a very large amount of data collected by organizations and consulting firms. This large number of stations and independent measurements comprise a loose "disintegrated" network the data from which are not made available to the broader user community. Also, as the data are not collected using verifiable quality control standards, they cannot be shared effectively and a large potential value is being lost.

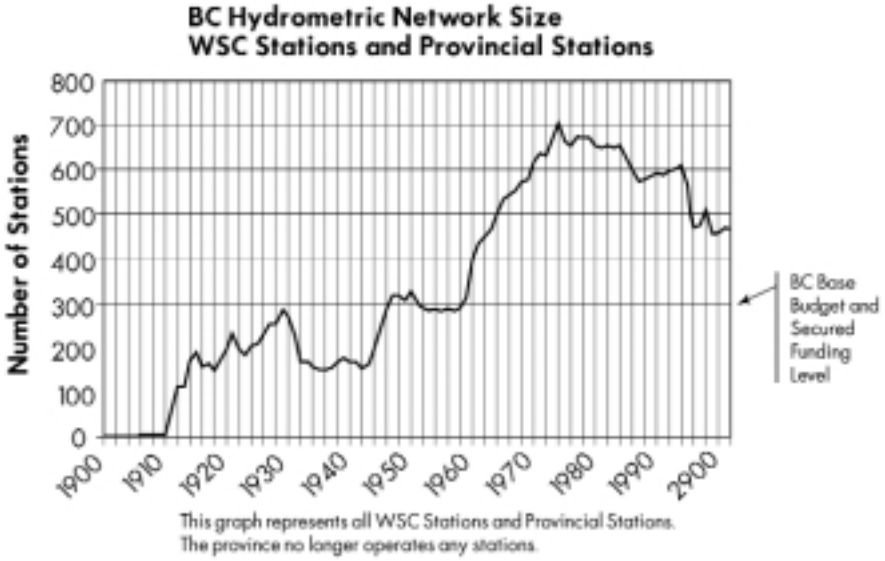
The following is a brief description of the "integrated" and "disintegrated" networks:

The BC/Canada Hydrometric Agreement and Network

The primary hydrometric network in BC is operated by Water Survey of Canada (WSC), Environment Canada, under the Federal-Provincial Agreement on Water Quantity Surveys commonly known as the "Hydrometric Agreement." The current agreement has been in place since 1975 and is one of 12 such agreements (Federal-Provincial/ Territorial) across the country. Under the agreement, the Province has a number of roles: funding a share of the network, program management input to WSC (called "co-management'), and business management for clients that provide outside funding.

Both parties have a designated Administrator and Coordinator for the Agreement program. The WSC uses in-house staff to conduct all monitoring operations to federal standards, assure data quality and "publish" data (from a national database) for use by staff, stakeholders and the public. This service is provided under full cost recovery—including station construction, operation and decommissioning. The WSC program in BC benefits from support from the WSC national office in Ottawa, which is funded entirely by Environment Canada.

The network is currently 461 stations, down from a peak of 601 in 1993/94. Stations are designated federal, provincial or federal/provincial class, with costs shared accordingly. The provincial portion includes both government and private (e.g. BC Hydro) components and has been supported partly from 1997/98 until 2001/02 by funding from Forest Renewal BC (FRBC). The total network budget for FY02/03 is approximately $4.5M divided among Environment Canada $1.4M; MSRM (Aquatic Information Branch) base budget $1.3M; MSRM special short term funding $0.7M; and other parties $1.1M.



To meet the provincial obligation of $2 million in fiscal 2002/03, MSRM's base budget of $1.3 million was supplemented by $.7 million in special funding. In fiscal 2003/04, the base budget has been reduced to $.95 million, sufficient to support a network of 300 stations. Therefore, $1.05 million is required to keep the current size of the network from dropping. Although special short-term money has been allocated for the 2003/04 fiscal year, there is no designated source of funds beyond that time. The network will drop to approximately 300 stations unless alternate funding is found.

Other Hydrometric Stations and Data (The BC Network)

Hydrometric data is also collected around BC by a variety of parties other than WSC. These can include corporations, consultants, local governments, etc. General purposes can include data for operational needs, regulatory requirements (water licenses, waste permits, etc.), and data for project development and approval process. Historically there has been a great range of quality of these hydrometric operations, and much of it has been poor quality. More importantly almost none of it is of "provable" quality or accuracy, and almost none of it has been captured in a central archive where it could be made available to users.

In the mid 1990's, with impetus and funding from FRBC, the Province began to develop a standard system for hydrometric data collection. The Manual of Standard Operating Procedures for Hydrometric Surveys in British Columbia was published in 1998, under the umbrella of the Resources Inventory Committee (RIC). An interim system for quality control was developed on a small scale, with "Certified Approvers" designated to carry out the essential task of data review and approval. This system has essentially fallen into disuse at this time, as the Province does not have the staff resources or budgets to create or operate a permanent system.

The Province also developed a database to capture time-series water data, including hydrometric information. This system, called Water Information Data Management (WIDM), has recently reached a reasonable level of functionality. It includes hydrometric forms for use in station operation, as laid out in the hydrometric manual.

Major issues exist around the subject of data standards. Historically, a variety of private and public parties have either operated or taken measurements from hydrometric stations to no particular standard. The Province has been developing a standard system (RISC Hydrometric Standards) over the last 5-6 years to support the collection of hydrometric data by any interested party, to provable standards. This is intended to provide a system whereby parties such as corporations, local governments, or consultants may operate a hydrometric station in a manner that will produce data of known quality. The RISC hydrometric standards comprise technical information, operational forms, and require review of station operation and approval of data by a certified individual. The RISC standard system is not fully functional at this time, due to an incomplete system for ongoing operation and management of the system, and lack of system components for certification of data approvers, audits, and several other key areas. Only a handful of stations are being operated under this system at this time (exact number not known).

MSRM's Hydrometric Operation

The hydrometric operation within the Resource Information Branch of the Ministry of Sustainable Resource Management consists of a senior engineer and a new position for an assistant engineer which has not yet been approved for permanent staffing. As of April 1, 2003, no one in the management hierarchy of the Ministry has a significant amount of experience or background in hydrometric programs and no one has the responsibility for the integrity of the "whole" hydrometric system or program.

Part II

Principal Uses of Hydrometric Data in Canada

- Aquatic Ecosystem Research
- Climate Change Research
- Environmental Impact Studies
- Fisheries Management
- Flood Forecasting
- Floodplain Management
- Forest Management
- Hydro-Electric Power Generation
- Infrastructure planning and design
- Interjurisdictional Water Apportionment
- International Relations
- Irrigation and Drainage
- Operation of Dams and Reservoirs
- Recreation (e.g. boating)
- Regional resource inventories
- Regional water management
- Sediment Studies
- Stormwater management
- Transportation/navigation
- Water quality studies
- Water Resource Assessment/inventory
- Water Resources Research
- Water supply studies
- Watershed studies

The Economic Benefit of Hydrometric Data

A Multiplicity of Uses

Hydrometric networks, and the data they generate, serve a multitude of users in a wide-ranging variety of ways. With technological advances allowing for the delivery of real-time and historical stream flow data directly to the public, both the number of users and the nature of their uses has expanded widely in recent years.

Economically, the most important use has long involved traditional engineering applications for the design of hydraulic structures - dams, reservoirs and water supply schemes, hydroelectric plants, bridges and other stream crossings, sewage treatment and waste disposal facilities, tailings ponds and mine process facilities, flood and erosion protection works, drainage and irrigation schemes, in-stream fisheries works, and other engineered structures.

In recent decades, as early communications advances allowed for some capture and delivery of real-time flow data to at least a few, key users such as BC Hydro, and the Provincial Emergency Program (PEP), the hydrometric network began to deliver important economic benefits in terms of optimising hydroelectric production as well as avoiding or reducing flood damages. These benefits have grown in step with ever-improving communications technologies and the wider employment of these technologies throughout the hydrometric network.

There have also been recent advancements in the creation of Integrated Stormwater Management Plans (ISMPs). Under the umbrella of Liquid Waste Management Plans, the province is requiring local authorities to develop ISMPs.

The recent development of making real-time and historical stream flow data for BC available on the world-wide web has not only allowed traditional users to have much more ready access to the data but is increasingly generating additional, often innovative, new and productive uses for the data. Many white water rafting, fishing guides and other eco-tourism managers now plan their river use around the data. Hydrologists, aquatic biologists, and other field personnel from both the public and private sectors routinely consult the data to optimise the timing of their field investigations. The data are reviewed by construction managers to plan the timing of in-stream or near-stream work, as well as to monitor the safety of ongoing work. Forestry personnel consult the data to determine the need for safety inspections of stream crossings and bank protection works. Government regulatory personnel evaluate the data to set or amend approvals for reservoir operations, in-stream works, and effluent releases. Farmers, public water supply managers, mine managers and others track the data to forecast potential shortages and to optimise water storage and abstraction operations. Stream keeper and other public interest groups use the data to more closely monitor the health of streams and rivers.

As awareness of the hydrometric data base grows, and particularly as the Province continues to implement its sustainable resource management strategies, including the move to "results-based" codes of operation, the use of the hydrometric system to effect operating efficiencies while continuing to meet resource protection requirements will also continue to grow.

Value of Hydrometric Systems

The value of the hydrometric system, at any point in time, is determined by the ongoing need for the types of information it provides, as well as its ability to deliver accurate and representative data to meet those needs. Any hydrometric network clearly cannot provide such data to all users for all locations and applications. Its utility will be limited by the number and location of points where data are collected, the length of available data records and by the accuracy of its records.

There are obvious difficulties in quantifying the value of a hydrometric system. The users are numerous, poorly identified and widely dispersed. The data are often used only years after collection, and then at a range of different scales (local, river basin, regional, even provincial), and in complex processes that vary by user and use and which do not easily lend themselves to a determination of data value.

Not surprisingly, the literature on the economics of hydrometric networks is somewhat sparse. While several references address the statistical value, and in some cases the economic value, of hydrometric data for specific projects or types of applications, and a few other studies address optimisation of network design or siting of specific stations, few economic studies have been carried out for whole networks.

Interestingly, the first such study appears to be a 1977 evaluation of the Canadian hydrometric network by Acres Consulting Services Ltd. This study concluded that:

- most of the quantifiable benefits of the hydrometric system included design-related savings in the construction costs of hydroelectric conveying and controlling structures, and highway bridges and other stream crossings.
- similar, but much lesser, savings were identified for irrigation projects, flood control works, and sewage disposal systems.
- a small benefit was identified related to the use, quite limited at the time, of real-time hydrometric data to operate flood warning systems.
- even with this limited quantification, the benefits of the Canadian hydrometric system outweighed the costs of the system by more than 9 to 1. For BC, the quantified benefits were 5.6 times the costs of what, at the time, was a network of 633 stations costing $2.5 million to operate ($7.8 million in 2003 dollars).

"New" uses related to sustainability of economic activity and environmental values were not considered.

A 1991 study of the UK hydrometric system, carried out by CNS Scientific and Engineering Services, proved to be even more limited in the types of benefits quantified. The only benefits quantified related to design and operation of potable water and irrigation schemes, and for flood protection and warning. Despite this limited outlook, and even after somewhat arbitrarily grossing up actual government expenditures on the hydrometric system by a further 150% for administrative overheads, this study concluded that its best estimate indicated benefits were 2.3 times grossed-up costs and, for just the benefits quantified, could be as high as 7 times costs.

In the early 1990s, Cordery and Cloke carried out a number of investigations of specific uses of the hydrometric data in New South Wales, Australia. At the time, the

hydrometric system in New South Wales comprised approximately 500 stations serving a hydrologically and topographically diverse land area of approximately the same size as BC and supporting similar levels of population and economic activity. Their conclusions included:

- if data from the 500 gauging stations were only used for the design of storage reservoirs, data collection benefits would remain in excess of costs until record lengths reached approximately 80 years.
- The benefits of hydrometric data stemming from the design of stream crossings alone between 1958 and 1987 were 22 times the costs of the entire hydrometric program in New South Wales during this period. Benefits identified included prevented capital losses due to over-design, avoided damages to structures due to under-design, and cost savings related to the potential delays and additional travel associated with avoided failures.
- The benefits of collecting hydrometric data for flood avoidance works outweigh collection costs by up to 80 to 1. They recommend that whenever data are scarce and a future need of this sort is likely, collection programs should be commenced immediately.

More recently, the University of Dundee (Black et al, 1999) has published a preliminary methodological guide for evaluating the benefits of hydrometric networks. While this guide is largely oriented to the evaluation of single watersheds, it does offer some insights into the evaluation of whole networks. In particular, one innovation found in this methodology is the concept of scaling benefits according to the representativeness, record lengths, and accuracy of the stations used to generate the benefits being evaluated.

This consideration is equally applicable to the evaluation of whole networks, but has not been employed in any of the network studies documented above. In these studies, the design benefits of a network are typically expressed as a percentage of the total construction costs of certain types of hydraulic structures, where the percentage benefit has been derived from individual case studies or from expert opinion that has been formed around specific design experience. Implicit in the estimates is the assumption that the available hydrometric information is representative, and has a sufficient record length and accuracy to be able to capture the estimated design benefit. When considering all of the design activity throughout a network jurisdiction (Canada, BC, the UK, New South Wales etc.), this assumption is not realistic. In many instances, the available hydrometric data will not be ideal for the task at hand and design benefits will fall short of the maximum. For this reason, the evaluation of the BC network herein employs the concept of scaling in an attempt to address the limitations of the network and to highlight the opportunity that is available to capture additional economic benefits through network continuation and expansion.

Optimal Versus Typical Scales for Hydrometric Systems

The literature on the economics of hydrometric networks indicates that substantial benefits accrue to the economies in which the networks operate. While it is a given that the overall economic utility of hydrometric systems will always increase with more stations and longer records, the question that must always be asked is whether such increased benefits

outweigh the costs of network expansion. Like the provision of any other good or service, the collection of hydrometric data is not immune to the principle of diminishing returns. However, review of the available literature strongly suggests that government owners and managers of hydrometric systems throughout the world have limited those systems to scales far below what would be optimal for the overall economies that they serve. As will be made evident in this report, the situation in BC is no different. Figures 1 and 2 illustrate this situation graphically.

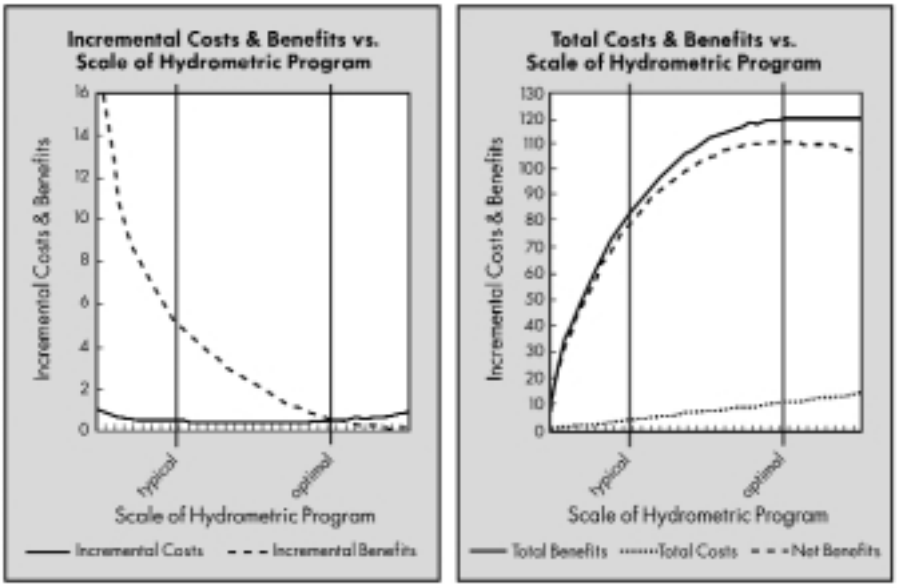


Figure 1 depicts the incremental or marginal costs of operating a hydrometric system, and the corresponding incremental benefits that arise out of the operation. Unit (per station) operating costs are fairly constant over a wide range of scales, other than at very small scales, where the high initial costs of establishing a centralized archive and administration weighs more heavily on the few available stations, and at very large scales, where it becomes more expensive to locate and operate additional stations in increasingly difficult, and often more remote, locations.

Initially, at small network scales, the value of each station is very high relative to costs. Initial stations are sited where they can do the most good, and users make maximum use of the limited data available. As the network expands to somewhat larger scales, the incremental benefits provided by additional stations begins to fall, but still remain many times above the incremental costs of operating those additional stations. The national, provincial and state networks examined in the literature appear to have scales that are situated in this intermediate area (line labeled "typical" in Figure 1) and, this too, appears to represent the position of the present network in BC. In fact, Figures 1 and 2 are meant to be representative of the BC hydrometric system, at least to the extent that some of the information portrayed in the figures can be deduced from the present situation.

Networks that are sized at "typical" scales fail to capture substantial amounts of potential hydrometric benefits. In Figure 1, the area between the incremental benefit and cost curves, to the left of the "optimal" line represents the net hydrometric benefits available for capture by an optimally-scaled network. However, a "typical" network only captures the benefits between the curves to the left of the "typical" scale.

Figure 2 presents the same information as Figure 1, but provides cumulative totals for benefits, costs and net benefits at increasing network scales. "Typical" and "optimal" scales are defined in the same locations as for Figure 1, but whereas in Figure 1 the optimum point occurs where incremental benefits just equal the incremental costs of adding another station, in Figure 2 this point coincides with the maximum of the net benefits curve.

Benefit-Cost Analysis of the BC Network

Benefit-cost analysis is a commonly used tool for government decision-making. In Figure 2, it is apparent that the benefit-cost ratio for the "typical" network is very high, with total benefits of over $80 million, compared to total costs of between $4 and $5 million, indicating a benefit-cost ratio of close to 20. This, in fact, is the approximate outcome of the economic analysis of the current BC hydrometric network, as outlined in later sections of this report.

It should be noted that benefit-cost ratios never say anything about optimality. In fact, it is a given that sub-optimal investments in hydrometric networks will always have higher benefit-cost ratios than optimal investments. Maximum benefit-cost ratios occur for networks that are substantially under-scaled, where the limited amount of hydrometric data collected is extremely valuable. Rather than being used to optimize investments, benefit-cost ratios are useful for comparing competing uses for scarce government finances. In this regard, it is obvious that in BC, as elsewhere, hydrometric systems represent extremely attractive public investment opportunities, capable of generating very high returns throughout the economy.

The Need for Hydrometric Data—by Sector

The need in British Columbia for hydrometric data to make important business decisions related to economic development, public safety and resource protection is very substantial. This section presents an analysis of the principal economic and resource management sectors that rely on water quantity data and information to make business decisions. A general description of each sector is followed by a discussion of how hydrometric data is used to make business decisions. Where available, the historical and possible future participation of data users in the hydrometric system have been indicated. An analysis of the economic benefit the data provides to the sector is then provided.

The sectors discussed are:

- **Forestry**
- **Transportation (Road and Rail)**
- **Hydropower**
- **Mining**
- **Agriculture**
- **Oil and Gas**
- **Sewage Treatment**
- **Water Supply**
- **Flood Mitigation**
- **Resource Management**
- **Government Programs**

Forestry Sector

Sector Description

The forestry sector remains one of the major drivers of the BC economy. It is by far the largest industrial employer in the BC, with employment widely dispersed throughout the province. In 1999, the forest industry directly contributed almost $3,600 million to provincial GDP and accounted for about 26,000 jobs. Another $5,400 million of GDP and 61,000 jobs were supported by wood, pulp and paper product manufacturing. If all related direct activities are considered, the sector's contribution rises to almost $9,000 million in GDP and about 90,000 employees.

Hydrometric Data Requirements

The forestry sector has a wide-ranging requirement for hydrometric data. Timber harvesting activities have potential impacts on watercourses and protection of riparian areas is a fundamental objective of the Forest Practices Code. In order to understand the

potential for peak flow events and drought periods, detailed hydrological analysis is required. The forestry sector operates in remote areas with widely varying topography and climate that results in significant variations in hydrology. Therefore the hydrologic analyses have to be supported by a comprehensive regional hydrometric data network.

As summarized by Shelley Higman, Terrain and Hydrology Specialist for Weyerhaeuser Canada, hydrometric data are used by the forestry sector for the following applications:

- design of drainage structures.
- estimates of stream potential for debris/sediment transport to downstream infrastructure.
- estimates of streambed scour.
- design of bank protection (i.e., armour along channel banks or road fills).
- assessment of fish usage and habitat quality (peak flows, low flows, flow velocities).
- design of stream restoration measures and habitat enhancement measures.
- correlation with stream channel changes visible on air photos, to help establish causes of channel change, and identify channel-forming events.
- where water extraction is planned or in place, estimates of available and residual stream flows (e.g. for habitat projects).
- design of storm water controls.
- correlation with harvest rates to establish relationships between harvesting, road density and potential flow changes.

Most of the riparian concerns are on small streams and rivers in remote areas. The BC hydrometric network is inadequate in providing information for this requirement. The tendency is for WSC gauges to be located on larger rivers and gauges on small streams are typically located in populated areas. This problem has long-been recognized and steps were taken to expand the network to small streams in remote areas under funding from FRBC. However, this funding has been curtailed and long-term funding for these stations is not committed.

Sector Participation in the Hydrometric System

The forestry sector has had a long history of participation in the hydrometric system. This has included setting up stream gauging stations both in partnership with government agencies and stations run by industry alone. Much of the data collected directly by industry is not generally available due to the absence of a hydrometric standards and dissemination system. The forestry sector has also participated in network funding through the now-defunct FRBC.

While the industry has supported the regional network in the past and continues to support the construction of stream gauging stations, the potential for an additional levy on the sector is unlikely to be favourably received in the current economic climate according to Jack Lavis, Manager of Weyerhaeuser's Nanaimo operations. Nevertheless, this sector has much to gain from a regional network and further consideration should be given to a

fair way of collecting contributions such as a surcharge on stumpage for a cut-block where there is a significant watercourse.

Economic Benefits

Construction of roads is a major forest sector activity and stream and river crossings are a major cost of forest road construction. Hydrometric data are required for design of hydraulic structures and in the absence of adequate data the structure is likely to be under-designed or over-designed. Under-design often leads to significant environmental costs as washouts of bridges and culverts result in erosion and downstream sedimentation in fish-sensitive streams. With the current results-based Forest Practices Code this could lead to penalties being assessed on the forestry sector. As a result, hydraulic structures tend to be over-designed due to lack of data.

Brian Guy of Summit Environmental Consultants provided an example of over-design at the CWRA workshop on February 18, 2003. In the absence of data, the Forest Practices Code states that a culvert opening area should be three times the cross sectional area of the bank full stream. According to Brian Guy this generally results in a culvert size that is much larger than what is required. Based on his discussions with one forestry company operating within the Southern Interior in an area poorly served by hydrometric data, he estimated that costs may be as much as a third higher than required because of this over-design factor. Extrapolated over the entire province, he suggests that such over-design costs total many millions annually. A similar assessment for bridges by John Morley, a hydrotechnical consultant to the Ministry of Transportation, indicated that lack of hydrometric data could increase bridge costs to the forest sector by 10 to 20% because of over-design.

Under-designing culverts and bridges due to the lack of data or poor data can also be extremely costly. While smaller structures are cheaper to build, failure or wash-out will make the project a lot more costly.

Because capital investment statistics for bridge and culvert construction in BC are not available for the forestry sector separately, and in the absence of any such figures provided by the forestry industry, the design-related benefits of the hydrometric system stemming from construction of stream crossings in the forestry sector are included in a later discussion of the transportation sector.

The design-related benefits of the hydrometric system for other hydraulic installations (bank protection, habitat restoration/enhancement measures, storm water controls etc.) have not been addressed in this study. No data are available on the extent of such works, and benefits are expected to be minor compared to those associated with forestry stream crossings.

During forestry operations, hydrometric data are used for monitoring streamflow and water quality downstream of harvesting operations. It is important for the industry to have data available to demonstrate compliance and be able to compare water quality during operations with background data collected historically. As water quality varies with discharge, water quantity measurements are an important component of this monitoring. As outlined above, the sector also uses hydrometric data for forestry operations in a variety of other ways, including habitat assessment, and applied research into the impacts of harvesting on local hydrology.

The increased emphasis in the province on sustainable resource management and the move to results-based codes of operation place substantial demands on the forestry industry to manage its timberlands effectively and in ways that respect other resource values including, in particular, aquatic habitats. While it is probably impossible to evaluate the potential benefits that the hydrometric system offers the forestry sector in these tasks, a later section of this report makes an allowance for such benefits within the context of the overall resource management sector that includes the forest industry.

Transportation Sector (Road and Rail)

Sector Description

Roads and railways provide needed infrastructure for a wide range of industry sectors within the economy, but are not considered a separate industrial sector. Most highways and roads in BC are built by public agencies, including the Ministry of Transportation, regional governments and agencies, as well as municipal governments. However, resource companies, principally those in the forest industry, also build thousands of kilometres of roads annually to service their holdings. Railways are built by both private and public rail companies.

Hydrometric Data Requirements

Construction and upgrade of roads and railways requires hydrometric data for design of stream and river crossings. Data are also required for design of flood and erosion protection works such as dykes and riprap. Regional data are critical for design, particularly on small creeks as transportation routes cross numerous small watercourses.

Some use of hydrometric data is also required for operational aspects of transportation routes. For example, gravel deposition can reduce the waterway capacity of bridge crossings. Hydrometric data are required to demonstrate the design capacity reduction, obtain approvals from fisheries agencies and identify low flow periods for gravel removal.

The current hydrometric network does not serve the transportation sector very well. Regional data on small streams are rare and where data are collected, it tends to be in populated areas rather than in remote locations.

Sector Participation in Hydrometric System

The transportation sector does not contribute directly to hydrometric network operations as transportation routes are extended over long distances and regional data are the primary requirement. However, a very large number of stream crossing structures are required in this sector each requiring a permit for construction under the Water Act. As improved hydrometric data would reduce the costs of construction, a levy could logically be applied to each new structure to contribute to the hydrometric program.

Economic Benefits

The economic benefits of hydrometric data to this sector primarily relate to cost savings in the design of stream crossing structures. John Morley, a hydrotechnical consultant to the Ministry of Transportation, commented that, in the absence of adequate data, bridge designs tend to be more conservative. The height and length of the bridge are typically increased to address the hydrologic uncertainty. This can add $40,000 to $50,000 to the cost of a typical bridge with total construction costs of $250,000 or greater. There would also be comparable savings in culvert construction costs.

These estimates are somewhat higher than benefit estimates found in literature reviewed for this study. Past studies have quantified benefits for hydrometric data used in the design of stream crossings for road and rail transportation. Estimated benefits range from 5 to 15% of the costs of these structures. For the present study, 15% has been assumed to be the maximum potential hydrometric benefits arising from use of hydrometric data for design of engineered bridges, trestles and culverts. This includes crossings built as part of the public transportation network, as well as crossings built by the forest industry to access its timberlands. Because many of the smaller stream crossings built by the BC forest industry are not engineered and do not appear to be included in Statistics Canada's capital investment surveys, a separate estimate of a potential 30% design saving has been assumed for such crossings.

As outlined above, the existing hydrometric network is inadequate for the current and future needs of this sector. For this reason, a scaling factor of 50% has been employed to estimate the expected level of design benefits arising from engineered stream crossings for provincial road and rail development in the near-term future. This factor suggests that 50% of the design benefits potentially available from design and construction of these engineered crossings are not being captured due to the inadequacy of the existing hydrometric system.

The hydrometric system is particularly inadequate for design of many small stream crossings built annually by the forestry industry to service their timber lands. These crossings are often not engineered, but rather are "designed" using simplified code "rules of thumb", such as the "3 times bank full" rule employed in parts of the BC Interior. The current hydrometric system is of some but limited utility in the design of these crossings. A scaling factor of 25% has been applied to potential design benefits to reflect the fact that these crossings are typically substantially over-sized because the existing hydrometric system does not provide adequate information to allow more appropriate designs.

For 1997, the most recent year that detailed capital investment data is available for BC, $802 million was invested in road and rail construction, of which $92 million was specifically for bridges, trestles and culverts. In 1996, the comparable figures were $983 million for total construction and $85 million for stream crossings. The BC Major Projects Inventory (MPI) tracks ongoing and proposed major capital investment projects in the BC economy. There are currently 8 road and rail transportation projects listed in the MPI. The MPI estimates capital investment averaging $267 annually over the next three-years (2004 to 2006). None of the $900 million of road construction announced in the February, 2003 provincial budget appears to be reflected in these statistics.

Based on very limited information provided by forest industry representatives, it is

estimated that at least $25 million in annual construction of small stream crossings, are not reflected in the Statistics Canada data on capital investment. There may be additional such crossings constructed annually by other resource sectors (e.g. the oil and gas sector).

Based on the above information on total investment, it is estimated that, over the next few years, investment of $100 million annually will be made for the construction of engineered stream crossings, both in the public transportation and forest sectors. At maximum benefits of 15%, and a scaling factor of 50%, the benefits that will accrue to the current hydrometric system as a result of this investment, are estimated to total $7.5 million annually. At maximum benefits of 30% and a scaling factor of 25%, additional benefits of $1.9 million are expected from annual construction of $25 million of additional small stream crossings by the forest sector. Because the present hydrometric network is inadequate to meet all the design needs for all of these crossings, it is estimated that it will fail to capture up to an additional $13.1 million annually in available design-related benefits. With appropriate expansion of the network, higher levels of design-related benefits could be captured in the future.

Hydropower Sector

Sector Description

The emergence in the last few years of a significant small hydropower sector in BC stems from recent changes in BC Hydro's strategies for dealing with demand growth. BC Hydro has made a voluntary commitment to source at least 10% of the growth in provincial energy demand to 2010 from independent producers of green energy throughout the province. Additional purchases of green energy will be made to meet Hydro's obligations arising from its sales of Green Power Certificates to BC and export consumers. Still further independent power generation will be built through Hydro's Power Smart program, which has now been expanded to encompass consumer-generated power initiatives. Since announcing these new initiatives, Hydro has initiated contracts and calls for proposals for substantially more green power than this 10% figure would indicate, and appears willing to continue to take on substantial amounts of green power so long as the cost of doing so is less than for its alternate sources of supply. As a result of its first call in 2000/01 for proposals for green energy projects, Hydro completed 20-year energy purchase agreements totaling 920 GWh annually for 22 projects proposed by various independent power producers. This amounts to somewhat more than one year's forecast growth in Hydro's total firm load requirements. Twenty of these projects involve small-scale hydropower developments, one is a biomass project and the other involves the use of landfill gas. In 2002, some of these projects were completed and connected to the provincial electricity grid. BC Hydro is currently reviewing responses arising out of its second call for proposals for additional green energy projects and expectations are that it will contract a similar amount of energy delivery as it did from the first proposal call.

BC Hydro is currently forecasting demand to grow by 1.7% annually over the next 10 years, or an average of about 1,000 GWh annually. Demand for peak power is expected to grow even faster. If only 10% of this growth is to be met from green energy, only about 100 GWh will be required annually. However, current expectations are that a much higher

proportion of the growth will be delivered by independent producers. Almost all of this is expected to come from small hydro projects, which currently appear to be the most cost-competitive independent power source. Paul Kemp, a principal of Canadian Projects Limited, which has constructed a number of small hydro projects in British Columbia, estimates that as much as 800 GWh of additional small hydro generation could be developed annually over the next several years. Based on typical industry capacity factors, this would require from 6 to 10 small hydro sites to be developed each year at a total investment cost of about $400 million annually.

The small hydropower sector is too early in its development to be noted in existing statistics on provincial economic activity. In 2001/02, BC Hydro contributed approximately $1,000 million to the provincial GDP and directly employed over 6,000 people.

Hydrometric Data Requirements

The hydro sector has a significant requirement for hydrometric data throughout the province particularly long-term flow data. Data are required for the following:

- Characterization of the water resource
- Assessment of flood flows for design of hydraulic structures
- Environmental requirements.

The hydrometric network in BC provides information on the distribution in time and space of the water resource. This information is critical during the reconnaissance phase for potential small hydro sites. The hydrometric program provides a resource database for investors to investigate development opportunities.

Once a site is selected for further investigation, hydrometric data are used to support feasibility studies. Most small hydro sites are run-of–river i.e. they do not have storage dams and flow availability is critical for determining the expected flow of benefits from the potential site. Long-term flow records are critical for this assessment as a short-term record length can be misleading for an investment that will require a stream of benefits over several decades to ensure a sufficient return on investment. If data are not available for the stream being investigated, regional flow data are used to estimate the likely long-term flow distribution at the site.

As part of the feasibility study, the investigator will use hydrometric data to determine the optimum plant capacity that makes the best use of the resource, determine the flow releases required for downstream riparian users and calculate the power benefits that will be generated from the site. The cost-benefit analysis of a small hydro site is driven by the flow data and thus the information provided by the hydrometric network is critical for making investment decisions in this sector.

At the diversion point on the stream, hydrometric data are used to design the size of the diversion weir to ensure that it can safely pass the design flood.

As part of the water licence application and review, flow data are required to determine required releases for fisheries and other downstream uses. Long-term data are necessary for this assessment.

The current hydrometric network is inadequate for the needs of the small hydro sector. Long-term data are generally only available on some large rivers, which are not useful for extrapolating to smaller streams for small hydro development. There are insufficient long-term data on smaller streams and very little data at high elevation locations where small hydro stations are often constructed. As a result, there is as great deal of uncertainty in the sector in characterizing the availability of streamflow that is the critical resource for generating benefits.

The most useful information for resource characterization for the small hydro sector would be provided by a regional network of stations on smaller streams at higher elevations. Such stations are rare in the current British Columbia hydrometric network.

The value of BC's Hydrometric Network to the small hydro sector is diminishing with time as the nearby and well-understood sites become developed and the sector expands into more remote and unknown areas of the province. Hence the network needs to be designed and expanded in such a way to cover the province in all of its hydrometric dimensions (by regional, by drainage size and by elevation etc).

Sector Participation in the Hydrometric System

While a number of small hydro developers are collecting streamflow data on sites where construction of a small hydro facility is under active consideration, they will still require long-term regional data to put the site-specific data into a long-term context. Therefore it is not feasible for this sector to replace the provincial hydrometric program with its own data collection programs.

Data collected by small hydro developers are generally not available to others. However, the sector would be willing to share data, meet provincial standards and would be willing to partner stations. According to Steve Davis, President of the Independent Power Association Of British Columbia, the value of a good gauge record to the small hydro sector is huge.

The small hydro sector would be willing to fund the regional network if the right funding formula could be found. Steve Davis, as well as Paul Kemp, favoured contributing to network funding through water rentals.

BC Hydro already contributes a substantial portion of the current provincial hydrometric operating budget. In the 2002/03 budget, BC Hydro committed somewhat more than $738,000 of the approximately $4.5 million required to fund the program.

The small hydro sector, like all licensed water users in the province, are obligated through legislation to annually report their water diversion usage. Currently, government almost exclusively uses this information to assess water rental fees. However, an opportunity exists to have this information integrated into the hydrometric database. The key to this is the development of a data standard that provides a suitable quality-controlled and formatted data-set that can be readily introduced to the database with confidence. This approach could be applied not only to the small hydro sector but also to the numerous water user groups in the province to gain a much better understanding of our water resources from an effort that is already underway but not fully capitalized on today.

Economic Benefits

Past studies have quantified benefits for hydrometric data used in the design of hydroelectric installations, in particular, design of the water conveying and controlling structures. Estimated benefits range from 5 to 10% of the costs of these structures. For the present study, 5% has been assumed to be the maximum potential hydrometric benefits arising from use of hydrometric data for design of hydroelectric conveying and controlling structures. As outlined above, the existing hydrometric network is inadequate for the current and future needs of this sector. For this reason, a scaling factor of 50% has been employed to estimate the expected level of design benefits arising from provincial hydroelectric development in the near-term future. Expressed differently, this factor suggests that 50% of the design benefits available from ongoing hydroelectric expansion will not be captured by the existing hydrometric system. Projects may be under or over-designed as a result of the deficiency in hydrometric information, resulting in operating or capital inefficiencies.

For 1997, the most recent year that detailed capital investment data is available for BC, $152 million was invested in hydroelectric generation production plants. In 1996, the comparable figure was only $72 million. Because small hydro investment has only commenced in BC in more recent years, these expenditure levels likely represent outlays made by BC Hydro and others in larger-scale hydroelectric projects. The BC Major Projects Inventory (MPI) tracks ongoing and proposed major projects in the BC economy. There are currently 15 hydro projects in the inventory, almost all of which are small hydro projects. For the overall utilities industry, which includes sewage treatment and potable water utilities as well as electricity generation projects, MPI estimates capital investment averaging $506 annually over the next three-years (2004 to 2006). As indicated above, Paul Kemp estimates that investment in the small hydropower sector will average $400 million annually over the next several years.

Based on assumptions outlined in previous studies, it is assumed that two-thirds of the capital costs of hydroelectric projects is taken up by works whose design is dependent upon hydrometric data. Based on this assumption, and the above information on total investment, it is estimated that, over the next few years, investment of $250 million annually will be dependent upon hydrometric data. While most of this is expected to involve investment in small hydro works, this estimate also includes the possibility of some expansion or capital modifications at existing large hydro installations. Such capital works are presently planned at Waneta, Brilliant, and Seymour Falls hydroelectric installations.

At maximum benefits of 5%, and a scaling factor of 50%, the benefits that will accrue to the current hydrometric system as a result of this investment are estimated to total $7.5 million annually. Because the present hydrometric network is inadequate to meet all the needs of the hydro sector, it fails to capture up to an additional $7.5 million in available benefits. Some portion of this additional amount could be captured with appropriate expansion of the network.

During operations, monitoring of flows is required to optimize power generation. Unless there is a WSC station close to the hydro facility, it is likely that the operator will establish a stream gauging station for flow monitoring. Regional hydrometric data will be occasionally useful during operations for regional analysis of drought sequences, planning

for system modifications and providing supporting data in the event that downstream riparian users raise concerns about operations.

The increased emphasis in the province on sustainable resource management and the move to results-based codes of operation place increased demands on the hydropower sector to manage water resources effectively and in ways that respect other resource values. While it is probably impossible to evaluate the potential benefits that the hydrometric system offers the hydropower industry in these tasks, a later section of this report makes an allowance for such benefits. The hydropower industry is but one part of the overall resource management sector.

It has been suggested by some that the lack of or inadequacy of hydrometric data may preclude economic investments in small hydro. In BC, the ultimate level of investment in small hydro development will be directly related to the quality and availability of hydrometric data. According to Steve Davis, the most critical data that investors look at is the stream flow. Ideally, financiers want to see reliable and uninterrupted data sets with a good length of record, taken close to the proposed diversion point.

This view was reinforced by Paul Kemp. Reductions in the availability of flow data have already had financial consequences regarding the availability of capital for specific small hydro opportunities. If the risk of a potential investment is too high because of uncertainties in the available flow information than investments in small hydro will ultimately reduce, once the inventory of economic sites better served with hydrometric records becomes developed. There are indications in the overall energy industry today that capital investments are being affected due to greater market uncertainties, one of which is fuel risk. For the small hydro sector, where water flow represents "fuel", this risk relates to hydrological uncertainty. Mr. Kemp noted that while one branch of the provincial government is supporting the development of green energy, another branch has been reducing the information base that makes investment possible.

Paul Kemp also noted that lack of hydrometric data also increases the environmental risk of small hydro projects. The environmental assessment process is based on assessing risk and making judgment calls. If there is insufficient information then poor decisions will be made.

In the short term at least, it is not expected that inadequate hydrometric data will lead to lessened investment in small hydro in the province, since there presently appears to be a substantial inventory of proposals in excess of BC Hydro's needs. However, this situation may well be encountered in the not-too-distant future, when this inventory of proposed sites is exhausted and more and better hydrometric information will be required to accurately identify additional economic sites. Because of the lag time involved in collecting adequate hydrometric information, the time to address these future data needs is now.

Mining Sector

Sector Description

The metal and coal mining sector of the BC economy had sales of $2,480 million in 2001, of which 90% were export sales. Almost 6,000 people were employed at 16 different mine operations throughout the province. If other aspects of the mineral

economy – including exploration, extraction of industrial minerals and construction aggregates, and refining, smelting and other downstream mineral processing – are included in the consideration, these totals rise to $5,300 million in sales (66% exported) and almost 19,000 people employed.

The metal and coal mining sector of the BC economy contributed an estimated $900 million to provincial GDP in 1999. The mining sector in BC is poised for a comeback after being depressed for several decades and long-term water quantity data is extremely important for the renewal of this sector.

Hydrometric Data Requirements

The mining sector requirement for hydrometric data includes all phases of mine development including project feasibility, project design, construction, operation and closure. The mining industry typically operates in remote areas where regional data is limited or absent. Water is a fundamental need for mineral processing for all sectors of the industry including base metals, gold, coal, iron and aluminum. Mining development requires background data for environmental impact assessment and there is usually a very limited time frame for measuring stream flows during the permitting period.

Mine development requires hydrometric data for:

- Water supply
- Flood management and design
- Operational water balance
- Effluent permitting & discharge strategies
- Possible local hydro electric power
- Closure planning

Mines need process water for operations and data requirements include regional historic flow rates, regional extreme low events, duration of low periods and average seasonal flows.

Data are also required for flood management and design. Facilities at risk include tailing ponds, plant sites, access roads, pipelines (for water, tailing, or natural gas) and construction camps.

For the operational water balance, most mines confine large volumes of water in tailing or sediment ponds and high levels of recycle are achieved. Planning is needed to ensure adequate water at all times The integration of local streamflow data with operational data is needed to establish a sound water balance including extreme low and high flows.

Some BC mines have a positive water balance and must discharge treated effluent under Ministry permits. Rigorous receiving water criteria also need to be satisfied. Permitting of a discharge needs accurate data for projecting dilution and planning adequate control programs to protect receiving environments.

According to Jim Robertson, Director, Environment for Placer Dome Inc., the mining sector needs confidence in the information being presented to agencies for environmental

approvals. With more credibility, supported by hydrometric data, there is reduced processing time.

As noted by Jim Robertson:

> *Hydrometric data is a key resource that is essential for effective resource and industrial management by the mining sector. The availability of good data will greatly assist the development of new sites and the closure of operating mines. Hydrometric data has definite economic benefits to mines.*

Sector Participation in Hydrometric Systems

The mining sector is interested in partnering data collection with WSC. However, it has been found that WSC is not very flexible in the type of arrangements that would suit the mining industry such as providing support in-kind for operations and maintenance of stations. The mining sector would support establishing provincial standards for hydrometric data collection and would contribute any data they are collecting.

Regarding contributing to the regional network, the mining sector could contribute through water licensing both for consumptive use and effluent disposal. As operating mines need local data for operations, the mining industry would consider constructing and operating local hydrometric stations that are required for operational decisions.

Economic Benefits

No discussion was found in the literature of the benefits of hydrometric data for the mining industry. However, it is clear that mine sites contain considerable engineering works whose design is dependent upon hydrometric data, and that design-related benefits accrue to the hydrometric system from the construction of these works in a similar manner as for hydraulic structures built in other sectors of the economy.

Lack of hydrometric data can lead to a conservative design for tailing management with more water stockpiled in the tailing pond. This results in higher dams and larger tailing ponds to hold extra water. This translates to extra costs for structures and higher risks for tailing pond integrity from major storm events and for water imbalances. The worst case is dam failure. Most recent tailing dam failures are related to water management. There may also be a requirement for variances to discharge non-compliant water.

If the flood data are inadequate then the plant layout cannot be optimized to minimize risks from floods. Lack of data affects perceived risk and may cause over-design and higher costs and result in higher financing and insurance costs. It may also delay the permitting processes and impact the construction schedule and costs.

Similar capital inefficiencies can occur in the design of water supply and process water facilities for the mine if hydrometric data are inadequate.

Overall, for the purposes of the analysis herein, it is assumed that design-related benefits of at least 5% of the hydraulic structures component of mine capital investment could be generated by the availability of sufficient hydrometric data. Because many of the new mine prospects that may be developed in the near-term future in BC are expected to be sited in remote locations poorly served by the present hydrometric system, a scaling factor of 25%

has been applied to estimate the potential benefits to the existing hydrometric network of ongoing investment in new and expanded mine facilities.

1997 is the most recent year that detailed capital investment data is available for BC. In that year $514 million was invested by the mining industry. This amount included $19 million in tailing disposal systems and settling ponds. In 1996, the comparable figures were $129 million of total mine investment, including $14 million in tailing systems and settling ponds.

The MPI currently lists 8 proposed new or re-opened mines slated to be developed in the province over the next few years. It also projects an annual average of $905 million to be invested in 2004 to 2006, which is substantially higher than in recent years.

Based on discussions with industry representatives, It is estimated that at least 10% of mining investment is for structures whose design is dependent upon hydrometric data. Based on this assumption, and the above information on total investment, it is estimated that, over the next few years, investment of $80 million annually will be dependent upon hydrometric data. At maximum benefits of 5%, and a scaling factor of 25%, the benefits that will accrue to the current hydrometric system as a result of this investment, are estimated to total $1.0 million annually. Because the present hydrometric network is inadequate to meet all the needs of the mining sector, it is estimated that it will fail to capture up to an additional $3.0 million annually in available design-related benefits. With appropriate expansion of the network, higher levels of design-related benefits could be captured in the future.

Hydrometric data also has an impact on the efficiencies of ongoing mine operations. This is best understood in terms of the inefficiencies that can occur when hydrometric data are lacking.

Production water balance may be inaccurate for low flow periods and contingency plans may be inadequate if based on poor hydrometric data. A production shut down or cutback in operations may result which is likely to have an economic impact on the company and any nearby community. Alternatively, the mine may apply for a permit variance to take excess water during a sensitive period from a fisheries perspective. If granted, such additional withdrawals may lead to fisheries and other environmental losses.

Lack of adequate hydrometric data can also result in overly conservative criteria outlined in a mine's discharge permit. The result may be increased operating costs for higher levels of treatment and more restrictive discharge periods. There may be difficulty in achieving the water balance and requests for permit variance may have to be made to discharge due to excessive internal water which, if granted, may have potential consequences for other downstream water resources and users.

The increased emphasis in the province on sustainable resource management and the move to results-based codes of operation place increased demands on the mining sector to manage water resources effectively and in ways that respect other resource values. While it is probably impossible to evaluate the potential benefits that the hydrometric system offers the mining sector in these tasks, a later section of this report makes an allowance for such benefits, but for the overall resource management sector within which the mining industry is but one player.

One other area of potential mining sector benefits for the hydrometric system involves the avoidance of potential lost investment in the mining sector due to hydrologic uncertainty. According to Walter Kuit, Director of Environmental Affairs for Teck-Cominco, having hydrometric data available is key to planning and developing new mining projects and lack of data can affect the timing and level of mining investment in the province. Investors want to minimize risks and mine development has a wide range of risks, of which many relate to water management and availability. Good hydrometric data is a strong selling point to an outside investor, according to Jim Robertson. Lack of data also increases the environmental risks and can result in delays and therefore costs, in mine permitting. Both the provincial and federal regulatory agencies have to be satisfied.

No case studies were identified showing that inadequate hydrometric data resulted in otherwise economic mining proposals being withdrawn from the BC economy, although some evidence suggests that lack of such data may have delayed implementation of some proposals for a few years.

Due to the obvious difficulties in quantifying hydrometric benefits related to avoidance of potential lost investment, no such benefits are included in the analysis contained herein.

Agricultural Sector

Sector Description

The agricultural sector is an important sector of the BC economy, providing a substantial amount of employment and economic activity in all regions of the province. In 1999, the agricultural industry directly contributed almost $1,100 million to provincial GDP and accounted for about 29,000 jobs. If related sectors of the economy are taken into account, the sector's GDP contribution rises to almost $2,300 million. In 2001, there were over 111,000 ha of irrigated crop production in BC, much of it in the dryland portion of the BC interior.

Hydrometric Data Requirements

Hydrometric data are used by the agricultural sector for design and operation of both irrigation and drainage systems. Long-term flow records are required for the design on storage dams and river intake systems to ensure that there will be sufficient water for the irrigation system design. While site–specific data may be available, the regional network is also used for this assessment. The data requirement for drainage systems relates to the design of hydraulic structures such as culverts, bridges, gates and pumping systems. Data on small watercourses are required for the design of drainage systems.

For operations, monitoring of flows at the water source is required. If a WSC gauge is not present, the irrigation district is likely to construct and operate a stream gauge. Hydrometric data are required for the operation of large-scale drainage systems such as the Barrowtown Pump Station that drains Sumas Prairie. The data are collected by the system operators and are not generally available to other users unless requested.

Sector Participation in Hydrometric System

As noted above, a site-specific gauging station is likely to be constructed for plant operations if WSC data are not available from a nearby gauge. Data are also collected for operations of large-scale drainage systems that are not part of the provincial network.

Economic Benefits

Irrigation and drainage system operators recognize the benefits of streamflow monitoring which is reflected in their willingness to pay for site-specific streamflow stations. The benefits for design relate to cost savings in the design of hydraulic structures. The benefits during operations relate to cost savings in pumping costs with fine-tuning of the system.

Past studies have evaluated some benefits accruing to hydrometric systems from irrigation and drainage developments. The 1991 study of the UK hydrometric system attributed substantial benefits associated with irrigation – about two-thirds of all benefits quantified. However, irrigation licenses in Britain are apparently firm commitments by the applicable water utilities to deliver agreed water volumes and so the utilities must scramble to arrange for alternate supplies during low flow events. In this situation, careful monitoring of streamflow data is done to minimize the high costs of securing alternate supplies. The "priority rights" associated with water licences in BC eliminates this situation. The 1977 study of the Canadian hydrometric system estimated that irrigation and drainage design-related benefits were 10% of total construction costs. This figure is used in the current study. Because it is expected that the existing hydrometric system will adequately serve most future construction of irrigation and drainage facilities, a scaling factor of 75% has been applied to the estimate of near-term benefits.

In 1997, $14 million was spent in BC on irrigation and land drainage schemes. A year earlier in 1996, the comparable figure was $42 million. For this study, it is assumed that $30 million will be invested annually on irrigation and drainage schemes in the near-term future. Given a maximum design-related benefit of 10% and a 75% scaling factor, this indicates that future irrigation and drainage development will generate $2.3 million annually as benefits of the existing hydrometric system. Appropriate expansion of the hydrometric system could produce as much as an additional $0.8 million annually of design benefits not captured by the present network.

No specific hydrometric benefits have been quantified for ongoing irrigation and drainage scheme operations. However, these benefits exist. Throughout the province, agricultural operators of many of these schemes have agreements in place with other resource interests to manage irrigation water storages, sub-irrigation schemes, and drainage operations in such a way as to provide enhancement benefits for fish and wildlife habitat. Other schemes face regulation of their water management to assure downstream habitat preservation. Monitoring of streamflow information is vital to such operations. While it is probably impossible to evaluate the specific benefits of the hydrometric system arising from ongoing irrigation/drainage scheme operations, a later section of this report makes a general allowance for such benefits, but for the overall resource management sector of which the agricultural sector is but one part.

Oil and Gas Sector

Sector Description

The oil and gas sector of the BC economy had record sales of over $5,600 million in 2001, along with record levels of drilling activity and investment. 850 new oil and gas wells were drilled during the year, an increase of 23% over the previous year. Almost 2,000 people were employed in oil and gas extraction activities and several thousand more were employed in various support activities.

The oil and gas of the BC economy contributed over $1,300 million to provincial GDP in 1999.

The following discussion is focused on oil and gas pipeline stream crossings. The Province of BC presently regulates approximately 24,000 km of natural gas gathering and transmission pipelines, and an additional 2,500 km of oil and natural gas liquid pipelines within BC. Additional pipelines are federally regulated. Hundreds of kilometers of new pipelines are built annually.

Hydrometric Data Requirements

The oil and gas sector primarily requires hydrometric data for design of stream crossings for pipelines. A secondary requirement would be for water supply for drilling operations and construction camps.

For pipeline construction, data are often required for remote areas and are used to estimate design flood discharges, water levels and scour depths. According to Tony Griffin, Vice-President for Integrated Pipeline Projects of Calgary, the flow rate drives the method of stream crossing. Higher streamflow rates result in more costly crossing methods.

Real-time hydrometric data from WSC are also used by the pipeline construction industry for warning of high flow conditions when contractors have a temporary stream diversion in place for crossing construction. Real-time data may also be monitored during flood discharges to determine the need for field safety inspections of crossings.

Economic Benefits

No discussion was found in the literature of the benefits of hydrometric data for the oil and gas industry. However, it is clear that the design of stream crossings for oil and gas pipelines is dependent upon hydrometric data, and that design-related benefits accrue to the hydrometric system from the construction of these works in a similar manner as for hydraulic structures built in other sectors of the economy.

Integrated Pipeline Projects were responsible for the recent construction of the $400 million pipeline from Yak to Oliver for BC Gas. About $200 million of this was direct construction costs. There were 155 stream crossings, which added about $10 million to the pipeline construction cost. Crossing costs therefore represented 5% of total construction costs or 2.5% of total project costs. For stream crossings where there was insufficient hydrometric data, there was increased risk and uncertainty in the design process. This added to the construction cost for the stream crossings as more conservative

designs were selected. In the event of under-design the consequences would be substantial, involving substantial repair costs, loss of use during repair, as well as environmental damage including damage to downstream fish habitat resulting from sediment deposition from construction workings.

With respect to any hydraulic structure, whether in the oil and gas sector or elsewhere, replacement/repair costs and loss of use costs are usually substantially greater than the incremental costs of over-designing the structure - usually orders of magnitude greater. This is why, in the face of hydrologic uncertainty, over-design typically occurs. Therefore, the benefits of good hydrometric data are generally limited to the incremental costs of the over-design, and not to the consequences of the structure failing.

Overall, for the purposes of the analysis herein, it is assumed that design-related benefits of at least 10% of the stream crossings component of pipeline capital investment could be generated by the availability of sufficient hydrometric data. Because many of the pipeline stream crossings that can be expected to be developed in the near-term future in BC will be sited in locations poorly served by the present hydrometric system, a scaling factor of 50% has been applied to estimate the potential benefits to the existing hydrometric network of ongoing investment in oil and gas pipelines.

1997 is the most recent year that detailed capital investment data is available for BC. In that year $116 million was invested in new gas pipelines. Fewer oil pipelines were constructed and, for confidentiality reasons, investment totals for oil pipelines have been withheld. From totals for all of Canada, it is apparent that the figure for oil pipelines could not be greater than about $53 million and was likely substantially less. In 1996, the investment totals for both gas and oil pipelines were withheld.

The MPI currently lists 5 proposed major pipelines to be built in the province over the next few years. It also forecasts an annual average of $825 million to be invested in the "other transportation" industry in 2004 to 2006. While this sector is where all oil and gas pipeline projects are placed, miscellaneous transportation projects such as ferry terminal redevelopment are also included in this category.

Based on discussions with industry representatives, it is estimated that at least 3% of oil and gas investment is for structures whose design is dependent upon hydrometric data. Based on this assumption, and the above information on total investment, it is estimated that, over the next few years, investment of $15 million annually will be dependent upon hydrometric data. At maximum benefits of 10%, and a scaling factor of 50%, the benefits that will accrue to the current hydrometric system as a result of this investment, are estimated to total $0.8 million annually. Because the present hydrometric network is inadequate to meet all the needs of the oil and gas sector, it is estimated that it will fail to capture up to an additional $0.8 million annually in available design-related benefits. With appropriate expansion of the network, higher levels of design-related benefits could be captured in the future.

As outlined above, the oil and gas sector makes some use of the hydrometric system related to temporary water supplies, as well as to monitor flow conditions at in-stream construction works and at installed stream crossings. While it is probably impossible to evaluate the potential benefits that the hydrometric system offers the oil and gas sector for such uses, a later section of this report makes an allowance for such benefits, but for the

overall resource management sector which includes the oil and gas industry as well as all other resource industries.

Sewage Treatment Sector

Hydrometric Data Requirements

Development and operations of sewage treatment systems require hydrometric data for two primary design issues:

- Design of flood protection works and establishing flood construction levels.
- Determining dilution flows for establishing criteria for plant treatment levels.

As sewage treatment plants are generally located adjacent to larger rivers, hydrometric data are usually available for the design process. Regional hydrometric data would also be used to assist in the determination of the design flood.

Streamflow data are also required for plant operations to support water quality monitoring and to confirm that adequate dilution flows are available. In the event that flow data are not available, it is likely that a stream gauging station would be constructed for plant operations.

Sector Participation in Hydrometric System

As noted above, a site-specific gauging station is likely to be constructed for plant operations if WSC data are not available from a nearby gauge.

Economic Benefits

The benefits of the hydrometric network for construction of sewage treatment plants relate to cost savings in design. If the plant has to be located at a higher elevation because of uncertainty regarding flood levels, then there would be increased costs for fill material. At some locations there would be increased capital and operating costs for pumping to raise the hydraulic grade line of the sewage.

Past economic studies provide some information about the benefits of hydrometric data for sewage disposal facilities. One reference to design-related benefits estimates these benefits at only 1% of overall construction costs. This figure has been adopted in this study. Because it is not expected that the existing hydrometric system will adequately serve all future construction of sewage treatment facilities, a scaling factor of 75% has been applied to the estimate of near-term benefits.

In 1997, $65 million of sewage treatment facilities were constructed in BC. In 1996, such projects accounted for $201 million of capital investment. The provincial Major Projects Inventory currently lists three such projects in its inventory totaling $104 million in proposed construction costs. However, the MPI does not provide a separate projection for sewage treatment construction activity over the next several years. Instead, it includes this capital category in a projection of investment in all utilities, including water works and hydropower plants. For the purposes of this study, it is assumed that construction of

sewage treatment plants will average $150 million annually in the near-term future. At maximum benefits of 1%, and a scaling factor of 75%, the benefits that will accrue to the current hydrometric system as a result of this investment are estimated to total $1.1 million annually. Because the present hydrometric network is inadequate to meet all the near-term needs of the sewage disposal sector, it is estimated that it will fail to capture up to an additional $0.4 million annually in available design-related benefits. With appropriate expansion of the network, higher levels of design-related benefits could be captured in the future.

In the UK, where real-time hydrometric data are used to assess dilution capabilities and fine-tune ongoing discharges, benefits can reach as high as 20% of a plant's annual variable costs of treatment. However, it is not apparent that this sort of use of real-time data is practised to a large degree in BC. Nevertheless, it is appropriate to attribute some benefits to the hydrometric system associated with sewage plant operations. Because of the difficulties in evaluating such specific benefits, which will vary tremendously from plant to plant, a later section of this report makes a general allowance for such benefits, but for the overall resource management sector of which sewage disposal utilities are but one part.

Water Supply

Hydrometric Data Requirements

Development and operations of water supplies have a direct requirement for hydrometric data. For major water supply systems, such as that operated by the Greater Vancouver Regional District (GVRD), there is an established network of streamflow stations to monitor flows into reservoirs. These data are used both for operations and planning of future water supplies.

Small water supply systems also have a requirement for hydrometric data and site-specific data are usually collected by the municipality responsible for operations. For planning future water supplies, use is made of the regional network. Long-term data are critical for this assessment.

Hydrometric data are used by water utilities to carry out drought frequency analysis, reservoir planning studies, reservoir operations, design of hydraulic structures including intakes and dams, and for monitoring riparian releases.

Sector Participation in Hydrometric System

The water supply sector contributes to the hydrometric network by providing funding for operation of stream gauging stations that are required for their system operations and planning. Typically, the utility covers the costs of construction and operation and the gauging stations are run by WSC. It is important to realize that these gauges are also of considerable value as part of the overall regional streamflow network and the data are available for other uses.

Economic Benefits

Water supply system operators recognize the benefits of streamflow monitoring. This is reflected in their willingness to pay for site-specific streamflow stations. A recent planning study of the GVRD water supply system benefited greatly from the streamflow record on the Capilano River that provided an 86-year period of record. Such a long record is unusual in BC and provided the GVRD planners with a high degree of comfort in the analysis.

The benefits of the regional network become apparent when there are new towns developed, such as at Tumbler Ridge and when there are significant population expansions such as are occurring in the Lower Fraser Valley.

Past economic studies provide considerable information about the benefits of hydrometric data for water supply utilities. Where reservoirs are involved, the design benefit is highly dependent upon the length of the hydrometric record. One reference suggests that a 6-year record implies a 30% error in required reservoir capacity, whereas a 20-year record cuts this error in half to 15%. Another study sets design-related benefits at 10% of reservoir construction costs. For the purpose of this study, this latter estimate is accepted. Because it is expected that the existing hydrometric system will adequately serve most future construction of water supply facilities, a scaling factor of 75% has been applied to the estimate of near-term benefits.

In 1997, only $4 million of water supply reservoirs were constructed in BC. In 1996, such projects accounted for $10 million of capital investment. The provincial Major Projects Inventory currently lists only one water supply project in its inventory, and this is for a filtration plant, and not reservoir development. For the purposes of this study, it is assumed that construction of water supply reservoirs will average $10 million annually in the near-term future. At maximum benefits of 10%, and a scaling factor of 75%, the benefits that will accrue to the current hydrometric system as a result of this investment are estimated to total $0.8 million annually. Because the present hydrometric network is not expected to meet all of the near-term needs of the water supply sector, it is estimated that it will fail to capture up to an additional $0.3 million annually in available design-related benefits. With appropriate expansion of the network, higher levels of design-related benefits could be captured in the future.

In the UK, the use of real-time hydrometric data to fine-tune permitted diversions by water utilities, which were governed by statutory requirements for specific downstream flows, accounted for about one-quarter of all the benefits estimated in a recent study of the UK hydrometric system. While this situation is not particularly applicable to BC, where many surface water supply projects are dedicated reservoir schemes, the hydrometric system does provide some operating benefits to BC utilities. During operations the site-specific gauging data may be used by water supply system operators to plan reservoir withdrawals and make operating decisions that recognize the requirements of downstream users and resources. While it is probably impossible to evaluate these specific potential benefits, a later section of this report makes a general allowance for such benefits, but for the overall resource management sector of which water supply utilities are but one part.

Hydrometric Data Requirements

Hydrometric data are required for design of dyke crest levels and riprap bank protection for flood protection works. A flood frequency analysis would be carried out to estimate the magnitude of design floods using long-term hydrometric data and a water surface profile analysis used to determine flood levels and velocities.

Neil Peters, the British Columbia Inspector of Dykes, noted that hydrometric data are critical when major flood events occur that result in flood damages. It is important to have a good understanding of the magnitude of the event to determine whether the water surface profile analyses are still valid and whether upgrades to flood protection works are required.

Real-time hydrometric data are also used for flood warning. The Province operates a flood warning program through its River Forecast Centre. Additionally, a few municipalities have established, or are considering the establishment of, upstream stations for flood warning.

In general, the hydrometric network is adequate for flood mitigation planning and flood warning on the Fraser River and for flood mitigation planning on the Okanagan River. According to Brian Symonds of the WLAP Penticton office, more real-time flood warning gauges would be desirable in the Okanagan. Other major BC rivers are less well served.

Sector Participation in Hydrometric System

The Province ensures that critical gauges are maintained for flood analysis and flood warning on the Fraser River system. To a lesser extent, the River Forecast Centre monitors gauges on other natural-flow rivers in the province, including the Similkameen, Elk and Skeena systems. These gauges are funded as part of the BC\Canada Hydrometric Agreement. For many other rivers, flood-warning gauges are desirable but the cost is often prohibitive for small communities. According to Neil Peters, WSC should be more flexible in their partnership arrangements. WSC are not prepared to cost-share gauges and communities have to bear the entire cost.

Economic Benefits

The benefits of hydrometric data for flood protection works relate to reduced costs for design of dykes and bank protection works. Good hydrometric data will provide a more accurate determination of the design flood.

Past studies have suggested that adequate hydrometric data offer design-related savings of 4-5% of the construction costs of flood protection works. For this study, a figure of 5% has been used. Because most flood protection works are built in areas reasonably well-served by the present hydrometric system, a scaling factor of 75% has been applied to estimate the potential benefits to the existing hydrometric network of ongoing investment in flood protection works.

Very little information is available on annual provincial expenditures on flood protection works. Statistics Canada's survey of capital investment does not include a separate category for such works and no flood protection projects are currently listed in the

Province's Major Projects Inventory. The Province has provided funding in the past through its Flood Protection Assistance Fund, but this program is slated to end. Approved project funding for fiscal 2002-03 totaled $2.6 million, of which about $2.2 million was for actual construction of flood protection works. Other upgrading or repair works were funded directly by dyking authorities or municipalities. No aggregated information is available for such expenditures, or on the extent of flood proofing expenditures made through municipal land development activities. For the purposes of this study, total ongoing construction expenditures on all flood protection works are estimated to be $10 million annually throughout the province. Dyking and emergency-preparedness officials warn that much more needs to be spent on upgrading and repairing the province's flood protection works but, without a major new initiative from senior government, ongoing expenditures are likely to remain constrained.

At maximum benefits of 5%, and a scaling factor of 75%, the benefits that will accrue to the current hydrometric system as a result of this investment are estimated to total $0.4 million annually. It is estimated that the present system will fail to capture up to an additional $0.1 million annually in available design-related benefits. With appropriate expansion of the network, and particularly if a major new flood protection program is introduced, higher levels of design-related benefits could be captured in the future.

For flood warning systems the benefits of hydrometric data are the opportunity to avoid flood damages both by evacuation as well as by sandbagging to temporarily increase dyke heights. Here, the present hydrometric system is presently capturing much more substantial amounts of benefits.

Flood warnings afford opportunities to move possessions, livestock, vehicles and machinery to higher elevations, and for residents to move to safety. Past studies have estimated the evacuation benefits of flood warning systems at 5 to 15% of the flood damages that would otherwise occur. For this study, a figure of 10% of total flood damages has been adopted. Based on discussions with officials of the Provincial Emergency Program, it is estimated that flood damages in BC average at least $40 million annually.

Warnings also provide opportunities to temporarily increase dyke heights through sandbagging. A good example is the 2002 spring freshet on the Bulkley River, which threatened to flood the municipality of Houston. Early warning of high flows allowed a timely start on sandbagging operations, which ultimately raised the dyke height by almost a full metre and contained the peak flow, avoiding flood damages that would have reached at least $40 million, by conservative estimates. Such avoided losses are not completely a benefit of the hydrometric system, since these savings would not have been realized without the combined efforts of the Provincial Emergency Program, various other government agencies, and hundreds of volunteers. However, officials at PEP credit much to the early notice provided by the flood warning system. Success stories like this one do not occur every year. For the purposes of this study, it is assumed that an average of $10 million of potential flood damages could be avoided annually if flood warning systems were available in all areas of the province at risk of flooding. 50% of these avoidance benefits are potentially attributable to the hydrometric program; the remainder are associated with other actions and programs that are activated by the flood warnings.

Because most of the floodplains in the province at risk of flooding are reasonably well-served by the present hydrometric system, a scaling factor of 75% has been applied to

estimate the potential benefits to the existing hydrometric network arising from current flood warning capabilities. Based on this scaling factor, and the above discussion of potential benefits, $6.8 million of flood warning and avoidance benefits are estimated to accrue to the present hydrometric system annually; up to a further $2.3 million of potential benefits could be captured in the future if the hydrometric system was expanded appropriately.

Resource Management Sector

Sector Description

The overall resource management sector in BC is comprised mainly of the resource industries – forestry, mining, agriculture, oil and gas - as well as water-based utilities including hydropower, water works, and sewage disposal utilities. These sectors have been discussed separately in previous sections. Fishing, hunting, trapping, eco-tourism and other resource-based tourism are also part of the sector.

Excluding the resource-based tourism elements, which are not tracked separately from other tourism activity in provincial economic account statistics, the resource sector accounted for approximately $11,000 million in direct GDP generation in 2001, and directly employed well over 80,000 people throughout the province. If related activities – support activities and related manufacturing – are also considered, the sector is clearly a dominant force in the creation of jobs and income in the provincial economy.

Hydrometric Data Requirements

With the exception of the commercial marine fishery, and hunting and trapping, all of these industries and economic activities are active users of the hydrometric system. Their uses of hydrometric data have been outlined in previous sections. The benefits flowing from their use of hydrometric data to design various types of hydraulic structures has been directly estimated in these report sections. As outlined in these sections, most of these sectors also use hydrometric data for operational use. Operating uses include the following:

- **Forestry:** hydrometric data are used for monitoring streamflow and water quality downstream of harvesting operations, to demonstrate compliance and allow comparison of water quality during operations with background data collected historically. As water quality varies with discharge, water quantity measurements are an important component of this monitoring. The forest industry also uses hydrometric data for forestry operations in a variety of other ways, including habitat assessment, and applied research into the impacts of harvesting on local hydrology.
- **Hydropower:** during operations, monitoring of flows is required to optimize power generation. Regional hydrometric data are also useful during operations for regional analysis of drought sequences, planning for system modifications and providing supporting data to evidence that regulatory and voluntary commitments to downstream riparian users have been met.
- **Mining:** for their operational water balance, most mines confine large volumes of water in tailing or sediment ponds and high levels of recycle are achieved. Ongoing monitoring and planning is needed to ensure adequate water at all times to avoid a

production shut down or cutback in operations. The integration of local streamflow data with operational data is needed to establish a sound water balance including extreme low and high flows. Some BC mines have a positive water balance and must discharge treated effluent under Provincial permits. Rigorous receiving water criteria also need to be satisfied and ongoing monitoring of streamflow data for receiving waters is a necessity. Alternatively, some mines may require additional water during a sensitive period from a fisheries perspective. A good understanding of streamflows is required in order to ensure that any such additional withdrawals do not lead to fisheries and other environmental losses.

- **Agriculture:** operators of many agricultural water management schemes have agreements in place with other resource interests to manage irrigation water storages, sub-irrigation schemes, and drainage operations in such a way as to provide enhancement benefits for fish and wildlife habitat. Other schemes face regulation of their water management to assure downstream habitat preservation. Monitoring of streamflow information is vital to such operations.
- **Oil and Gas:** real-time hydrometric data from WSC are used by the pipeline construction industry for warning of high flow conditions when contractors have a temporary stream diversion in place for crossing construction or repair. Real-time data may also be monitored during flood discharges to determine the need for field safety inspections of crossings.
- **Sewage Treatment:** streamflow data are required for plant operations to support water quality monitoring and to confirm that adequate dilution flows are available in receiving waters.
- **Stormwater Management:** Integrated Stormwater Management Plans (ISMPs) require stream flow data.
- **Water Works:** during operations gauging data are used by water supply system operators to plan reservoir withdrawals and make operating decisions that recognize the requirements of downstream users and resources.

Economic Benefits

Such operating uses of the hydrometric system are fundamental to ensuring that use of BC's water resources is sustainable. The increased emphasis in the province on sustainable resource management and the move to results-based codes of operation place increased demands on all of the players within the resource sector to manage water resources effectively and in ways that respect and promote other resource values. As outlined in the preceding sections on individual resource industries and economic activities, it is impractical to attempt a detailed evaluation of the operating benefits that the hydrometric system provides to the resource sector. Such an evaluation would require that each individual player – each forest company, hydro plant, mine, irrigation and drainage scheme, oil and gas company, sewage treatment plant, and water utility – would have to be assessed, since use and benefits are expected to vary widely. Rather than attempt such an impractical task, this review makes the simple suggestion that it is likely that the widespread availability of adequate hydrometric information throughout the province would result in at least a 1% increase in the GDP contributions of the resource sector. Because

the existing hydrometric program does not adequately address all of the operating needs of the resource sector, a scaling factor of 50% is also suggested, indicating that the sustainable resource management benefits accruing to the present hydrometric program are at least 0.5% of the ongoing GDP of the resource sector. Given a present GDP of approximately $11,000 million, this amounts to at least $55 million annually. With appropriate expansion of the program, up to an additional $55 million in sustainable resource management benefits could be obtainable in the future.

Government Users

This section provides a brief overview of the principle federal and provincial users of hydrometric data. Municipal government uses are primarily related to water supply, sewage treatment and flood mitigation which have been described earlier in this part of the report. The operational integrity of the programs described are directly impacted by the availability of appropriate hydrometric data.

Federal Government Users

The primary federal government user of hydrometric data in BC is Fisheries and Oceans Canada. They required water quantity information for research and programs concerned with habitat assessment, habitat conservation and stewardship, habitat enforcement, hatcheries, lake enrichment, and water quality.

Provincial Government Users

Lands and Water BC (LWBC)

Land and Water British Columbia Inc. is a Crown Corporation operating as an agent of BC government to carry out activities such as issuing land tenures, allocation and disposition of surplus land, and the administration and licensing of Crown water resources.

LWBC's Water Management Program is a major user of hydrometric data for each of the following program areas:

- **Dam Safety:** the Corporation is responsible for regulating approximately 2,700 licensed dams in the province. Responsibilities include Dam Owners Requirements; Emergency Preparedness; Operation, Maintenance and Surveillance and the Provincial Dam Safety Program
- **Water Licensing:** which includes responsibility for water licences; bottled water; data queries; expropriations; fees and rentals; First Nations; legislation; Quick Licensing; scanned licences; water users communities; water power projects; Water Protection Act Information and water rights
- **Water Use Planning:** which uses information from river forecasts, snow surveys and from water use planning at BC Hydro
- **Water Utilities:** LWBC regulates the forming and operating of water utilities and approves tariffs

Ministry of Water, Land and Air Protection (MWLAP)

The Ministry of Water Land and Air Protection programs require hydrometric data for programs related to flood protection, water quality monitoring and standards development, climate change and waste permit licensing and monitoring. Some ministry staff are also responsible for signing-off water licence applications.

The Environmental Protection Division's mission is to protect and enhance the quality of British Columbia's water, land and air in a way that contributes to the economic development of the province. This division establishes ambient quality standards, policies and legislation; establishes regulations, policies, best management practices, and stewardship agreements to ensure environmental objectives are met.

The Environmental Stewardship Division's need for hydrometric data relates to its role of environmental stewardship of biodiversity, wildlife, fish and protected areas; and the management of hunting, angling, park recreation and wildlife viewing.

Ministry staff in Victoria and the regions use hydrometric data in performing their roles. There is much transition taking place in the ministry and the role and responsibility of the regional hydrologist is changing with different roles being applied to this position in each region. Thus, it is difficult for the regional hydrologists to know what their precise hydrometric data needs will be.

Ministry of Sustainable Resource Management

The provincial River Forecast Centre (RFC) is currently in the Ministry of Sustainable Resource Management but is likely to move to the MWLAP. Staff of the (RFC) collect and interpret snow, meteorological and streamflow data to provide warnings and forecasts of stream and lake runoff conditions around the province. Most of the meteorological and streamflow data are collected by other agencies, but the RFC is the lead agency in the province for the collection, quality control, analysis and archiving of snow data.

Ministry of Forests

In British Columbia, the major potential hydrologic effects of timber harvesting and road building are increases in the magnitude of peak flows, increases in the amount of surface erosion, increases in the frequency of landslides, and physical changes to streams.

The ministry's Research Branch, which operates under the Forest Sciences Program, has more than 55 scientists and technicians working in Victoria, regional and district offices, and research stations. The Forest Hydrology Research Program determines the effects of forestry activities on water quality, water yield, erosion, sedimentation, and stream channel morphology. They also develop and verify guidelines for improved forest practices. Their research covers a large range of topics relevant to forest hydrology, such as streamflow, water quality, snow accumulation and melt, the energy balance, evapotranspiration, interception, soil moisture, fish habitat, climate change, and general watershed management.

The Engineering & Operations Section is responsible for ensuring forest transportation and harvesting systems are designed, built, maintained, deactivated and administered in an efficient and economical manner. They are also responsible for coordinating and facilitating delivery of the ministry's watershed restoration program.

The Roads and Structures Section provide professional engineering technical advice to regional and district staff related to road and structures planning, construction, maintenance and deactivation activities. They also carry out quality assurance activities on provincial road and structures, construction, maintenance and deactivation channels.

The Forest Investment Account (FIA) is a new provincial government mechanism for promoting sustainable forest management in British Columbia. It is founded upon a Vote of the Legislature, authorizing the Minister of Forests to provide funding for certain forest management activities. Specific amounts have been dedicated to program elements at the provincial level, other amounts have been allocated for disbursement to tree farm licence holders and certain tenure holders in each timber supply area. The FIA contributed $145,000 in financial support to MSRM for the operation of the BC/Canada Agreement Network in fiscal 2002/03. (The Forest Renewal BC contribution in 2001/02 was approximately $1 million.)

Provincial Emergency Program

The Provincial Emergency Program (PEP) relies heavily on hydrometric data for their flood damage prevention programs. The benefits to PEP was covered under the discussion of Flood Mitigation beginning on page 31.

Part IV

Assessment and Diagnosis: Meeting Users' Business Needs

Providing hydrometric data for users to make their water quantity-related business decisions is the fundamental raison d'etre of the hydrometric program—this is why the program exists. In this part of the report an assessment and diagnosis of the ability of the program to meet the business needs of key economic sectors and various provincial and federal government programs is provided. The analysis of user needs is followed by an assessment and diagnosis of the current state of the program delivery capacity within the Water Survey of Canada (WCS) and Ministry of Sustainable Resource Management.

Use and Adequacy of the Present Network

The major sectors of the provincial economy that have a continuing use for hydrometric data have been discussed in the previous sections. It appears that some sectors such as water supply, agriculture and sewage disposal are reasonably well-served by the hydrometric network. In cases where data are inadequate, it is common practice for utilities to fund the construction and operation of stream gauging stations as their needs are site-specific.

The sectors that are least well-served are those that require regional data, often on small streams throughout the province. These include the major economic sectors of forestry, transportation, IPP hydro, mining, and oil and gas.

There are potentially significant benefits from the operation of stream gauges for flood warning. There are flood warning systems on the major rivers upstream of the larger communities in the province. Other communities are less well-served.

The benefits of the hydrometric network for all sectors primarily relate to cost savings in design and construction and reduced operating costs. Where data are inadequate, there is increased uncertainty in the design process and to compensate for the risk conservative decisions are made. These decisions are made not only by project designers and operators but also by regulators. This sometimes leads to less water being allocated for the project than is available and; in other instances approvals may be delayed or, in the extreme, not provided due to this uncertainty.

In the case of the small hydro and mining sectors, investors require low risk regarding available water supplies for power generation, mill operation and waste disposal. Streamflow records are key to demonstrate project feasibility and the absence of adequate data can lead to reduced investment in the province.

Many of the sectors collect their own hydrometric data that are not captured by the WSC system. All the sector representatives interviewed indicated that they would be willing to share data and welcomed the idea of a provincial standards system.

There is an expressed willingness to contribute to network operations through a levy on water rates and by cost sharing site-specific construction and operation of stream gauging stations. The current policy of WSC is to require the total costs to be met by partners requiring the installation of a stream gauging station. The need for more flexibility in arrangements with WSC was mentioned by a number of sector representatives. While

flexibility means partners want government to pay more towards shared costs, existing program budgets do not provide flexibility to accommodate those wishes.

Benefit-Cost Analysis

Table 1 summarizes the evaluation of the benefits of the hydrometric system contained in the previous report sections. Benefits are grouped by sector and by type of benefits. Three types of benefits have been quantified in this study – design-related benefits, flood warning and avoidance benefits, and sustainable resource management benefits.

Design-related benefits stem from the use of hydrometric data to optimize the design of various types of hydraulic structures, namely road and rail stream crossings (including those of the forest sector), hydroelectric plants, the various hydraulic structures of the mining industry, the in-stream works of agricultural water management schemes, the pipeline crossings of the oil and gas industry, the hydraulic components of sewage treatment plants, the dams and reservoirs of water work utilities, as well as dyking, floodproofing and other flood protection works. Based on estimated levels of investment in these structures in BC, a total of almost $47 million of construction costs could be saved annually if adequate hydrometric information was available. It is estimated that the present hydrometric program provides sufficient data to capture $22.1 million of these benefits. A further $24.8 million of design-related benefits are presently being lost due to insufficient data, resulting in over-designed or inefficiently designed hydraulic structures. With appropriate expansion of the hydrometric program, these additional benefits could also be captured.

Flood warning and avoidance benefits are generated through the use of hydrometric data to either reduce flood damages through flood warnings which allow for removal of possessions, livestock, vehicles and machinery to higher elevations, and for residents to move to safety, or to avoid flood damages completely through temporarily increasing dyke crests by sandbagging. Given the prevalence of flooding throughout BC, and the average level of flood damages incurred in the province, it is estimated that a total of over $9 million could be saved annually if sufficient hydrometric data was available to provide effective flood warning systems in all areas of the province at risk. At present, the existing hydrometric network is considered reasonably effective in this regard, capturing an estimated $6.8 million of these benefits. However, up to an additional $2.3 million in flood mitigation benefits are obtainable through appropriate expansion of the network. The calculation of these benefit amounts is detailed in Table 1. (see next page)

Table 1 also presents an estimate of the sustainable resource management benefits that accrue to the present hydrometric system. These benefits relate to the use of hydrometric data for the day-to-day operations of the resource sector in their efforts to achieve sustainable resource management objectives and requirements. Such benefits are exceedingly difficult to quantify with any accuracy. To do so would require an inordinate amount of detailed research, well beyond the scope of this review. Instead, this review makes the simple suggestion that it is likely that the widespread availability of adequate hydrometric information throughout the province would result in at least a 1% increase in the GDP contributions of the resource sector. This amounts to $110 million annually. Because the existing hydrometric program does not adequately address all of the operating needs of the resource sector, only about half of these potential benefits, or $55 million, are estimated to be generated by the existing network. With appropriate expansion of the

Table 1
Benefit/Cost Analysis – BC/Canada Hydrometric System
Design-Related Benefits

Design-Related Benefits	projected future annual investment $millions	maximum potential hydrometric benefits %	scale factor for existing hydrometric program %	projected hydrometric benefits for existing program $millions	remaining uncaptured hydrometirc benefits $millions
Road and Rail Transportation					
Capital Investment, Road and Rail Transportation					
Capital Investment, Engineered Stream Crossings	100	15%	50%	7.5	7.5
Other Stream Crossings - Logging Roads	25	30%	25%	1.9	5.6
Hydroelectric Generation					
Production Plants					
est. Hydraulic Structures Component	250	5%	50%	6.3	6.3
Mines					
Tailing Disposal Systems, Settling Ponds					
Total Mine Investment					
Mines - est. Hydraulic Structures Component	80	5%	25%	1.0	3.0
Agriculture					
Irrigation and Land Reclamation	30	10%	75%	2.3	0.8
Oil and Gas Pipelines					
Oil Pipelines					
Gas Pipelines					
Total Pipelines					
Pipelines - est. Stream Crossings Component	15	10%	50%	0.8	0.8
Sewage Treatment					
Sewage Treatment and Disposal Plants	150	1%	75%	1.1	0.4
Water Works					
Reservoirs, Including Dams	10	10%	75%	0.8	0.3
Flood Protection Works					
Dyking Works and Floodproofing	10	5%	75%	0.4	0.1
Total Design-Related Benefits	670			22.1	24.8
Flood Warning & Avoidance Benefits	actual or avoided damages $millions				
Flood Warning Benefits	40	10%	75%	3.0	1.0
Flood Avoidance Benefits	10	50%	75%	3.8	1.3
Total Flood Warning & Avoidance Benefits				6.8	2.3
Resource Management Benefits	GDP of resource sector $millions				
Sustainable Resource Management					
Operating Benefits	11,000	1.0%	50%	55.0	55.0
Total Operating Benefits				55.0	55.0
Total of Benefits Quantified				83.9	82.1
Total Costs – Existing Canada/BC Network				4.4	
Benefit/Cost Ratio – Existing Network				19.1	

program, up to an additional $55 million in sustainable resource management benefits could be obtainable in the future.

The total of the annual benefits generated by the existing hydrometric program, as detailed in Table 1, is $83.9 million. A further $82.1 million is considered obtainable through appropriate expansion of the network. The expansion required to obtain these additional benefits is substantial. The principal of diminishing returns suggests that the expansion required to capture all of these benefits is probably well in excess of a doubling of the network, and possibly in excess of a tripling of network size.

The cost of operating and maintaining the present network of 461 stations is about $4.4 million annually. The estimated benefit/cost ratio of the current network is therefore 19.1. Every dollar spent continuing to support the present network returns more than nineteen dollars in benefits. Even if the sustainable resource management benefits, which have only been estimated on a "first principles" approach, are excluded from consideration, the present network returns almost seven dollars of direct benefits for every dollar expended.

It is also clear that expansion of the network is in the best economic interests of the province, and would promote Provincial goals of economic growth and sustainable resource development. Even if a tripling of network size was required to capture all of the benefits that the existing network fails to garner, it is likely that such an expansion would have a benefit/cost ratio of as high as 9 to 1. Less ambitious expansions would have appropriately higher benefit/cost ratios.

The proposal herein to implement a standards management and information delivery system for data from non-WSC gauges probably offers a particularly cost-effective means of expanding the overall availability of hydrometric data in the province. It is estimated that such a program would cost no more than $300,000 annually to operate. Opinions vary considerably among water resource experts on the amount of additional hydrometric data that such a program would collect, and even more concerning the utility of such data. Conservative estimates suggest that such a program would add the equivalent of about 30% more gauges to the present network of 461 gauges. However, this additional data is not expected to have the same utility as the data presently available through the existing network. This is thought to be the case for a variety of reasons, including the overlap of some "informal" stations with existing WSC stations, lower accuracy/standards, discontinuous records, and short record lengths. Conservative estimates suggest that the data captured from these "informal" gauges may only be 30% as useful as current data from WSC gauges. Other opinions suggest that these estimates are far too pessimistic. However, even if these estimates represent a "worst-case" scenario, the annual benefits of the proposal would still amount to almost $7.6 million, compared to annual costs of only $0.3 million, for a benefit/cost ratio of over 25 to 1.

Regardless of how the network is expanded, it is clear that expansion, not contraction, of the network is the correct direction to move towards achieving an "optimal" network. No analysis can define precisely the size of such an optimal network or BC. However, it is also clear from the analysis herein that the present network would have to be increased considerably before it approached an optimal size, and that there are few public investments available today that would generate such substantial returns as would such an expansion.

There are some that suggest that public funding of the hydrometric system is not warranted; that, if the benefits of hydrometric data are as substantial as indicated in this

review, the largely private beneficiaries of the data should be the ones that fund the system. While it is appropriate for private beneficiaries to participate in program funding, and considerable willingness to do so has been documented in this report, it is unreasonable to suggest that government should not continue to play a major role in program funding. This is true for many reasons. Firstly, government requires the data generated by the hydrometric system to effectively regulate, manage and protect Crown land and water resources. Secondly, several public agencies and Crown corporations are direct users of the data for the design and operation of public works, including highways, bridges, forest service roads, hydroelectric installations, in-stream fisheries works, and other public investments. Thirdly, only government is in a position to coordinate and lead a program given such a widespread and diverse user group. And fourthly, private users are rarely completely aware of all the benefits flowing from optimizing the design and operation of hydraulic structures, let alone held responsible for all of the costs stemming from sub-optimal design and operation. Economic analysis always assumes "perfect knowledge" and the absence of "external diseconomies". Perfect knowledge implies users are completely aware of the ramifications of their hydrometric analyses, structure designs, and operating decisions. In the absence of external diseconomies, users would be completely responsible for all of the costs stemming from these actions, including all costs arising from potential hydrologic failure of their structures. Since neither of these situations is completely realistic, there is a substantial divergence between benefit estimates and private sector willingness-to-pay. It is important to note that this situation should not be construed to suggest that the benefits estimated above are any less real.

The State of Program Delivery

British Columbia does not have an effective well-managed hydrometric program. Existing hydrometric operations suffer from a lack of focused, committed executive level leadership or vocal, supportive champions. Champions in the user community have difficulty being heard by the "service" providers due to the lack of an effective forum and consultation mechanism.

Existing hydrometric staff keep the program operating as effectively as possible under difficult circumstances. However, the best the understaffed and under-funded hydrometric unit can accomplish is to meet the administrative requirements the BC/Canada Hydrometric Agreement. Considerable time is spent trying to negotiate sufficient funding support from various government users to meet the Province's obligations. Considerable time is also spent planning changes to the network of stations (decommissioning or moving stations) as a result of decreasing funding for the network. There is little time to even think about developing the kind of comprehensive program user need requires.

To make their critical business decisions, the organizations operating in the sectors discussed in this report must have access to geographically relevant and accurate, quality-assured hydrometric data. Our analysis clearly demonstrates the sizable impact this data has on economic development, public safety and resource protection in the province. Meeting broad client needs and maximizing the economic and other benefits provided by hydrometric data requires a comprehensive, well managed water quantity data management program. Users have indicated that they feel left out of important hydrometric network decisions. They feel that network size, location and technological

component issues are being made by the service providers without consulting the clients. This is leading to a major disconnect between client and service provider. The perception is that decisions are based entirely on internal budget availability with little regard for client need. There is no capacity at current staffing levels for staff to work with the broad user community, though there is effective interaction with paying customers.

A comprehensive, well managed program begins with an intimate knowledge of client business decision and data needs. This enables the establishment of networks and standard management systems that meet existing needs and are responsive to changing needs. Program management also requires constant communication with clients to educate them on best network use practices and to encourage their participation in funding network operations.

A hydrometric network of data collection stations, data bases and reporting mechanisms are the technical or system part of a hydrometric program. To operate effectively, the integrity of the "whole" collection, storage, analysis, retrieval process must be maintained if it is to provide the data needed for business decisions. The integrity of the whole system has been compromised in recent years by the over-emphasis on elaborate information systems at the expense of gathering important data.

In recent years there has been considerable emphasis, in government and the private sector, on improving access to information on natural resources. This includes such concepts as integrated map-based information systems with "smart" capabilities, which are basically the natural evolution of data processing technology. The hope is that these will produce great efficiencies in resource management, and there have been major commitments (funding, staff resources) made along these lines in government. While the potential benefits of these new systems are intuitively apparent, the benefit/cost of these systems has yet to be determined. More importantly, these new systems in no way diminish the need for the fundamental data collection programs, like the hydrometric program, that are the foundation of resource management decisions and that are needed to populate the new systems. It could be said that a paradox now exists, where there is strong support for state of the art information systems while basic resource data collection programs are in disarray.

BC/Canada Agreement Network

The BC/Canada network has been under duress in the last decade from a number of sources including funding cutbacks from the federal and provincial governments, policy changes from the mid-1990's federal program review, uncertainties of other funding sources, technological change, retirements of significant numbers of staff, and more. During the 1990's the WSC network dropped from approximately 600 stations to the present 461. Program management has been extremely difficult because of inadequate and uncertain funding. To express it positively, the program has been sustained remarkably well under the circumstances. However, there are significant outstanding financial liabilities ($2 million provincial share for deferred work and decommissioning of stations) and challenges for ongoing operations, and these must be addressed in the next year or two.

Water Survey of Canada (WSC)

The WSC share in funding the network has been reduced from approximately 50% in the mid 1990's to the present level of approximately 33% in 2002-03. The dollar amount of funding from Environment Canada is presently expected to be stable, but this of course is subject to impacts from budget process and policy changes. Although the program is joint-managed, the WSC has the prime responsibility on staffing decisions. There is a significant graying of the workforce and many experienced technicians have begun to retire. Uncertainties around funding prevent the hiring of permanent staff so vacancies are filled with temporary placements or by engaging retired personnel on contract.

The WSC's management of their operations is quite remarkable under the circumstances, but significant issues and challenges must be addressed.

BC Ministry of Sustainable Resource Management

Under the Federal-Provincial Agreement, the Province has a number of roles: funding a share of the network (determined on a station by station basis), program management input to WSC (called "co-management), and business management for clients that provide outside funding.

The issue of base funding is a serious risk at this time, as evidenced by the significant variations in the Ministry 3-year budget figures over the last 6 months. Also, there is the related issue of the funding shortfall resulting from the closure of FRBC, which was funding nearly $1 million of hydrometric operations. At present a small percentage of this has been taken up by the BC Forest Investment Agency (FIA), but FIA is not considered stable long term funding.

The capacity for the Province to participate in co-management of the WSC program, or to carry out their part of network management work is relatively poor at this time. The Province has only one program expert in Victoria, and the support from regional offices of SRM, WLAP, or LWBC is very uncertain. It has been observed that water management in the province is in disarray, and this is just one part of that situation.

The Province's ability to carry out the business management work for the BC/Canada Federal-Provincial Agreement is in reasonable condition at this time. That ability is provided primarily by one staff position, working under the supervision of the Provincial Agreement Coordinator. It is noted that the Province is credited (i.e. paid) for doing this work, as part of annual budgeting for the BC/Canada program.

The State of the Informal BC Network

Hydrometric data is also collected around BC by a variety of parties other than WSC. These can include corporations, consultants, local governments, etc. General purposes can include data for operational needs, regulatory requirements (water licenses, waste permits, etc.), and data for project development and approval process. Historically there has been a great range in the quality of the hydrometric data collected by these operations, and much of it has been poor quality. More importantly almost none of it is of "provable" quality or accuracy, and almost none of it has been captured in a location where it could be made available to other users.

In the mid 1990's, with impetus and funding from FRBC, the Province began to develop a standards system for hydrometric data collection. The Manual of Standard Operating Procedures for Hydrometric Surveys in British Columbia was published in 1998, under the umbrella of the Resources Inventory Committee (RIC). An interim system for quality control was developed on a small scale, with "Certified Approvers" designated to carry out the essential task of data review and approval. This system has essentially fallen apart at this time, as the Province does not have the staff resources or budgets to create or operate a permanent system.

The Province also developed the WIDM database to capture time-series water data, including hydrometric. This system has recently reached a reasonable level of functionality. It includes hydrometric forms for use in station operation, as laid out in the hydrometric manual.

If a viable standards system were created, it would enable the verification of data accuracy for these stations operated by parties that were willing to use the system. The data could be captured in WIDM and disseminated to users in support of resource management activities. It is worth note that the hydrometric standards manual is for open water flow conditions only (no ice effects), and that it offers several levels of data accuracy.

The Consequences of the Current State of Program Delivery

Two issues were identified in the sections immediately above. The Federal-Provincial Agreement Network will be cut to approximately 300 stations from the present 461 if funding is not secured to replace the existing shortfall in base funding. Operations capacity will be lost and could not be rebuilt for at least five years. The provincial share of the existing liability for decommissioning stations is approximately $2 million. An additional financial liability of approximately $1 million will be created for decommissioning more discontinued stations. Also, a smaller network will be substantially less able to meet the growing need for hydrometric data for design of hydraulic structures, flood warning, and resource management.

Continued lack of funding of the BC Network will continue to prevent the program from providing an optimum level of data. If resources are found to develop and operate a standards system, this will enable collection of provable quality data that can be captured from the existing non-WSC stations and disseminated for use in resource management. This could significantly enhance or complement the database from WSC operations, though such stations would often not be comparable to WSC stations in quality or length of operation. If resources are not found for this, the work on standards development to date will be largely wasted, and data quality will not be provable and thus in most cases could not be trusted for use in resource management.

Part V

Prescription: Towards an Effective Client-focused Program

The recommendations in this Prescription section of the report speak to some of the key "root" issues that must be addressed if hydrometric data are to be provided as part of a well-functioning program making a major contribution to the economic and resource well-being in British Columbia.

Provide Leadership for Renewal

Provide the Leadership to Move Forward

Leadership is the biggest challenge facing the program. Strong, dedicated executive-level leadership is essential to implement the changes required to turn existing hydrometric operations into an effective comprehensive program. The hydrometric community is large and diverse with hundreds of participants and requires leadership to ensure its interests are being served. The government service delivery organizations need leadership to consolidate and enhance their funding and to enable staff to focus on meeting user needs. MSRM must reaffirm its commitment to the hydrometric program and to providing quality hydrometric data for the user community in British Columbia.

Recommendation One:

MSRM must reaffirm its commitment to the hydrometric program and to providing quality hydrometric data for the user community in British Columbia.

Without strong provincial leadership the hydrometric program is in danger of major deterioration. This deterioration would have major economic development and resource sustainability impacts that would persist for years. While MSRM has a policy of moving away from data collection, they also have a responsibility to lead economic renewal. Water quantity data are a critical foundation for economic development in the province. Letting this program wither would be short-sighted and would constitute a failure to lead economic renewal in the resource sector.

Effective leadership requires an understanding of the tremendous value of hydrometric and related data. It also requires a commitment to building a program that works to maximize the benefits for the well-being of the province. The Ministry of Sustainable Resource Management is in the best position to provide the required leadership. It is critical that an executive level provincial government official demonstrate leadership by taking action on the recommendations made in this report. It is unreasonable to expect such leadership to come from somewhere else. There is no "somewhere else."

MSRM must provide the leadership for the renewal of the hydrometric program.

Promote the Program

Promoting the program is a critical leadership role that requires attention. To meet its potential, the program has to move from its historical roots as a primarily technical operation to being a dynamic business-oriented organization that promotes and markets its services and benefits to the user community. Promoting and marketing the program will create a more global awareness of its benefits and facilitate the development of alternate funding mechanisms.

Recommendation Two:

MSRM must lead the creation of a business-oriented, user-focused program that will promote the program to users and other supporters.

Many business users also indicated their need for the analysis of hydrometric and other related data. Leadership is required to either develop, or encourage the development of,

the processes and tools for providing "value-added" analysis.

Creating a dynamic, business-oriented, user-focused operation will require the creation and staffing of positions with people that have the skills and abilities to succeed. Leading the transition to an alternate institutional structure will be an important step for promoting the program and obtaining funding support.

Expand the Core Network

Improve the BC/Canada Agreement Network

Immediate action to consolidate funding for the existing base network is critical. Constant funding uncertainty is a root cause of the problems facing the program and leads to sub-optimal decisions on network size and configuration. The BC government must take the lead in developing the funding mechanisms required to support the BC/Canada Agreement Network at its existing size and plan for its expansion. This includes encouraging both levels of government to increase their commitment to the economic development, public safety and resource protection of British Columbia by increasing support for the network.

Recommendation Three:

MSRM should take the lead in developing the funding mechanisms required to support the BC/Canada Agreement Network at its existing size and plan for its expansion.

Implement a BC Standards Management System

Expand the Volume of Quality Data

A comprehensive BC standards management system is critical to the future well-being of the hydrometric system. Due to reductions to the BC/Canada Agreement network and uncertainties of provincial funding, data users have been forced to rely on their own data gathering. Without a standards management system, much of the data collected has been substandard quality. Use of such data leads to either conservative risk and design decisions or to the potential for bad decisions. There is also not a formal mechanism for the sharing of data amongst users.

The amount of benefit provided by ensuring accurate data and making that data available through BC government data bases would be at least an order of magnitude greater than the modest amount of funding required. While this review did not allow for the detailed costing of the staff and resources required to operate a BC standards management system, an approximate estimate of the amount required is $250,000 to $300,000 per annum.

A viable standards system would enable the verification of data accuracy for these stations operated by third parties. The data would be captured in WIDM and disseminated to users for their engineering and resource management activities.

Recommendation Four:

MSRM should implement a standards management system for the collection, storage and dissemination of the significant volume of data being collected through the informal "disintegrated" network.

Lead the Development of Suitable Funding Mechanisms

The Role of Data Users

The critical role of government in funding the collection, storage and dissemination of core

Recommendation Five:

MSRM should undertake a detailed analysis of the various funding mechanisms and develop and implement a strategy for program funding (e.g.: base budgets, dedicated surcharges on license and permit fees, cost sharing partnerships).

or base hydrometric data was discussed in the previous section. The future well-being of the hydrometric program also requires the user community to contribute to funding the program. Users of data are found in the provincial government (especially WLAP, LWBC, Forests, PEP), the federal government, and in each of the economic sectors described in this report. Finding and implementing suitable mechanisms for participants of varying size from each sector to contribute is an important role for the hydrometric program.

Mechanisms

The following is a brief discussion of some of the principal mechanisms that would be included in the strategy:

- **Base Budget Allocations**

  Provincial government organizations are involved in the hydrometric program as service providers (MSRM) and as users (e.g.; WLAP, LWAP, PEP, Forests). It has been recommended that base budget cover the cost of providing base scientific, economic development, public safety and resource management data. Determining and obtaining fair use-based contributions from various government organizations is required. Once the level of user benefit is determined, appropriate base budget transfers can be negotiated or the case made for all government requirements to be allocated by Treasury Board to the MSRM budget.

- **Dedicated Fees and Licence Surcharges**

  Feedback from larger companies using hydrometric data indicated a willingness to contribute to the network via surcharges on fees and licenses. Using this mechanism is dependent upon current government policy and will require considerable lead time to develop the case and steer it through government approval processes.

  Major resource users could also be required to fund stations as a water licensing requirement.

- **Cost-sharing Partnerships**

  Opportunities exist for more users to contribute to cost-sharing existing or new stations. While details could not be researched during this business review, identifying opportunities and negotiating cost-sharing partnerships will be a key requirement for a renewed hydrometric program.

- **Charging for Data**

  This is the least viable method for generating significant amounts of funds. At best, experience has shown that fees can be charged to cover the cost of data dissemination. Fees will not cover the cost of data collection and storage. Users require more education on the real benefit of data to their business decisions, productivity and profitability.

Establish a Hydrometric Program Management Board

Move Toward a New Institutional Structure

Developing a suitable institutional arrangement to coordinate the diverse user and service delivery community in collectively managing and supporting the renewal and development of the hydrometric programs is critical. There is a need for a common organizational focal point where all players can come together for the overall well-being of the program and the essential business needs. Unless representatives of the major users and service providers work together, the state of the hydrometric program will continue to deteriorate.

The first step is the creation of a management board that will develop a step-by-step renewal plan for the hydrometric program. The management board will take the lead in promoting the hydrometric program renewal and building the partnerships that will provide the program's long-term funding. To succeed, the management board will require a small focused secretariat.

Recommendation Six:

MSRM should take the lead on the development of a Hydrometric Program Management Board with broad representation from major user sectors and service providers to oversee the direction and management of the "whole" system.

There are several models in existence that can guide the development of this proposed management board. Two examples are provided here:

- **Fraser Basin Council**

  The Fraser Basin Council is a not-for-profit, charitable organization established in 1997 to ensure the sustainability of the Fraser Basin. The Council works to facilitate problem solving by bringing together the people necessary to make decisions that balance social, economic and environmental values. The Council has a board of 36 members reflecting government (including First Nations) and non-government interests.

- **Clean Air Strategic Alliance (Alberta)**

  The Clean Air Strategic Alliance (CASA) was established in March 1994 as a new way to manage air quality issues in Alberta. CASA is a non-profit association composed of diverse stakeholders from three sectors. Senior representatives from each sector, government, industry, and non-government organizations (such as health and environment groups) are committed to developing and applying a comprehensive air quality management system for the people of Alberta through a collaborative, consensus-based process.

While it was not within the scope of this report to develop a plan for the creation of a management board, the authors see the board having some of the following features:

- the principal role of the board will be to oversee the entire program and to promote action on the recommendations herein that ensure the well-being of the program and maximum benefit to users.
- representation will be from all the major sectors using hydrometric data and from the Water Survey of Canada and the Ministry of Sustainable Resource Management.
- the board will be chaired by someone acceptable to the user and service delivery members.

- a small secretariat will be created to support the board, develop a comprehensive business and funding plan, and promote the program to users, service providers and supporters.

Future steps could see the development of a Public Private Partnership taking a more hands-on management role. The secretariat could conceivably manage (or manage the contract for) the implementation and operation of a standards management program for the non-WSC network.

Move Forward: Keep the Momentum Going

Recommendation Seven:

MSRM organize a meeting between representatives of key business sectors and senior government officials to discuss the users' business needs for hydrometric data, and to explore options for program renewal and funding mechanisms.

Engage the User Community

This business review was conducted from the perspective of the user community and the data they require to make important business decisions. Meeting client needs is what makes a program viable. During consultations, several business sector leaders expressed their desire to meet with senior government officials to discuss their data needs and their thoughts on program renewal.

It is extremely important that a meeting take place to begin the public-private collaboration that will begin the hydrometric program renewal. It is recommended that a meeting be scheduled as early as possible in the new fiscal year.

Succeed by Doing What is Necessary

The hydrometric program's key infrastructural importance in the province is much greater than most senior government and business officials appreciate. The program provides quality data that is the foundation for a vast array of economic development, public safety and resource protection business decisions. This lack of appreciation has led to neglect which, in turn, has created a program on the brink of collapse.

The action required to renew the BC Hydrometric Program is relatively straightforward and the funding required is minimal in relation to the vast benefit the program provides users. However, the program will not renew itself. Leadership, focus, the dedication of the required resources and commitment to follow-through are essential to build the program the province needs.

Now is the opportunity for the Ministry of Sustainable Resource Management to lead the renewal of the hydrometric program. The ministry is urged to take up the challenge.

"It is no use saying 'We are doing our best'

You have got to succeed at doing what is necessary."

Winston Churchill (1874 – 1965)