CITY OF WHITEHORSE

WATERSHED MANAGEMENT PLAN

Vol. 2: RISK ASSESSMENT AND RISK MANAGEMENT STRATEGIES FOR DRINKING WATER PROTECTION

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EXECUTIVE SUMMARY

This is the second report on a Watershed Management Plan for the City of Whitehorse. The first report entitled "City of Whitehorse Watershed Management Plan: Background/Status Report" provides information on the current status of the drinking water supply for the City of Whitehorse and the watershed that provides it.

This Watershed Management Plan is intended to set the direction for managing the City of Whitehorse source water areas for the long-term protection of source water quality. This marks the first time that a formal process has been undertaken in recognition of the importance of the watershed of the upper Yukon River basin for producing an ample supply of safe, high quality drinking water. The Watershed Management Plan is also guided by the knowledge that the watershed fulfills many other economic, social, cultural, spiritual and environmental needs; for example, as captured in the Yukon River Corridor Plan.

The Watershed Management Plan was prepared to assist the City with adopting a "source-to-tap" approach to drinking water protection, often referred to as a multi-barrier approach. The plan covers the Yukon River Corridor downstream from the Yukon River Bridge at Marsh Lake to the outlet from Schwatka Lake, as well as the sub-watersheds entering the Yukon River between these points. The influence of land use decisions and activities further up river (for example, along the shores of Marsh Lake) are recognized in the Watershed Management Plan.

This plan complements the vision and guidance provided in the City's Official Community Plan (2002) and the Yukon River Corridor Plan (1999).

The vision of the Watershed Management Plan is captured in the following statements:

> *"The watershed of the Yukon River, its sub-watersheds and lakes in the Whitehorse region, and the groundwater aquifers they are connected to, are essential to the health of the community. Governance of these resources shall focus above all on the protection of source water quality*
>
> *In addition, watershed management strategies and initiatives shall recognize the value of the watershed for social, cultural and economic activities, as well as the integral role of these activities in sustainable communities. Strategies and initiatives shall embrace only those activities that are compatible with and enhance, source water protection.*
>
> *Watershed management is a shared responsibility and brings with it a commitment to collaborative management."*

Four major goals were established to assist with the realization of this vision. These address:

(i) Raw Water Quality,
(ii) Riparian Zone Protection and Buffer Zones,
(iii) Recharge Area Protection, and
(iv) Stormwater Management.

These goals partly reflect the concern about the many, often small-scale but cumulative threats to hydrological, hydrogeological and ecosystem functioning throughout the watershed.

The area that supplies the City's drinking water, either as groundwater via the Selkirk Aquifer or as surface water via Schwatka Lake, is a moderately developed, multi-use watershed. This poses some immediate challenges for the City. One of these is the ability to police and enforce for a myriad of human activities in the watershed that could result in pathogens, contaminants, sediments, and/or nutrients affecting the drinking water supply. A second challenge is associated with activities and land developments/uses that could impair the functioning of the watershed but which are beyond the jurisdiction of the City to control.

The City of Whitehorse is among a small minority of communities in Canada that have prepared detailed watershed management plans for drinking water protection. This places the City on the leading edge of current deliberations about drinking water protection. Source-to-tap approaches to drinking water protection should include an ongoing evaluation of source water quality in the areas of the watershed that contribute to groundwater and surface water supplies; not just at the drinking water intake point or in the distribution system. Currently, there is a very limited amount of surface and groundwater quality data for critical points in the watershed. This places the City at a temporary disadvantage. Such data are useful for identifying problem areas in the watershed and then addressing them.

Recommendations provided in the Watershed Management Plan were developed from a detailed evaluation of the current state of the watershed, followed by an assessment and prioritization of activities that potentially place the source water supplies at risk. Possible risks to drinking water quality are driven by (i) pathogens that cause water-borne human disease; (ii) sediments that cause 'turbidity' which in turn undermines disinfection or may be accompanied by pathogens; (iii) chemical contaminants; and/or (iv) nutrient inputs that can result in blooms of noxious algae or more directly in human health risks (for nitrate). Of these, the major concerns for the City's drinking water supply are possible pathogen risks and sediment inputs, based on the current status of the watershed.

Higher priority issues identified for the City's watershed include the following:

- Direct faecal inputs by mammals
- Use of Schwatka Lake by waterfowl and other birds
- Fertilizer application in the Riverdale area
- Domestic use herbicides, pesticides, fertilizers, etc.
- Flooding of Marsh Lake waterfront properties
- Presence of gas station, fuel tanks, other activities near Selkirk well field
- Breaks/leaks in Riverdale area sewage lines
- Stormwater runoff
- General increase in human activities
- Agricultural parcels near the river; Developments on Marsh Lake

- Septic fields in country residential developments
- Developments on tributary streams
- Feces in lakeside and streamside areas

In light of the higher priority risks, the concern about cumulative effects on watershed integrity, and the value placed on community-based environmental stewardship, detailed watershed management options were recommended in the following categories:

- Implementation of Additional Treatment,
- Protection of Well-head and Groundwater Recharge Areas,
- Participation in Local Area Planning exercises,
- Increased Protection of the Riparian Zone,
- Riparian Zone Restoration and/or Mitigative Actions,
- Modifying Float Plane Facilities,
- Re-visit Country Residential Planning,
- Reducing Risks from Domesticated Animal Feces,
- Enhanced Management of Mining Activity within the Watershed,
- Establishment of an Exclusion Zone Around the Schwatka Lake Intake Pipe,
- Develop Guidance for Organized Sporting and Cultural Events on and Around Schwatka Lake,
- Water Quality Monitoring Within the Watershed,
- Public Education, and
- Harmonizing City and Yukon Government, and Regional Planning for Source Water Protection.

Instalment of a filtration treatment plant for the Schwatka Lake supply is briefly discussed as a viable method for addressing two of the highest priority risks: inputs of pathogens associated with water-borne human illnesses by (i) mammals, and (ii) birds on or near the reservoir. This was not evaluated in detail, however, since guidance on treatment technologies at the source intake is beyond the scope of the Watershed Management Plan, which focuses on barriers to drinking water impairment within the watershed above the point of intake.

Prior to the development of the Watershed Management Plan, there existed a management void in the protection of groundwater quality beneath primarily residential developments in the Riverdale area. The Selkirk Aquifer is located about 6 to 8 metres below the ground surface in highly permeable sand and gravel. This makes the source supply vulnerable to chronic inputs of pesticides, herbicides, or nutrients from fertilizer use. The groundwater is also vulnerable to petroleum hydrocarbon leaks or sewerage line leaks within the southern portion of Riverdale. The detailed evaluation of potential for contaminant releases, development of spill release contingency plans, and public education will help to minimize risks.

Several specific sites and activities have been the focal point of concerns about the integrity of the Schwatka Lake drinking water supply. The rapid movement of water (and theoretically of pathogens, sediments, and contaminants) in surface water flows throughout the watershed suggests that risks to water quality need to be evaluated and managed along sub-watersheds, not just near the Yukon River and Schwatka Lake. A major recurring theme in the Watershed Management Plan, therefore, is the importance of riparian zone protection, and also restoration in some cases. This is consistent with guidance provided in the City's Official Community Plan and Yukon River Corridor Plan; however, additional riparian zone protection measures are required based on a specific evaluation of set-back effectiveness for limiting protistan, viral and contaminant inputs into the drinking water supply.

There are many facets of effective riparian zone protection. Specific recommendations include the generic increase in setback distances on both sides of lakes, rivers, streams and wetlands to 50 metres from the current 30 metres. Set-back effectiveness is also affected by the quality of the buffer zone as well.

Another recurring theme in the Watershed Management Plan is the importance of an ongoing water quality monitoring program. The monitoring of surface water quality (and sediment loads) at key points within the watershed will provide basic information needed to assess the need for further enhancements to land-use restrictions and set-backs within specific sub-watersheds. Routine, long-term monitoring provides the best measure of effectiveness of the Watershed Management Plan in achieving its overall objectives.

The City's Official Community Plan and enhanced Zoning Bylaws are effective guidebooks for future developments in the watershed. These do not address several specific situations that currently exist, but which are in contravention of the spirit of the intent of the OCP and this Watershed Management Plan. Chapters 4 and 5 discuss property acquisitions, entry into voluntary agreements, and public education as the major tools available for redressing the past loss of set-backs and the associated value of the riparian zone in minimizing pathogen and sediment inputs. In some cases, land acquisition may be a viable alternative for the City; however, this needs to be carefully considered based on the number of land holdings throughout the watershed that are deemed to be non-compliant with the spirit and intent of source water protection measures. The availability of water quality and sediment source data from at least one round of study would greatly assist with decisions about prioritizing weak links in the City's multi-barrier protection strategy.

Activities on Schwatka Lake such as recreational boat use (including hydrocarbon spills) or swimming were rated as having a lower risk than direct pathogen introductions through defecation into the water by wildlife. Very little research could be found on the relationship between swimming activity and human health risks from treated drinking water. There is ample research evidence, however, for increased disease incidence in swimmers themselves from contaminated lake water. It bears remembering that swimmers may be more immediately at risk from pathogens in Schwatka Lake than those who consume drinking water, following chlorination disinfection.

An amalgamation of activities on the western shore of Schwatka Lake is recommended, accompanied by recommendations for measures to address the past loss of the riparian zone, which is entirely de-vegetated along the existing road. The activities that unfold on the western flank of the City's drinking water reservoir are less likely to cause risks for the drinking water supply if there are ways to encourage best management practices: for example, for garbage and solid waste handling; for addressing human sanitary needs; for managing domesticated animals; for ATV use, vehicle parking, and traffic; and for fuel handling.

Human activities that may escape attention based on a formalized evaluation of possible human health risks via the drinking water supply should nonetheless be scrutinized for possible restrictions based primarily on whether they advance or undermine watershed stewardship goals. This is consistent with the vision of the Watershed Management Plan.

A public education campaign about watershed functioning and water quality issues will be important for virtually all of the above-listed watershed/source water management options. Implicit in this is an understanding of the central role of community-based environmental stewardship. Some portion of the public may balk at recommendations for the establishment of an exclusion zone (including the adjacent terrestrial zone) around the Schwatka Lake intake pipe or changes to traditional uses along the western shore of Schwatka Lake. Many of the recommended options described in Chapter 4, however, were shaped by a concern that many undesirable activities around Schwatka Lake are difficult if not impossible to prevent through policing and enforcement. Public education and promotion of watershed stewardship are the most viable means for encouraging consistent, appropriate and responsible human actions, as opposed to those that increase risks to the watershed and drinking water supply.

Chapter 7 (partially prepared by the City of Whitehorse rather than the consultants) describes the approach to be taken to implement the Watershed Management Plan. It provides a preliminary schedule and estimated implementation costs.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

This is the second of a two-volume report on a Watershed Management Plan for the City of Whitehorse. The first volume entitled "City of Whitehorse Watershed Management Plan: Background/Status Report" provides information on the current status of the drinking water supply for the City of Whitehorse and the watershed that provides it.

The Background/Status Report (Vol. 1) contains information about-

- Spatial boundaries of the City of Whitehorse Watershed Management Plan;
- What we know from past studies on the watershed and drinking water supply (including drinking water quality);
- Current and projected drinking water needs;
- Current land use and jurisdictional control in the watershed within and beyond the city limits;
- Overview of the surface water supply, including alternatives;
- Overview of the groundwater supply;
- An evaluation of drinking water quality up to the present time;
- Experience with drinking water and watershed protection in other communities;
- Regulatory/policy approaches elsewhere for source water protection; and
- Public consultations in Whitehorse undertaken in support of the development of the Watershed Management Plan.

This Watershed Management Plan (**WMP**) is intended to set the direction for managing the City of Whitehorse source water areas for the protection of source water quality. The year 2003 marks the first time that a formal process has been undertaken in recognition of the importance of the watershed of the upper Yukon River basin for producing an ample supply of safe, high quality drinking water.

The Watershed Management Plan is also guided by the knowledge that the watershed fulfills many other economic, social, cultural and environmental needs; for example, as captured in the Yukon River Corridor Plan.

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The recent greater emphasis throughout North America on protecting source water areas at the landscape scale has been catalyzed by several recent cases where treatment of drinking water supplies alone has not been enough to prevent human illnesses, sometimes with tragic consequences. It has been argued that Canadians have for several decades been highly complacent about their drinking water supplies, a luxury that we can no longer afford.

The public in Canada is generally aware of the recent Walkerton tragedy, but there are several other recent examples of disease outbreaks attributed to contaminated drinking water. In 1994, for example, there was a cryptosporidiosis outbreak among residents of Clark County, Nevada (Craun and Frost, 2002)[1]. The source of the outbreak remains a mystery, however. Health officials could not identify any water treatment deficiencies or breakdowns, and the water quality, based on the available results, was deemed to be excellent prior to, during and after the outbreak. The community of Kelowna, B.C., experienced a cryptosporidiosis outbreak in 1996 the specific cause of which also remains a mystery.

[1] Craun, G.F., Frost, F.J, 2002. **Possible information bias in a waterborne outbreak investigation.** International Journal of Environmental Health Research, **12**(1): 5-15.

Similarly, the Greater Victoria Water District in 1995 struggled with a toxoplasmosis outbreak, the source of which was never established. **Several Canadian case studies are discussed in Volume 1.**

Ultimately, source water protection and multi-barrier approaches are undertaken with the specific intent of better identifying risks to drinking water quality. Identified or suspected risks can then be addressed through a variety of risk management strategies. An ability to identify emerging risks at an early stage is beneficial. It allows for longer time periods in which risk management approaches can be considered and implemented.

The initial and ongoing evaluation of source water quality and land use activities throughout whole watersheds provides direct knowledge about trouble spots and activities, which if left undiagnosed or untended could result in serious impairment of potable source water quality and/or quantity. Ultimately, ongoing diagnosis of source water quality at the watershed scale offers us some hope of avoiding past mistakes. Numerous communities throughout North America have had to abandon various surface water or groundwater supplies and find alternatives, after the supplies were compromised (see Chapter 4 of Volume 1).

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The City of Whitehorse obtains its drinking water from two major sources. Surface water is drawn from Schwatka Lake, which provides about two-thirds of the water used annually. The lake was created by the construction of a hydroelectric dam across the Yukon River in 1959. Groundwater is obtained from the Selkirk well field, in the Riverdale area, which pumps about one-third of the city's water needs into the water distribution system.

Objectives

The specific objectives of Volume 2 of the Whitehorse Watershed Management Plan are three-fold:

1) **Evaluate the potential risks to Whitehorse drinking water quality** based on source water origins and human or other activities and inputs in the larger watershed.[2]

2) **Provide detailed recommendations on appropriate risk management strategies**.

3) **Evaluate the management tools** (e.g. bylaws, policies, planning processes, territorial or federal regulations) **currently available to the City of Whitehorse for undertaking risk management and source water protection goals**, discuss their adequacy, and propose solutions where there are deficiencies.

Report Structure

The final chapter (Chapter 8) of Volume 1 of the Watershed Management Plan proposed a vision and specific goals for source water protection based on a multi-barrier approach. It is reproduced here as **Chapter 2**, since the Watershed Management Plan and future activities arising from the Plan emerge from this vision.

Chapter 3 provides an assessment of risks to drinking water quality (and by extension to human health). We describe the risk assessment approach, evaluate specific sources of risk for drinking water supplies, how such source materials change along pathways through the watershed, and conditions that can lead to human exposures to pathogens or chemical toxicants via drinking water.

Chapter 4 provides recommendations on risk management arising from the formalized risk assessment as well as best management practices for source water protection.

Chapter 5 summarizes the available policies, guidelines, regulations and other management tools that are relevant for source-water protection at the watershed level.

Chapter 6 provides a summary of major conclusions and recommendations.

Finally, **Chapter 7** suggests a possible approach to implementation of the Plan in relation to some of the concerns expressed by the general public, along with a proposed schedule and estimated implementation costs**.**

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[2] In addition to areas that drain directly into the Yukon River, the northern portions of Marsh Lake, or Schwatka Lake, there are five sub-watersheds that contribute to the study watershed: Yukon River East, Cowley Creek, Wolf Creek, McRae Creek, and McLean Creek.

2. VISION AND GOALS

The overall purpose of the Watershed Management Plan is reflected in the City's Official Community Plan, which states:

> "*The protection of Schwatka Lake and the surrounding watershed is of paramount importance. The City shall preserve, protect and enhance water supply areas by keeping recharge areas free from incompatible development and sources of contamination.*"

Leadership by the Whitehorse community

The Watershed Management Plan is intended to set the direction for managing the City of Whitehorse source water areas for the purpose of protecting source water quality over a time frame spanning the immediate future through the next century. The year 2003 marks the first time that a formalized watershed-based planning process has been undertaken. This is in recognition of the importance of the watershed of the upper Yukon River basin for producing an ample supply of safe, high quality water for southern Yukon and especially City of Whitehorse residents. **The Watershed Management Plan is also guided by the knowledge that the watershed fulfills many other economic, social, cultural and environmental needs.**

From Source-to-Tap: A Multi-Barrier Approach

The protection of source water quality through watershed management is important as the first element of a multi-barrier approach for protecting and enhancing human health and well-being (Figure 2-1), given the importance of adequate supplies of safe drinking water. In simple terms, the failure to prevent inputs of pathogens or chemical contaminants into source areas can lead to an over-reliance on treatment and monitoring at the tap. The presence of turbidity increases the possibility of inadequate disinfection. Elevated nutrient inputs increase risks of noxious and harmful algal blooms as well as the risks associated with disinfection byproducts.

What is the Catalyst for Source-to-Tap Drinking Water Initiatives?

According to the Federal-Provincial-Territorial Committee on Safe Drinking Water[3]:

> "In the past, many agencies in Canada and around the world have relied heavily on compliance monitoring as the mechanism for managing drinking water quality and therefore protecting public health. Compliance monitoring relies on sampling small amounts of water in a drinking water system and testing those samples for the presence of known and quantifiable organisms or substances. This approach has major limitations, including the shortcomings of sampling and monitoring techniques; inadequate consideration of the range of factors that affect drinking water quality; and failure to provide an effective response to microbiological pathogens and contaminants without a prescribed numerical guideline value or established method of analysis."

A **Source-to-Tap** approach means placing greater emphasis on preventing drinking water contamination, especially through the enhanced protection and monitoring of source water areas. It also means looking at drinking water collection and distribution systems more holistically, so that communities do not become over-dependent on treatment or compliance monitoring at the point of consumption to prevent water-borne illnesses.

[3] Federal-Provincial-Territorial Subcommittee on Drinking Water, 2001. Guidance for Safe Drinking Water in Canada: From Intake to Tap (12 pages) (available online at http://www.hc-sc.gc.ca/hecs-sesc/water/index.htm)

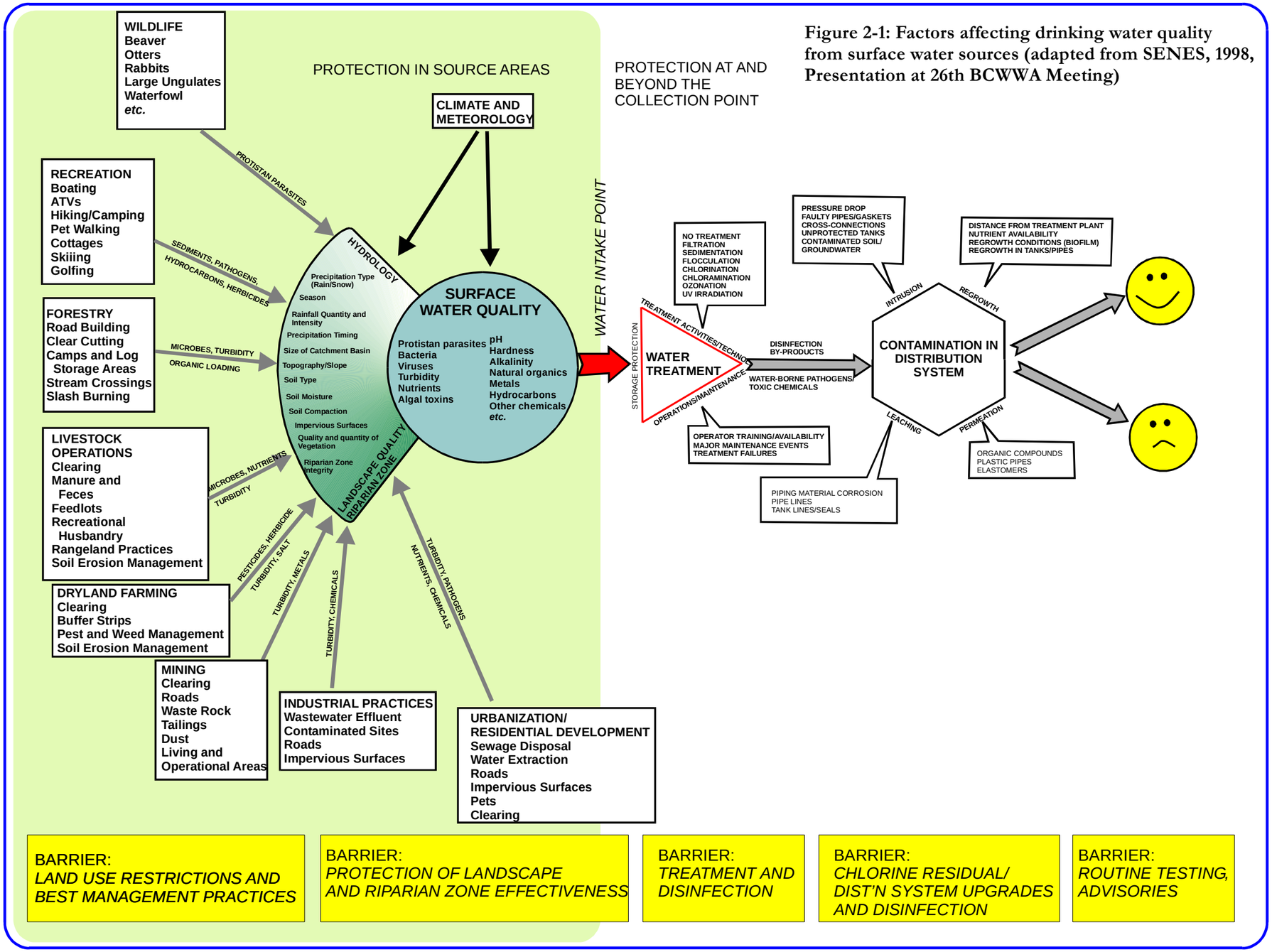


Figure 2-1: Factors affecting drinking water quality from surface water sources (adapted from SENES, 1998, Presentation at 26th BCWWA Meeting)

According to the Committee[3], **a comprehensive multi-barrier drinking water approach includes**:

The terms "Source-to-Tap" and "Multi-barrier Approach" are used interchangeably herein

- ☐ Source water protection;
- ☐ Sanitary surveys of the source area and distribution system to identify and prioritize risks to health;
- ☐ Watershed or well-head protection plans;
- ☑ Expansion capacity for population growth;
- ☑ For treated water, continuous optimal treatment;
- ☑ Routine maintenance of the distribution system;
- ☑ Treatment plant and distribution system classification, operator training and certification.

The checked boxes are the items that the City of Whitehorse, like the vast majority of Canadian municipalities, has already addressed, in whole or in part, through ongoing planning and day-to-day implementation. The City has also already started down the road to source water protection, and watershed or well-head protection; for example, through components included in the recently completed Official Community Plan.

It should be noted that the City of Whitehorse is also engaged in two planning processes related to the drinking water supply that parallel the development of the Watershed Management Plan.

First, the City is currently considering the possibility of moving from an unfiltered surface water supply to the implementation of filtration for the Schwatka Lake source water. Turbidity levels of Schwatka Lake often exceed 1 **NTU** (Nephelometric Turbidity Unit) during the summer time. In 2002, turbidity levels of source water spiked at greater than 10 NTU on 5 days (in the period from May 1st to June 1st).

The current Canadian Drinking Water Quality Guidelines for turbidity is 1 NTU, and the Federal-Provincial-Territorial Committee on Drinking Water is considering lowering this to no greater than 0.3 NTU for 12 consecutive hours, and never in excess of 1 NTU.

What is turbidity?

It is a measure of water clarity. The higher the turbidity, the less clear the water is, owing to the presence of fine particles that interfere with light transmission. Turbid water often appears cloudy.

NTUs (Nephelometric Turbidity Units) are how turbidity is routinely measured.

Why is turbidity important?

Elevated particle levels, measured as turbidity, can result in increased health risks for drinking water supplies in three ways:

1) The surfaces of fine particles provide **micro-environments for the survival and growth of microorganisms**,
2) The turbidity can at times be an indication of **increased concentrations of noxious algae and microroganisms**, and
3) The particulates can **undermine the effectiveness of disinfection treatment** of drinking water supplies, by consuming chlorine or other oxidants and by providing refuge areas for bacteria where the exposure to the disinfectant is less.

Second, the City has undertaken a preliminary evaluation of the possibility of decreasing the reliance on the Schwatka Lake surface water supply, and increasing the use of groundwater from the Selkirk Aquifer to supply the needs of the community. In 2003, Gartner Lee prepared a report for the Yukon Territorial Government, DIAND Water Resources, and City of Whitehorse entitled *Upper Yukon River - 2001 Groundwater Inventory Project*. Part 3: *Preliminary Groundwater Inventory of the City of Whitehorse* (February 2003). The aquifer would require better characterization, however, before the feasibility of use of groundwater without augmentation with the Schwatka Lake supply can be firmly established. One drawback of switching entirely from a Schwatka Lake to groundwater supply is that the groundwater in the Selkirk Aquifer tends to exhibit slightly greater hardness (higher mineral content) than Schwatka Lake water. Greater hardness can result in increased deposits of scale (calcium, magnesium, iron and other mineral deposits) in the distribution system and in household appliances, unless the groundwater is first treated to reduce hardness. There are also aesthetic (taste) concerns associated with hard water.

It should be noted, above all, that the Schwatka Lake surface water and upper-most groundwater aquifer within the Chadburn/Hidden Lakes outwash deposit, which includes the Selkirk Aquifer, is in fact the same inter-connected supply.

For each of the seven components of a multi-barrier water protection approach as identified above, the following enabling mechanisms are important:

- Management, including legislative and policy frameworks, financial capacity, designation of responsible parties, and standardized operating procedures;
- Monitoring (from source-to-tap);
- Contingency planning for emergencies and catastrophes;
- Research and development;
- Standards, guidelines, and objectives; and
- Public awareness and involvement.

Watershed-based planning for source water protection in the Yukon is a relatively new endeavour:

A major short-term challenge, therefore, will be to re-establish an appropriate balance between all of the activities and land-uses that unfold in areas that serve to collect, filter, and channel water into surface and groundwater supplies that have utility as a potable water source.

The implementation of a watershed-based plan for source water protection is built around a **risk management framework** that integrates the best available scientific understanding of watershed processes and human health risks from drinking water consumption, with viable management approaches. Risk assessment and risk management decisions are not just based on what is known about possible risks, but also on the degree of confidence in our ability to draw conclusions about or foresee risks. Decisions that are accompanied by a high degree of uncertainty generally include an appropriate degree of conservatism: If there is a possibility of erring, then the risk management decision intentionally seeks to err on the side of being over-protective of human health as opposed to being under-protective. Alternatively, or in addition to intentional over-protection, decisions in the face of a high degree of uncertainty will often lead to further research and monitoring as a practical means of reducing our

The WMP is built around a risk management framework.

Risk management decisions intentionally err on the side of being over-protective where there is uncertainty.

uncertainty and increasing the assurance about the soundness of risk management decisions.

Adaptive management is also embraced as part of the plan, given the long-term goals. Finally, **community-based stewardship**, **public education**, and the **cooperation between many jurisdictions with partial control over activities in the watershed** are seen as integral parts of an effective long-term plan.

Building on the City's Official Community Plan, the following vision statement captures the City's watershed management interests:

The Vision

"The watershed of the Yukon River, its sub-watersheds and lakes in the Whitehorse region, and the groundwater aquifers they are connected to, are essential to the health of the community. Governance of these resources shall focus above all on the protection of source water quality

In addition, watershed management strategies and initiatives shall recognize the value of the watershed for social, cultural and economic activities, as well as the integral role of these activities in sustainable communities. Strategies and initiatives shall embrace only those activities that are compatible with and enhance, source water protection.

Watershed management is a shared responsibility and brings with it a commitment to collaborative management."

2.1 Watershed Management Goals

Building on the vision statement, the City of Whitehorse Watershed Management Plan establishes four goals that guide concrete management programs and directions.

2.1.1 Raw Water Quality Goals

Raw water drawn from Schwatka Lake (or possibly other lakes in the future) or from the regional unconfined aquifer represents the integration of complex and diverse hydrological, physical, biological, geochemical, and hydrogeological processes occurring in the larger watershed. This includes, in particular, precipitation, run-off, infiltration, interactions with vegetation, microbial processes in soils, sediment

transport in surface water, and dissolved materials transport in surface and groundwater.

Routine sampling of source waters provides direct evidence of source water quality. In addition, such sampling provides evidence of trends over time, which might indicate a deterioration of conditions in the watershed. Finally, spatially focused sampling of surface and groundwater can be used on occasion to detect problem hotspots.

In light of this-

1) **A major goal of the watershed management plan is to maintain City of Whitehorse source water supplies so that they meet or exceed limits stated in the existing and any new *Canadian Guidelines for Drinking Water Quality* as they apply to unfiltered water sources prior to treatment.**

Ideally, water collected from anywhere in the watershed should meet or exceed the quality specified in the drinking water guidelines with some key exceptions. Natural surface waters may be unsuitable for human consumption without prior disinfection due to faecal coliform bacteria, protozoan and other types of parasites, nitrate, and other substances contributed by birds and other wildlife. Also, turbidity may render surface waters unsuitable for human consumption.

The goal implicitly recognizes that maintenance of drinking water quality will evolve as Canadian drinking water quality guidelines evolve, in response to the underlying scientific and health knowledge.

Maintaining water quality throughout the watershed minimizes the reliance on either dilution within the watershed, or on processes in the lower watershed that encourage either the destruction of potentially harmful protozoans and bacteria or break down of chemical contaminants.

2.1.2 Riparian Zone Protection and Buffer Zones

The Riparian Zone may be defined as the area of vegetation that borders rivers, streams, and wetlands, and which is a transitional area between terrestrial and aquatic ecosystems. The plant and animal communities found in the riparian zone are typically different from those found farther upland. Although riparian areas may occupy only a small percentage of the area of a watershed, they represent an extremely important component of the overall landscape.

Why is the Integrity of the Riparian Zone Important?

The riparian zone has many important biological and hydrological functions.

Of direct relevance to source water protection is the role of riparian zone vegetation in -

- filtering sediment, nutrients, pathogens, and chemical contaminants from upslope sources;
- stabilizing soils and prevention of erosion on banks and floodplains;
- moderating downstream peaks in water runoff and flooding through temporary water storage;
- helping to maintain cool water temperatures through provision of shade and production of microclimates; and
- maintaining channel form and aquatic habitat.

Various studies suggest that the functional importance of the riparian zone is greater for smaller streams than for large streams and rivers. Smaller headwater systems comprise a much greater percentage of the overall area of watersheds in comparison with major channels. In addition, shoreline inputs in small streams, as opposed to major channels and reservoirs are invariably accompanied by a much higher ratio of introduced runoff relative to the stream volume, resulting in much more limited potential for dilution of suspended sediments, nutrients and various contaminants potentially entrained in the surface flows.

In light of this –

2) A goal of the City of Whitehorse Watershed Management Plan is to encourage management decisions that recognize the significance of the riparian zone for water quality protection.

2.1.3 Recharge Area Protection

An aquifer recharge area may be defined as the surface area that receives rain or snow and passes a portion downward where it replenishes groundwater within an aquifer. The primary recharge area of a specific aquifer may or may not correspond with the surficial area directly above the aquifer, since much of the groundwater supply may originate from land areas many tens to hundreds of kilometers upgradient, especially for deeper aquifers. The extent to which water permeates downward into the local aquifer or is captured in surface runoff depends primarily on the permeability of soils, the interaction with vegetation, and cultural modification of the ground surface; for example, based on placement of impervious surfaces such as roadways and parking lots.

Recharge to an aquifer influences not just the quantity of groundwater, but also its quality. Human activities in the aquifer recharge area, if not adequately managed, can first act as a source of nutrients, chemicals and pathogens to the groundwater, and second impair the ability of soils and their associated microbiological communities to effectively treat the contaminants as the water passes through the soil.

In light of this –

3) A goal of the Watershed Management Plan is to protect groundwater quality in recharge areas for current and possible future drinking water sources.

2.1.4 Stormwater Management

Stormwater consists of that portion of rainfall and snowmelt that does not infiltrate through the soils, but rather runs across the surface, along with the materials (soils, chemicals, bacteria) that it collects as it runs downhill in the watershed. Historically,

stormwater collection systems have been constructed to prevent the pooling of water and flooding of parts of built-up areas, by rapidly channeling water toward lower areas of the watershed. An unfortunate consequence of historical stormwater management practices has been the creation of direct conduits for contaminants to enter into important waterways, although in recent years some of these historical effects have been ameliorated by the use of detention structures.

In light of this –

4) A goal of the Watershed Management Plan is to re-evaluate stormwater management as a component of community planning with the specific intent of protecting the quality of surface and groundwater.

2.2 Integration with the Yukon River Corridor Plan

Whitehorse City Council on December 13, 1999, adopted the *Yukon River Corridor Plan* prepared for the City of Whitehorse in consultation with its residents by Gartner Lee Ltd., Applied Ecosystem Management, Aboriginal Public Relations Consulting Services, Midnight Arts Research and Writing, Mougeot GeoAnalysis and UMA Engineering Ltd. **The overall objective of the plan is to guide future development activities within the municipal boundaries of the Yukon River Corridor.** This plan also forms a substantial part of the basis of the more recently adopted Official Community Plan for the City of Whitehorse. The Yukon River Corridor Plan, in particular, addresses the preservation of environmental integrity and heritage resources. Overall, the plan seeks to encourage opportunities in consideration of the valuable attributes of the Yukon River Corridor, and to raise public awareness.

Planning principles used to develop the Yukon River Corridor Plan include the following:

The overall land use and preservation goals which are designed to guide planning for the Yukon River Corridor are reflected in the following statements:

- Respect the range of natural wilderness environments afforded by the Yukon River Corridor.
- Draw people to the Yukon River to appreciate and experience the ecology, natural and human history.
- Accommodate a range of outdoor and recreation activities that are compatible with the natural setting and character of the River.
- Encourage land use, tourism, and recreational pursuits that complement Corridor potential and the established built environment of the City.
- Blend new facilities built in the non-urban areas of the Corridor with their surroundings through extensive use of natural materials to complement the environment.
- Emphasize linking of green spaces to accommodate people's desires for a wilderness experience, while preserving appropriate travel Corridors for wildlife.

Many of the principles inherent in the *Yukon River Corridor Plan*, as well as the City's *Official Community Plan*, are consistent with the vision and goals for the City's Watershed Management Plan for drinking water protection. Above all, they share the premise that planning processes need to be integrated, are most effective at resolving conflict and avoiding unwanted surprises when centred around a landscape or ecosystem-level approach, and are most effectively implemented in concert with public awareness, education, and collaboration.

It will nonetheless be important to concretely identify potentially competing principles and priorities among the various planning exercises, toward the possible need to make some tough but balanced decisions.

2.3 The Watershed Management Plan as a Long-term Management Tool

Watershed Management Planning for drinking water protection is as varied as the communities in which it unfolds. A key element in establishing a Watershed Management Plan initially is to obtain community buy-in of the benefits of adopting precautionary source water protection activities. The challenges with obtaining broad-based public support are greater in communities that depend on drinking water from highly developed, multi-use watersheds than where there is less at stake relative to previous expectations and habituations.

A key element in establishing a WMP initially is to obtain community buy-in of the benefits of adopting precautionary source water protection activities.

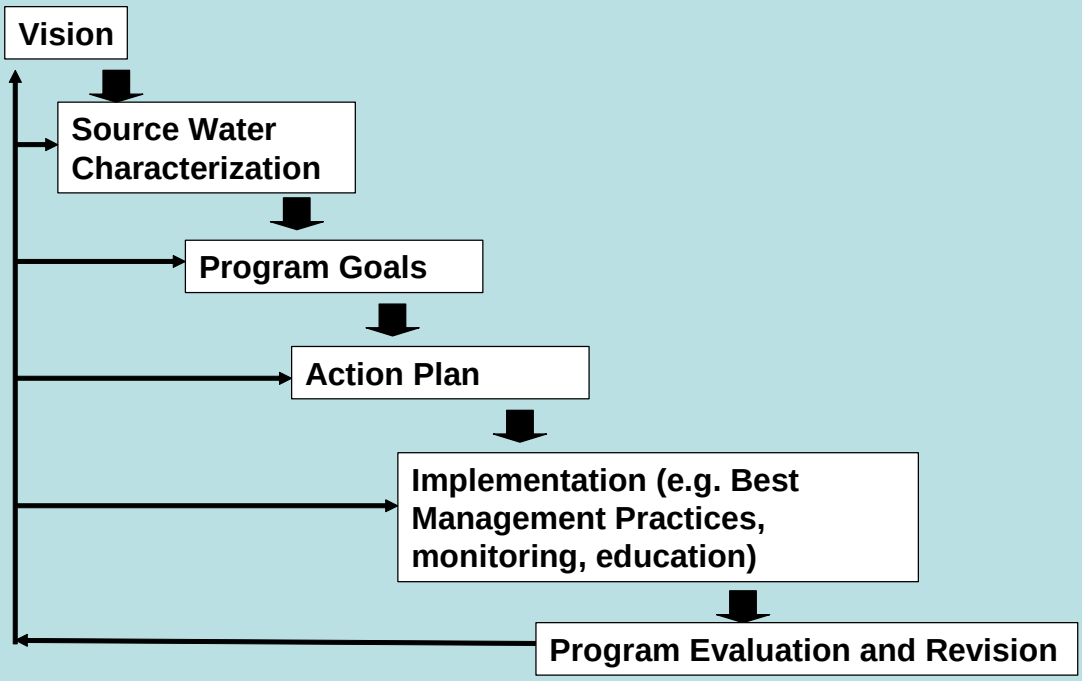
According to Gullick (2003)[4] **some of the benefits of source water protection** (and development of a Watershed Management Plan) **include the following:**

- improved public health protection through reduction of known and emerging contaminants, especially for sensitive sub-populations;
- aesthetic water quality protection (e.g., prevention of taste and odor problems);
- regulatory benefits (for example, less conflict with territorial and federal regulatory initiatives; greater predictability regarding future trends in drinking water protection);
- current and future cost savings (e.g., less treatment required);
- meet customer expectations and improve customer perceptions;
- maintain or improve source water quality for other users; and
- provide for general environmental stewardship (e.g., improve the overall environmental quality of the watershed and adjoining aquifers).

[4] Gullick, R.W., 2003 (November). AWWA's Source Water Protection Committee Outlines How to Maintain the Highest Quality Source Water. AWWA Journal, Nov. 2003: p. 36-42.

Gullick (2003) further identified key elements for a successful source water protection program (Figure 2-2).

Figure 2-2: The six essential elements of successful source water protection programs



Above all, specific actions (arising from an action plan) tend to be broadly supported to the extent that there was prior strong support developed for the vision of the Watershed Management Plan, followed by specific program goals.

One challenge with the development of the Whitehorse WMP is that some of the drivers require development of concrete plans and implementation strategies over relatively short time periods. This is without the prior development of broad-based public support for the vision of the WMP and its four goals, as well as education about the importance of riparian zone protection.

Note also that an early essential element is "source water characterization". Currently, adequate characterization data are lacking for City of Whitehorse source water areas.

Finally, it is important to appreciate that the WMP process is both long-term and cyclic – basically an adaptive management and continuous improvement model. Lessons learned as a community moves down from one element to the next can be used to re-visit the overall vision, goals, and action plan. The plan also necessarily includes a periodic program re-evaluation and revision. This may involve a re-focusing to improve effectiveness in key areas. Also, since the process is iterative and long-term, some specific actions may be easier to implement at a later date, where there is strong initial resistance.

The WMP process is both long-term and cyclic – basically an adaptive management and continuous improvement model.

Once the WMP is adopted initially, it forms the skeleton for planning to achieve long-term source water protection. The need for specific actions, therefore, can be tempered by emerging data on source water quality as well as other major changes in the watershed. Decisions about the timing of implementation for specific actions ultimately hinge on implicit or explicit estimations of the short-term risks of increased water-borne illness incidence in the absence of such action.

3. ASSESSMENT OF RISKS

This chapter –

- ***Explains what environmental risk assessment is all about*** *(p. 19-29),*
- ***Presents some qualitative and quantitative approaches that can be used to assess risks*** *(p. 21-32),*
- ***Describes the risk assessment model used to analyze relative risks in Whitehorse*** *(p. 29-32),*
- ***Provides the outcome of the risk assessment exercise*** *(p. 32-69)*

The goal of *environmental risk assessment* is to help managers make effective and prioritized decisions that have the greatest potential to improve human health outcomes or ecosystem health. Environmental risk assessment (**ERA**) is useful only to the extent that it guides informed *risk management* decisions. Risk assessment is also intended to be a transparent decision-making tool, with clearly documented assumptions.

This Chapter describes the ERA framework, and then proceeds to an assessment of various potential risks to drinking water quality within the watershed. The following sections focus primarily on *human health risk assessment* (**HHRA**), as opposed to *ecological risk assessment*, given the overall objectives of the Watershed Management Plan.

3.1 The Risk Assessment Framework

Very few things in life are completely risk-free. Humans routinely make decisions about a course of action based on perceptions of *acceptable* versus *unacceptable risk*. Risks tend to be viewed as more acceptable if they are based on low probability events and/or of lesser as opposed to greater consequence for those affected. Conversely, the greater the probability of some negative effect, the more unacceptable the risks become.

Perceptions about risk can be far from intuitive…

While most community members have some implicit understanding about higher versus lower risk activities, there is nonetheless a tendency to view risk as an all-or-none issue. Many people react to perceived risks based on either being adversely affected or not (all or none), regardless of the estimated quantitative probability.

As an example, many people react to quantifiable risks by an implicit assumption that the risks are either zero (non-existent) or one (100%). Regardless of the incidence of lung cancer among smokers within the population, behaviors are sometimes shaped by the logic that individuals will either get lung cancer or they won't. Such perceptions of risk (or reward) can be counterproductive to societal change.

Related to this is the common perception that the possibility of any risk is undesirable regardless of the actual probability. As a result, some individuals may have an unwarranted fear of a risk based on the former rather than the latter.

We sometimes refer to individuals or groups of people as being risk-adverse or, alternatively, being risk takers. This may be underlain, in part, by human perceptions that potential risks exist in one of two states – being present or absent, rather than existing along a continuum.

Although intuitively more challenging, the implicit understanding of a continuum of potential risks is an important pre-condition for decisions based on lower versus higher risk issues.

Voluntary versus involuntary risks

Public perceptions about risk are influenced by a large number of factors. For example, people tend to react differently to risks based on whether they are perceived to be *voluntary* risks (e.g., life-style choices such as diet or smoking) as opposed to *involuntary* risks – those over which the individual has little if any control. **Some of the risks associated with drinking water are considered to be involuntary, given the necessity to ingest water to stay alive.**

Risk makers versus risk recipients

Another issue that tends to influence perceptions about risk is the degree of overlap between parties that, through their actions, may increase the potential for human

health risks and the parties who are the group most vulnerable to such risks. Where the parties responsible for increasing potential risks are not the same as the risk recipients, there is a strong issue around social equity: Benefits accrued to one particular group are seen to be at the expense of another group, who is at greater risk as a consequence.

Specific risk management decisions by the City of Whitehorse need to consider whether the beneficiaries of some activity that increases risks to the drinking water supply are a relatively small minority of the larger community.

Human health risks from any set of stressors or activities can be evaluated based on two major factors:

1) the **probability** of an unwanted and harmful event occurring, and

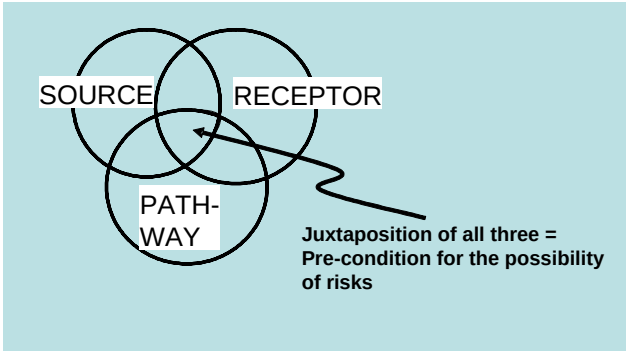
2) the **severity of consequences** should it occur.

Furthermore, the probability and severity of risks is directly influenced by three major components:

1) *sources* of potential risks,

2) humans or other *receptors* about which we are concerned, and

3) environmental *pathways* that potentially connect the receptors to source inputs.



For there to be a human health risk, there must exist a source, a potentially exposed group, and the environmental pathway(s) connecting them.

The pathways not only link source to receptor, they also modify the degree of potential exposure, since most *stressors* or *hazards* can change in magnitude over space and/or time.

The receptors of concern for the Watershed Management Plan are humans that drink water from the City of Whitehorse supply. This ERA and the Watershed Management Plan considers sensitive individuals within the larger population of Whitehorse, including immunologically weakened individuals, pregnant women, young children and the elderly. While a healthy adult may suffer few if any longer term health effects of a *Giardia* infection, weaker individuals who are exposed to *Giardia* cysts often suffer much greater consequences.

The risk analysis for drinking water protection includes a consideration of sensitive individuals

The ERA framework is often used to rule out the possibility of risks for specific scenarios. **For cases where there is no source, no receptor, and/or no viable pathway that would connect the two, the associated risks are deemed to be negligible.**

The environmental risk assessment framework provides clues about risk management options:

Environmental risks can be reduced by –

- **Reducing or eliminating sources** (stressors, toxicants, pathogens, etc.). – for example through land use restrictions or use of best management practices.
- **Eliminating possible receptors.**
- **Curtailing exposure pathways**, so that the exposure of receptors to the source of possible risk is reduced or eliminated.

  For source water protection, this underscores the importance of set-backs from water bodies, and riparian zone protection. Any conditions that limit the extent to which materials and surface flows are retarded and treated prior to entry into the water body serve to reduce risks by directly reducing the potential for exposure by humans.

Referring to Figure 2-1 (p. 7), drinking water protection barriers based on land use restrictions and/or best management practices seek to reduce or eliminate sources of potential risk before they are introduced into the watershed. Drinking water protection barriers based on riparian zone protection and riparian zone restoration (which often includes best management practices and land use restrictions, as well) aim to shape the

potential exposure pathways within a watershed so that the potential magnitude of movement from sources to the drinking water intake point is strongly reduced.

It is often not possible to exclude the possibility of risks based on the absence of one of the major risk components (source, pathway receptor). However, for risk scenarios with some, limited probability of occurrence (0 < probability < 1), this still does not mean that the risks are unacceptably high. A more detailed analysis of risks typically focuses on estimates of the severity or consequences of risks.

3.1.1 Quantitative Risk Assessment Models

In many cases, the probability of human health risks can be quantified. In practice, the quantification of risks is carried out by comparing how much of something a person might be exposed to (the estimated magnitude of exposure) with the threshold level for negative consequences.

A risk quotient[5] (**RQ**) is simply the ratio between how much the expected exposure is and the estimated 'safe' threshold.

$$\text{Risk Quotient (RQ)} = \frac{\text{Estimate of Exposure Magnitude}}{\text{Estimated Threshold of Effects}} \quad \textbf{(1)}$$

A *risk quotient* substantially greater than 1.0 implies that the degree to which humans are exposed exceeds their tolerable or allowable limits established to prevent effects. Conversely, a risk quotient less than 1.0 suggests that any risks are acceptable, since the degree of estimated exposure is still lower than the estimated threshold of effects.

Interpretation of the risk quotient needs to consider any assumptions used when estimating either safety thresholds of magnitude of exposure. Also, such estimates are usually accompanied by some uncertainty. The accepted practice in human health risk assessment, therefore, is to intentionally over-estimate the magnitude of exposure in the face of uncertainty, and to intentionally under-estimate tolerable exposure limits. This results in risk quotient estimates that tend to be higher than the actual risks, with the degree of over-conservatism related to the degree of uncertainty about exposures and toxicological knowledge.

The accepted practice in human health risk assessment in the face of uncertainty is to intentionally over-estimate the magnitude of exposure, and under-estimate tolerable exposure limits.

A simple quantitative risk assessment of some chemical contaminants can be carried out for the City of Whitehorse drinking water supply, using past

[5] Risk Quotients are sometimes referred to as "Hazard Quotients" or "Exposure Ratios."

sampling data (an estimate of human exposures) **compared with the Canadian Drinking Water Quality Guidelines** (safe threshold values). The monitoring data and guidelines are provided in Section 3.5 of the Background/Status Report (Vol. 1 of the Watershed Management Plan).

Table 3-1 provides a summary of the City's drinking water quality information, and compares the average or maximum observed values of various parameters to Canadian Drinking Water Quality Guidelines, where they exist. For contaminants such as coliform bacteria, the risk quotient assumes human ingestion prior to the point at which the Schwatka Lake water supply is disinfected through chlorination. The risk quotient values, therefore, predict risks from consuming source water prior to any form of treatment.

This simple risk assessment shows the following:

1) The source water quality for groundwater extracted from the Selkirk Aquifer poses no unacceptable risks based on human consumption even before any form of treatment. While a maximum turbidity value of 4 NTU was observed, the average turbidity was around 0.6 NTU, lower than the current Canadian Drinking Water Quality Guideline for turbidity. Occasional high turbidity readings would not be expected to cause possible health problems unless accompanied by water-borne diseases such as pathogenic enteric viruses and bacteria.

2) Schwatka Lake water samples **prior to disinfection** have shown seasonally elevated levels of faecal coliforms and cysts of the protistan parasite *Giardia lamblia*. Both average and maximum turbidity concentrations also suggest the potential for human health risks *if* disinfection and treatment are not effective in reducing levels in final consumed water.

   It should be noted that water samples are also routinely collected by the City from within the distribution system following chlorinated disinfection. In these samples, faecal coliforms generally have not been detected.

   The issue of protistan parasites in the surface water supply is examined in more detail later in this chapter.

3) The maximum measured concentrations of arsenic, aluminum, and selenium in the Schwatka Lake supply exceeded their respective Canadian Water Quality Guidelines. The average values, however, were much lower than the guidelines, and the average concentration better reflects chronic (long-term) exposures in humans, and the associated risks.

Table 3-1: Screening Level Evaluation of Human Health Risks from City of Whitehorse Drinking Water Based on Source Water Chemistry Data

[units in mg/L (milligrams per litre) unless otherwise indicated]

Substance	*Selkirk Aquifer*			*Schwatka Lake*			Canadian Drinking Water Quality Guideline (CDWQG) mg/L	Selkirk Aquifer	Schwatka Lake
	No. Data Points (No. of Detected Results)	**Average** (Range of Values)	**Maximum Value** (MV)	**No. Data Points** (No. of Detected Results)	**Average** (Range of Values)	**Maximum Value** (MV)		**Risk Quotient** (=MV/CDWQG)	**Risk Quotient** (=MV/CDWQG)
Faecal coliforms (no./100 mL)	26(0)	**nil**	nil	682 (82)	**3.6** (<2-23)	23	0	**0**	**>1**
***Giardia lamblia* cysts** (no./100 L)	0			45(22)	**2.3** (<0.2-30)	*246*[A]		**Note D**	**Note D**
hardness	30	**119** (40-164)	164	29	**26.6** (41-160)	160			
pH (unitless)	32	**8.0** (7.5 - 8.6)	8.6	31	**7.8** (6.9-8.6)		6.5-8.5		
Turbidity (NTU)	30	**0.60** (0.05 - 4.0)	4	29(19)	**2.6** (0.13-7.6)	7.6	1 NTU	**4.0**	**7.6**
Nitrate	30 (12)	**0.30** (0.028-2.5)	2.5	29(9)	**0.38** (0.013-1.74)	1.74	45	**0.056**	**0.039**
Temperature (^{o}C)	29	**5.1** (3.1-6.8)	6.8	27	**5.5** (0.4-13)	13	≤15 deg C		
Aluminum	9 (4)	**0.066** (<0.005 - 0.109)	0.109	6(5)	**0.086** (<0.01-0.22)	0.22	0.1	**1.1**	**2.2**
Antimony	9 (2)	**0.00025** (<0.0002-0.0003)	0.0003	6(0)	(<0.0002-<0.2)		0.006	**0.050**	
Arsenic	29 (6)	**0.0033** (0.0005-0.0045)	0.0045	30(3)	**0.1** (<0.01-0.3?)	0.3[B]	0.025	**0.18**	**12**[B]
Barium	9 (9)	**0.025** (0.020-0.033)	0.033	6(6)	**0.027** (0.025-0.030)	0.03	1.0	**0.033**	**0.030**

Substance	*Selkirk Aquifer*			*Schwatka Lake*			Canadian Drinking Water Quality Guideline (CDWQG) mg/L	Selkirk Aquifer	Schwatka Lake
	No. Data Points (No. of Detected Results)	**Average** (Range of Values)	**Maximum Value** (MV)	**No. Data Points** (No. of Detected Results)	**Average** (Range of Values)	**Maximum Value** (MV)		**Risk Quotient** (=MV/CDWQG)	**Risk Quotient** (=MV/CDWQG)
Cadmium	9 (2)	**0.00015** (<0.00001-0.0002)	0.0002	6(1)	(<0.00001-0.0007)	0.0007	0.005	**0.040**	**0.14**
Chromium	9 (1)	**0.0005** (<0.0005-0.0005)	0.0005	6(1)	(<0.0005-0.001)	0.001	0.05	**0.010**	**0.020**
Copper	29 (11)	**0.01** (0.002-0.024)	0.024	30(24)	**0.035** (0.002-0.24)	0.24	1	**0.024**	**0.24**
Lead	29 (5)	**0.0029** (0.0002-0.006)	0.006	29(1)	**0.006** (<0.004-0.006)	0.006	0.01	**0.60**	**0.60**
Iron	29(15)	**0.062** (<0.002-0.28)	0.28	30(26)	**0.19** (0.006-1.16)	1.16	0.3	**0.93**	**3.9**[C]
Selenium	9 (2)	**0.0004** (<0.0002-0.0005)	0.0005	6(1)	(<0.0002-0.04)	0.04	0.01	**0.050**	**4.0**[B]
Uranium	5 (2)	**0.002** (0.0015-0.0026)	0.0026	6(0)	(<0.06-<0.07)		0.02	**0.13**	
Zinc	29 (11)	**0.009** (0.001-0.039)	0.039	30(22)	**0.0065** (<0.001-0.014)	0.014	5	**0.0078**	**0.0028**

NOTES:
A) Average and range based on collated data from 1999-2002. The single value of 246 cysts/100 mL, recorded for a sample collected on Dec. 27, 1997, is probably an erroneous result since the laboratory did not analyze the sample within the specified time period for quality assurance.
B) The single analytical result for arsenic and selenium, on which the risk quotient is based, is considered unreliable. The major portion of samples did not exhibit detectable concentrations in excess of the CDWQG.
C) The Canadian Drinking Water Quality Guideline for iron is based on "aesthetic" concerns only (e.g. taste, odor, staining) and not on human health risks.
D) It is not possible to estimate a risk quotient, since there is no known threshold for adverse effects.

Based on the current situation, there is little risk to residents of Whitehorse who ingest drinking water from the following substances:

- Nitrate
- Metals
- Disinfection byproducts (Trihalomethanes)

In almost all cases, the maximum concentrations measured were still far lower than their respective Canadian Drinking Water Quality Guidelines.

Most other substances have not been routinely evaluated, or even tested on a one-time basis. Any such water quality assessment, however, would only be justified to the extent that there are possible sources. The adequacy of the currently available monitoring data is discussed in Chapter 4 of this report.

Table 3-1 underscores the importance of pathogens (faecal coliforms, *Giardia*) and surface water turbidity for drinking water protection in Whitehorse.

This provides part of the rationale for the importance of these two major issues for prioritizing risks of various activities and issues, as discussed further on.

(see also Figure 3-3on page 46 for information on Giardia trends in Schwatka Lake samples since the beginning of 1999)

Non-quantitative approaches for assessing and prioritizing environmental risks:

The quantitative risk assessment model is difficult to apply for some sources of risk where there is not a clear relationship between the concentration of a stressor in source water and human health outcomes. For infectious disease it is often difficult to predict based on our best scientific knowledge how many cysts or potentially pathogenic bacteria or viruses, if ingested, would lead to an increased potential for adverse health problems.

With respect to *Cryptosporidium* or *Giardia,* the Federal-Provincial-Territorial Taskforce on Drinking Water Quality in 1999 concluded –

> "Although *Giardia* and *Cryptosporidium* can be responsible for severe and, in some cases, fatal gastrointestinal illness, it is not possible to establish maximum acceptable concentrations (MACs) in drinking water at this time. Routine methods available for the detection of cysts and oocysts suffer from low recovery rates and do not provide any information on their viability and human infectivity. Nevertheless, until better monitoring data and information on the viability and infectivity of cysts and oocysts present in drinking water

are avail able, measures should be implemented to reduce the risk of illness as much as possible."[6]

According to the Federal-Provincial-Territorial Taskforce[7], the most important aspect of drinking water quality is based on microbiological quality, to ensure that risks of exposure to pathogens are minimal. Bacteriological quality is currently managed within Canada based on a guideline that the Maximum Acceptable Concentration for coliforms is zero coliforms per 100 mL sample (or thermotolerant bacteria, where applicable) *within the drinking water distribution system.* In other words, final drinking water sample should contain no faecal coliform bacteria.

When assessing risks in *source water supplies* as opposed to treated water, we might also assume that any presence of faecal coliforms increases risk. If we were to attempt to develop a risk quotient, however, assuming an acceptable health threshold of zero, then the denominator in equation 2 (p. 24) would be zero, and it would not be possible to calculate a risk quotient that is a rationale number.

For cases where it is challenging to develop numerical guidelines for source water supplies, it becomes difficult to make any strong assertions about acceptable versus unacceptable risks. On the other hand, it is clear that human health risks associated with drinking water ingestion are increased with increased concentrations in source water of potentially pathogenic protozoans, microbes, and turbidity. This issue goes to the heart of the city's Watershed Management Plan.

When human health risks cannot be confidently quantified, they can still be formally ranked in light of the expected factors that increase risks.

3.1.2 Qualitative Risk Assessment Models

When human health risks cannot be confidently quantified, they can still be formally ranked in light of the expected factors that increase risks. For example, Thompson (1999) developed a comparative risk matrix for abandoned mine sites, as shown in Table 3-2.

[6] Federal-Provincial-Territorial Task Force on Drinking Water Quality 1999. *Protozoa: Giardia and Cryptosporidium.* 28 pages.

[7] Federal-Provincial-Territorial Task Force on Drinking Water Quality, 2001. *Guidance for Safe Drinking Water in Canada: From Intake to Tap.* 12 pages.

Table 3-2: Calculation of Risk Using a Comparative Risk Matrix (after Thompson 1999[8])

	CONSEQUENCES				
LIKELIHOOD	***Very Low:*** **1**	***Minor:*** **2**	***Moderate:*** **3**	***Major:*** **4**	**Catastrophic: 5**
A: *Almost certain*	**15** *(Significant)*	**10** *(Significant)*	**6** *(High)*	**3** *(High)*	**1** *(High)*
B: *Likely*	**19** *(Moderate)*	**14** *(Significant)*	**9** *(Significant)*	**5** *(High)*	**2** *(High)*
C: *Moderate*	**22** *(Low)*	**18** *(Moderate)*	**13** *(Significant)*	**8** *(High)*	**4** *(High)*
D: *Unlikely*	**24** *(Low)*	**21** *(Low)*	**17** *(Moderate)*	**12** *(Significant)*	**7** *(High)*
E: *Rare*	**25** *(Low)*	**23** *(Low)*	**20** *(Moderate)*	**16** *(Significant)*	**11** *(Significant)*

This comparative risk approach was adapted for use in assessing risks in a watershed to sources waters that provide drinking water, as described below.

[8] Thompson, S.D., 1999. Risk Assessment for Mines. In *Proc. Queensland Mining Industry Health and Safety Conference.*

For source water protection, major factors that are known to increase risks of water-borne illness or other human health risks include -

- **The nature of the source activity or situation:**

  Can it contribute human pathogens that can survive in water?

  Is it a potential source of turbidity to surface waters?

  Can it contribute chemical contaminants to source water areas?

  Can it contribute nutrients to source water areas?

- **Spatial extent and/or intensity of a set of activities in the watershed or recharge area**; and

- **Proximity of the set of activities to the drinking water intake pipe(s) or upstream/upgradient areas where there is little potential for source reductions along the flow path.**

Activities closer to the groundwater and surface water source areas are a higher priority for managing risks than those farther away.

For the purpose of the City of Whitehorse Watershed Management Plan, the model used for evaluating potential risk factors and prioritizing issues is shown in Table 3-3.

The three major components are consistent with the generalized risk assessment model as described previously; i.e. -

- **Source Characteristics** are evaluated with a priority given to possible sources of human pathogens (protistan or other parasites, bacterial and viral diseases); lesser priority given to sources of turbidity, chemical contamination, or nutrients.

- The pathways are evaluated in terms of the **Proximity to Water**.

- The **Spatial Extent and/or Intensity** of an activity, land use or other issue is expected to influence both the importance as a source and tendency for migration along the transport pathways in the watershed.

- Finally, the receptor scenario involves the consumption of drinking water by residents in or near Whitehorse. Since this is common to all issues under consideration, it is not used as a factor for prioritization.

Table 3-3: Model for Prioritizing Risk Factors for the City of Whitehorse Drinking Water Supply.

SOURCE CHARACTERISTICS

Input Source is-	Risk index
Major source of possible contamination by pathogens	4
Minor source of possible contamination by pathogens	3
Major source of possible non-pathogenic contaminants	2
Minor source of possible non-pathogenic contaminants	1

High Priority

X

Low Priority

PROXIMITY TO WATER

Area/activity of interest is -	Risk index
0-50 m from closest source water area	4
50-250 m from closest source water	3
250-1,000 m from closest source water	2
> 1,000 m from closest source water	1

X

SPATIAL EXTENT

Area involved encompasses -	Risk index
1 - 10% of effective sub-watershed	4
0.1 - 1% of effective sub-watershed	3
0.01 - 0.1% of effective sub-watershed	2
<0.01% of effective sub-watershed	1

High Priority

Low Priority

Road works; residential developments; agricultural, forestry and mining activities; or recreational activities would be afforded a relatively high priority if they encroached on riparian zones of even third and fourth order (smaller tributary) streams within a distance of 50 metres or less (perhaps greater if closer to main channels and lakes).

For some watersheds, this would not make sense. The surface water transit times, however, throughout the major portion of the Yukon River watershed encompassed by the Watershed Management Plan are expected to be very short relative to the period required for any substantive protozoan, bacterial or viral die-off. In other regions of Canada, streams may have several reaches where the channel widens, and there is quiescent flow (in ponds and wetlands, for example). For the sub-watersheds included in the Whitehorse WMP area, stream and river gradients tend to be quite steep, with few low-gradient areas along the entire flow path. Overall, the conditions may not exist for removal of contaminants, once introduced to flowing waters, via sediments or other processes, suggesting that the magnitude of risks once materials are introduced to actively flowing surface waters fall within a relatively narrow range. The evaluation of *proximity to water*, therefore, mostly considers how close an activity or issue is to any riparian zone area within the watershed and its sub-watersheds.

Based on the scheme provided in Table 3-3, large-scale land uses are deemed to be a higher risk for surface water quality than spatially limited and isolated activities, such as hiking. Therefore, roads are not identified as a problem *per se,* but stretches of road that interact with or pass near to riparian zone areas are expected to negatively impact the surface water quality.

The Whitehorse Risk Assessment Model

As discussed earlier in Chapter 3, there are many ways to try to measure risks. The model for evaluating risk factors presented in Table 3-3 is one such system. This is a qualitative model, and is relatively simple to use to compare various activities by assigning values for each of the three components (described on page 31). The risk indices produced from this model can be grouped into relative rankings of "Very High", "High", "Medium" and "Low".

During public consultation we heard from some people that this model does not result in an appropriate ranking of risks. Certainly, there is a degree of subjectivity involved in assigning risk indices, as with any qualitative model. The overall risk rankings must be viewed in relation to the purpose of the risk assessment, which is to help prioritize and focus the City's management efforts. That is, the higher ranked risks should be a higher priority. There would be no real value in trying to differentiate between risk rankings through a more definitive or quantitative approach.

Surface Water Quality – The Focus on Sub-Watersheds

As summarized in Volume 1 of the WMP, there is very little information on the quality of source water before the water reaches the Schwatka Lake intake pipe.

A limited scope "Water Contaminants Evaluation," however was completed in 1998. According to the report –

> *"The Whitehorse watershed is the most developed and impacted stretch of the Yukon River."*

Samples of surface water were collected from mid-channel at 11 sites chosen to be representative of inputs from sub-watersheds. Among these were southern Marsh Lake, the mouth of the McClintock River, the mouth of the Wolf Creek/Cowley River system, and Schwatka Lake.

Samples from the McClintock and Wolf Creek systems both had detectable chrysotile asbestos (1.3×10^5 and 1.3×10^7fibres/L, respectively) albeit at concentrations similar to or lower than the USEPA safe drinking water threshold (1×10^7 fibres/L; there are no Canadian guidelines). This probably reflects the presence of natural asbestos-bearing minerals in these watersheds.

The Wolf Creek/Cowley River sub-watershed sample also had a much higher concentration than in other samples of the nutrient phosphate (0.11 mg/L P_{O4}-P compared with 0.03 mg/L in Marsh Lake) and total dissolved solids (290 mg/L compared with 40 mg/L in Marsh Lake). Copper, iron, manganese, silicon, sodium and sulfur were also higher than in the other 10 water samples. So was the measured concentration of *Giardia* cysts (13 cysts/100 L compared to 0 detected in the Marsh Lake sample and 5 cysts/100 L detected in the McClintock River sample).

Based on this snap-shot in time, it is plausible that the Wolf Creek/Cowley River catchment results in a spike in phosphate, dissolved solids and *Giardia* to Yukon River mainstem flow, just up river from Schwatka Lake.

The comparative risk model in Table 3-3 is illustrated in Figure 3-1.

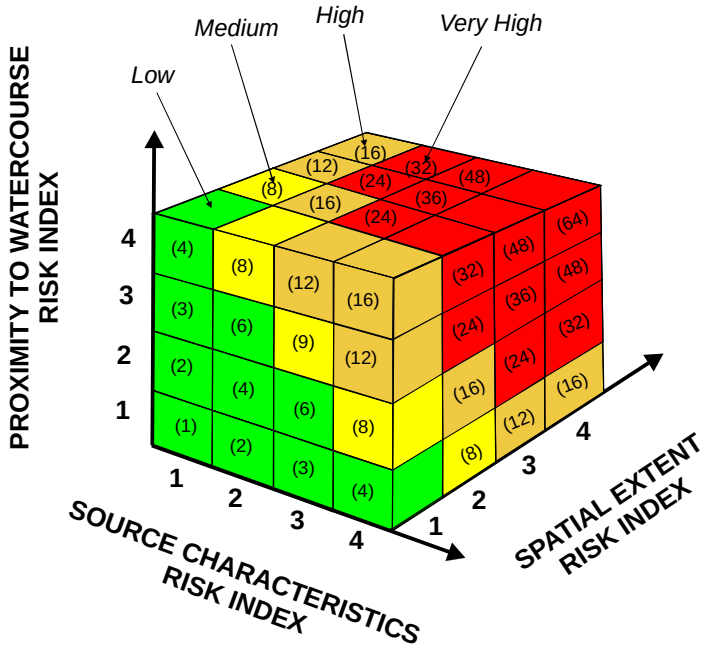


Figure 3-1: Comparative Risk Matrix for Source Water Quality Issues, City of Whitehorse.

Note that the numerical values of the scale shown in Figure 3-1 as well as Tables 3-15 and 3-16 (Section 3-3) provide an approximation only of the comparative risks. A maximum score of 64 does not imply a 4-fold greater risk potential than an activity/issue assigned a score of 16.

Above all, the comparative risk model used here allows us to divide activities and issues into those with higher risk potential (i.e. the orange and red-coloured cubes in Figure 3-1) versus lower risk potential (i.e., the green and yellow-coloured cubes). Note that this model tends to screen issues in, as opposed to screening them out – an aspect that we feel is appropriate in the absence of more detailed information during the early stages of the WMP.

There may be merits to addressing any or all of the issues/activities herein for source water protection; however those with a higher comparative risk are deemed to be higher priority.

In summary, two models are used for assessing risks to the City of Whitehorse drinking water supply:

1) Quantification of the potential human health risks where the exposure via drinking water can be quantified, and where the thresholds of acceptable exposures in human populations can also be determined quantitatively.

2) Relative risk ranking based on an appreciation of the factors that increase risks via drinking water consumption, as described immediately above.

3.2 Sources of Risk to the Drinking Water Supply

A list of activities and situations was developed based on concerns about the watershed and the City's drinking water supply. This was based on -

- a review of the City's drinking water source areas and current land use or other activities; and

- consultation with Whitehorse community members, city staff, the Watershed Management Plan Steering Committee, and various technical experts (see Vol. 1: Background/Status Report, Chapter 6).

Possible sources of risk are evaluated based on eight major risk categories. These categories capture the major areas of concern for human health protection and drinking water quality for any source water supply that includes both surface and groundwater:

Table 3-4: Major Categories of Risk for Whitehorse Source Water

Schwatka Lake	Selkirk Aquifer
1. **Contamination by human-borne pathogens** (for example, enteric bacteria associated with sewage);	2. **Contamination by human-borne pathogens (for example, enteric viruses such as Norwalk virus, bacteria associated with sewage);**
3. **Contamination by animal-borne pathogens** (*Cryptosporidium, Giardia*, other protozoans);	
4. **Contamination by chemical substances** (for example, fuel spills);	5. **Groundwater contamination by chemical substances** (for example, leaking underground storage tanks);
6. **Nutrient inputs** (for example, agricultural run-off; fertilizer use within or near the riparian zone of sub-watersheds);	7. **Nutrient inputs** (for example, from fertilizer use in the Riverdale area on lawns and gardens);
8. **Elevated turbidity and/or dissolved organic matter** (for example, as associated with land clearing, stream crossings, and other activities that enhance erosion and unfiltered run-off).	

Figure 3-2 provides a summary of the major land uses in the watershed, which are discussed in more detail in the Background/Status Report (Vol. 1). This provides an indication of the spatial extent and location of some of the identified possible sources of risk.

B SIZE 11" x 17" (279mm x 432mm)

LITTLE TAKHINI CREEK WATERSHED
NINE MILE CREEK WATERSHED
MACAULEY CREEK WATERSHED
MACAULEY CREEK WATERSHED TAVERN CREEK SUBWATERSHED
PORTER CREEK WATERSHED
MCINTYRE CREEK WATERSHED
MCINTYRE CREEK WATERSHED RESERVOIR LAKE
YUKON RIVER NORTH WATERSHED
LABERGE CREEK WATERSHED
CROUCHER CREEK WATERSHED
LONG LAKE COMPLEX WATERSHED
HILLCREST MELTWATER CHANNEL WATERSHED
CANYON CREEK WATERSHED
COPPER CREEK WATERSHED
BASALT CREEK WATERSHED
CHADBURN LAKE COMPLEX WATERSHED
CANTLIE LAKE WATERSHED
MCLEAN LAKE CREEK WATERSHED
MCRAE CREEKS WATERSHED
MCRAE CREEKS WATERSHED SOWDON CREEK SUBWATERSHED
SOWDON LAKES WATERSHED
YUKON RIVER SOUTH WATERSHED
MIRERS CREEK WATERSHED
WOLF CREEK WATERSHED
WOLF CREEK WATERSHED MARY LAKE SUBWATERSHED
COWLEY CREEK WATERSHED

Little Takhini Creek
Nine Mile Creek
Macauley Creek
Tantalus Creek
Porter Creek
McIntyre Creek
Maxwell Creek
Crestview Sewage Lagoon
Livingstone Trail Sewage Lagoon
Old Whitehorse Sewage Lagoons (emergency)
Stinky Lake
Long Lake
SELKIRK WELL FIELD
Riverdale Area
Proposed Commercial/ Tourism Development
Lakeside Road
Float Plane Docks
Water Intake
Boat Launch and Picnic Area
Recreational Area (Hiking, Skiing)
Schwatka Lake
Hidden Lakes
Chadden Lake
Chadburn Lake
Cantlie Lake
Yukon River
Mary Lake
Golden Pond
Murray Lakes
Douglas Lake
Swamp Lake
Kookatsoon Lake
AGRICULTURAL AREA
ALASKA HIGHWAY

LEGEND
- CITY OF WHITEHORSE BOUNDARY
- WATERSHEDS
- PAVED ROADS
- GRAVEL ROADS
- KWANLIN DUN LANDS
- TAAN KWACH'AN LANDS
- AGRICULTURAL LAND
- RURAL LAND
- TIMBER LAND
- MINERAL CLAIMS

SCALE 1:100000
0 1000 2000 3000 m

PLOT:
UMA FILE NAME: 2501 024 01 01 (0251b-06.dwg)

City of Whitehorse
Watershed Management Plan

Watersheds

Figure 3-2

3.2.1 Contamination of Schwatka Lake by Human-borne Pathogens

Pathogen risks are generally the most immediate concerns for drinking water safety based on past human experience. On rare occasions, drinking water supplies have been compromised due to the input of chemical substances such as road salt (chloride ions), metals/metalloids such as arsenic, water soluble fractions of petroleum hydrocarbons such as benzene, herbicide by-products, or other industrial use chemicals, including the degreaser and dry-cleaning solvent trichloroethylene (TCE). More typically, health managers have been concerned with sewage-related or other inputs in drinking water supplies that carry with them a risk of contamination by human disease-causing organisms.

> ***The emphasis on disinfection*** for the vast majority of surface drinking water supplies is based on concerns about pathogen risks. The possible sources of pathogen introduction into the drinking water system merit careful examination, however, since treatment alone may not be 100% effective in reducing pathogen risks.

Water-transmitted human-borne pathogens include –

- parasitic worms such as helminths and nematodes,
- protozoans including *Giardia lamblia* and *Cryptosporidium parvum*,
- gut-born (enteric) bacteria, and
- gut-borne (enteric) viruses.

Possible source types and activities for the City of Whitehorse surface water supply for these are listed in Table 3-5. Potential sources of the animal-borne pathogens are separately addressed in Section 3.2.3.

Table 3-5: Identified Concerns for Pathogen Sources to Schwatka Lake (not prioritized)

- Agricultural parcels near the river and developments on Marsh Lake,
- Septic fields and rural-residential developments; developments on tributary streams,
- Interaction of septic fields in waterfront properties and flooding events (especially around Marsh Lake),
- Proposed hotel and/or restaurant development at northwest end of Schwatka Lake (Lot 401),
- Swimming within the reservoir,
- Recreational activities around the reservoir.

3.2.2 Contamination of the Selkirk Aquifer by Human-Borne Pathogens

Historically, groundwater supplies have been considered by many to be a safe source of drinking water, requiring little or no treatment to minimize pathogen risks. It has been widely believed that the upper soil mantle effectively removes pollutants during infiltration and percolation (Azadpour-Keeley et al, 2003)[9]. It is also widely assumed that potentially pathogenic bacteria and viruses, in particular, are removed from groundwater supplies due to the natural filtration properties of the aquifer soils.

As in the case of Walkerton, harmful and other bacteria can be introduced to groundwater extraction wells or to the aquifer near the point of utilization through direct conduits. If there is the possibility that surface water can infiltrate the well-head or other abandoned wells, boreholes, and vertically placed structures, then there exists the potential for contamination of groundwater supplies by pathogens.

[9] Azadpour-Keeley, A., Faulkner, B.R., Chen, J.-S., 2003. *Movement and Longevity of Viruses in the Subsurface.* USEPA Ground Water Issue. 24 pages.

Recent Concerns About Viruses in Groundwater Supplies

Even in the absence of situations that can lead to the direct input of contaminated water into the aquifer, **there is a growing recognition that groundwater supplies are vulnerable to contamination by enteric viruses and bacteria** (Azapour-Keely et al, 2003).

Enteric micro-organisms, including bacteria and viruses, are the ones that are adapted to living in the gut of humans (or other animals that they infect).

Macler (1995; as reported in Azapour-Keeley et al, 2003) estimated that approximately 20% to 25% of groundwater sources in the United States are contaminated with microbial pathogens. A major portion of U.S. groundwater supplies also likely contain enteric viruses.

Table 3-6 lists some of the major known water-transmitted enteric viruses.

Pathogens, Parasites, and Protozoa – What's the difference?

A **pathogen** is any microscopic organism that causes disease. This is a broad term, and includes some of the protozoa, parasitic worms, viruses, bacteria or fungi.

A **protozoa** is any microscopic, single-celled organism. The term **protista** is sometimes used interchangeably. Only some protozoa cause disease, so only some of them are pathogens.

A **parasite** is an animal that lives in or on a host (another animal or plant), obtaining nourishment from the host without killing it. Not all parasites are pathogens. Animals (including humans) usually have some parasites living in them that do not cause disease.

Giardia and *Cryptosporidium* are protozoa; but they are also parasites and pathogens!

Table 3-6: Water-borne Viruses

Group	Pathogen	Associated Disease
Enteroviruses	**Poliovirus**	Meningitis, paralysis, fever
	Echovirus	Meningitis, diarrhea, rash, fever, respiratory disease
	Coxsackievirus A	Meningitis, herpangina, fever, respiratory disease
	Coxsackievirus B	Myocarditis, congenital heart anomoalies, pleurodynia, respiratory disease, fever, rash, meningitis
	New enteroviruses (types 68-71)	Meningitis, encephalitis, acute hemoragic conjunctivitis, fever, respiratory disease
	Hepatitis Type A	Infectious hepatitis
	Enterovirus 72	Diarrhea, vomiting, fever
	Norwalk virus	Gastroenteritis
	Calcivirus	Gastroenteritis
	Astrovirus	Not clearly established
	Reovirus	Diarrhea, vomiting
	Rotavirus	Respiratory disease, eye infections, gastroenteritis
	Adenovirus	Gastroenteritis
	Snow-Mountain Agent Epidemic, non-A, non-B hepatitis	Hepatitis

(From Azadpour-Kelley *et al.*, 2003)

Major activities that can introduce potentially pathogenic viruses to groundwater include-

- land disposal of untreated or treated wastewater or separated solids,
- septic tanks and sewer lines, and
- landfill leachate.

Within properly functioning septic fields, for example, microbial communities in unsaturated near-surface soils assist in the removal of most bacteria, phosphate and most of the nitrate; however, polioviruses (sometimes used as the indicator organisms for enteroviruses in general) may escape removal/degradation processes and be introduced into groundwater.

Survival of Viruses in the Subsurface Environment

The actual risk from enteroviruses and other pathogens depends on their tendency to survive and be transported in the subsurface environment.

This in turn depends on both the extent of their retention on soil particles and their survival.

Field studies suggest that retention on soil particles over a distance of 7 to 18 m resulted in a decrease in viral counts in the range of 25% to 100%.

Some of the environmental factors that may influence viral survival and/or rates of transportation include –

soil temperature

moisture content

salt concentration in the soil

soil organic matter content

microbial activity

pH

presence of viral aggregates (many viruses agglomerated together)

virus type

The Federal Republic of Germany uses viral persistence and groundwater modeling efforts to establish well-head protection zones based on three tiers of protection. An area within the immediate radius of extraction wells provides for an exclusion of any potentially contaminated activity. The size of the exclusion zone is based on the belief that a 50 day water residence time in the aquifer is sufficient to inactivate pathogens that might be present. A validation study by Matthess et al. (1988), however, suggested that the 50 day residence time may be inadequate to achieve the intended reduction in viruses by the objective of seven orders of magnitude (7 log units), which might require up to 170 to 270 days (Azadpour-Keeley et al., 2003).

Any source of enteroviruses to the groundwater that is closer to the extraction wells in the Selkirk field than the distance equivalent to greater than 100-200 days groundwater travel time could be of concern, based on the survivability of enteroviruses in groundwater. Given the relatively coarse, porous nature of the Chadburn/Hidden Lakes outwash deposit that forms the Selkirk Aquifer, this implicates a large area up gradient from the drinking water extraction wells. This further emphasizes the importance of identifying and controlling sources of contamination for source water protection.

Given the potential for survival in groundwater of enteroviruses, and – to a lesser extent other human pathogens, possible sources to the Selkirk Aquifer are listed in Table 3-7.

Table 3-7: Identified Concerns for Pathogen Sources to the Selkirk Aquifer (not prioritized)

- Faecal material input based on inadequate well-head protection, Selkirk well field as well as exploratory and monitoring wells in the Chadburn/Hidden Lakes outwash complex,
- Breaks or leaks in sewer lines in Riverdale area

3.2.3 Contamination of Schwatka Lake by Animal-borne Pathogens

Giardia lamblia and *Cryptosporidium parvum* are protozoan intestinal parasites, both of which have been implicated in numerous water-borne outbreaks of gastroenteritis. As discussed in Volume 1 of the Watershed Management Plan, there are differences in the major sources of these two protozoans to drinking water supplies, as well as their life cycles. Major oocysts sources for *Cryptosporidium,* for example include animal husbandry (livestock operations especially) as well as sewage treatment effluents (Park

What We Know About Beaver Fever (*Giardiasis*) and *Cryptosporidiosis* in Whitehorse

Giardia lamblia and *Cryptosporidium parvum* are protozoan intestinal parasites, both of which have been implicated in numerous water-borne outbreaks in North America of gastroenteritis (gastrointestinal illness, including stomach cramps and diarrhoea).

The major portion of knowledge about water-borne protistan diseases in the Whitehorse area comes from graduate research conducted by Pat Roach in the early 1990s.

Roach concluded from the examination of fresh feces samples collected near Whitehorse that *Giardia* was present in 1990 in both human and animal excreta.

Both animal and human feces, therefore, can serve as source to the watershed.

Roach routinely detected *Giardia* cysts (the resistant resting/transmission stage of the parasite) in sewage effluent and lagoon samples from various Yukon communities.

Cryptosporidium was also detected in a sample collected on July 16, 1991, from the Schwatka Lake intake area, at a concentration in the range of 51-100 oocysts/100 L. Oocysts (again, the resting/transmission stage) were subsequently detected in raw sewage collected from the Marwell Lift Station, Whitehorse on July 22nd, 24th, July 30th and Aug. 15th. From this it can be concluded that residents of Whitehorse have served as carriers for both protozoans at times.

Health researchers are only now beginning to understand the extent to which protistan cysts or oocysts measured in water supplies are viable: i.e. have an ability to infect humans once ingested in drinking water.

and Huck, 2003)[10]. Major oocysts sources for *Giardia* are mammalian and avian wildlife faeces and human faeces. There are, nonetheless, several similarities in environmental persistent of the encysted forms of the two disease organisms as well as resistance to disinfection as part of drinking water treatment.

According to Roach[11], there were approximately 150 documented cases of water-borne disease outbreaks in North America attributed to *Giardia* up to 1991-92.

[10] Park, C.H., Huck, P.M., 2003. *A conceptual model for Cryptosporidium transport in watersheds.* Water Quality Research Journal of Canada, 38: 77-113.

[11] Roach, P.D., 1992. *Yukon Water Policy Relating to Giardia and Cryptosporidium.* M.Sc. Thesis, University of Calgary. 150 pages.

There has been considerable speculation regarding the source of *Giardia* infections in Whitehorse residents. Small numbers of cases of *Giardiasis* have been reported in Whitehorse in most years over the last decade or more, but interviews with affected individuals have generally indicated that the source of infection was the consumption of untreated surface water outside of the City, as opposed to use of the City's drinking water.

It is clear that the City has not yet experienced an epidemic outbreak of either *Giardiasis* or *Cryptosporidiosis,* even though the diseases (especially Giardiasis*)* are endemic (routinely present in low numbers and a low percentage of the population) in both city residents and wildlife in the watershed. The City's own data indicate the presence of *Giardia* cysts on occasion in the Schwatka Lake supply (Figure 3-3), although there remains considerable uncertainty about the viability of cysts enumerated by the analytical methods used.

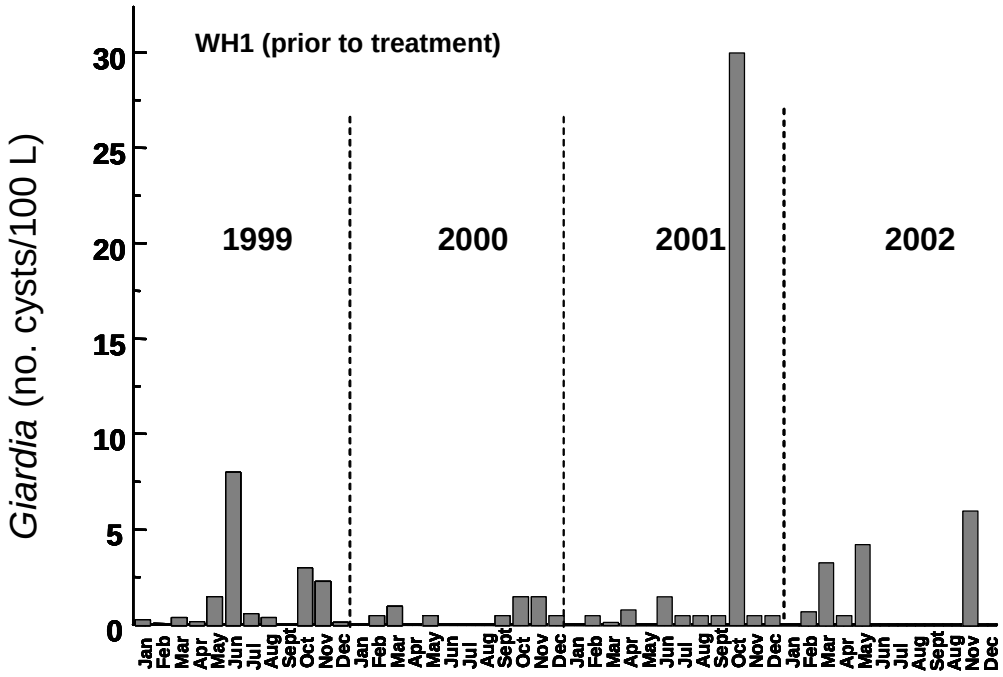


Figure 3-3: *Giardia* Cysts in Schwatka Lake (1999-2002)

The finding of a few high *Giardia* cyst counts (up to 30/100 L) may reinforce the concern that disease incidence and severity in the watershed overall has the potential to increase through positive feedback mechanisms: Increased rates of infection in either a subset of the wildlife or human vectors could lead to increased water-borne disease transmission, which in turn could lead to further increased rates of infection.

The scientific and health community does not adequately understand the conditions that might result in epidemic proportion outbreaks from the normally endemic infection rates. In *lieu* of this, therefore, any additional measures that reduce sources of protozoan cysts or oocysts to the drinking water reservoir are prudent.

Park and Huck (2003)[10] provided an extensive review of the fate of *Cryptosporidium* oocysts in the environment, and have developed a conceptual model for watershed-based transport. This conceptual model is probably useful for examining the fate of *Giardia* cysts in the watershed as well.

The health community does not fully understand conditions that might result in epidemic proportion outbreaks from the normally endemic infection rates.

In *lieu* of this, therefore, any additional measures that reduce sources of protozoan cysts or oocysts to the drinking water reservoir are prudent.

Is Enhanced Treatment the Answer to Protistan Parasites in the Drinking Water Supply?

Owing to the challenges in inactivation of *Cryptosporidium* oocysts with chlorination or other types of conventional disinfection, enhanced treatment is often chosen.

The extent of such enhanced treatment, however, should be determined not by average expected concentrations of oocysts in source water but rather by predicted peak values, where predictions can be made within an accuracy that is an order-of-magnitude or better.

Furthermore, future increases in parasite concentrations in source waters could overwhelm the design capacity of any new treatment facility.

One take-home message, therefore, is that enhanced treatment alone may not be adequate in the absence of a reasonable understanding of the sources of oocysts (or cysts) to the source water or variability. This further emphasizes the need for watershed-based monitoring and management.

There has been some speculation that *Giardia* cysts often detected during the summertime in Schwatka Lake surface water are dominated by non-viable (dead, non-infective) cells. Given the rapid surface water transport times within the watershed, however, it is expected that there would be insufficient time for the majority of protozoan cysts or oocysts to die before the water enters Schwatka Lake.

Table 3-8 lists the identified sources or contributing factors.

For the City's source water areas, the die-off rates of *Cryptosporidium* oocysts are likely to far exceed transportation times from sources to the water intake point.

Table 3-8: Identified Concerns for Protozoan Pathogen Sources to Schwatka Lake (not prioritized)

- Direct faecal inputs contributed by beavers and other mammals in the watershed,
- Use of Schwatka Lake by migrating waterfowl,
- Deposition of feces in lakeside and streamside areas where there is high potential for direct, poorly filtered wash-in (e.g. roadway area on w. shore of Schwatka Lake),
- Use of livestock manure for horticultural or agricultural soil amendment, and manure stockpiles at livestock operations,
- Swimming within the reservoir,
- Trail development and use around the reservoir (and contamination from dog feces),
- Residential and other developments on tributary streams.

A Model for the Transportation of Protozoan Oocysts in Watersheds

Cryptosporidium oocysts are spherically shaped, 4-6 μm (micrometer) diameter, organic particles initially found in faecal matter excreted by host organisms such as livestock or humans. Because the cysts are not markedly hydrophobic (literally "water-hating" in translation), they tend to detach from waste materials or soil/sediment into running water. In water, the oocysts exist in one of two forms; (i) detached, individual oocysts; and (ii) attached to or embedded in other suspended particulates. There are two transport mechanisms, therefore, that have different implications for removal by coagulation, flocculation, and sedimentation, or for oocyst viability before or during disinfection treatment. Transportation characteristics for *Giardia* cysts are expected to be similar what is described here.

Overland transport of oocysts in snowmelt and precipitation runoff is controlled primarily by overland flow velocities and characteristics. Any landscape features, therefore, that retard and dampen peak surface runoff will increase oocyst travel times in the watershed, and decrease inputs into the lower watershed from *Cryptosporidium* point- sources.

In general, enhanced soil erosion increases the potential for oocyst and cyst transport to the drinking water intake point in a surface supply. Furthermore, the condition of the landscape – especially features that encourage surface runoff as opposed to water permeation and infiltration - will increase the risks associated with introduction of protozoan pathogens to surface water supplies.

Once oocysts are introduced to the water, one mechanism for removal is settling (sinking). Experimentally estimated settling velocities for individual oocysts are quite low (1.3 mm/h; Medema *et al.*, 1998, as reported in Park and Huck, 2003), suggesting potential large transportation distances for single unattached oocysts in surface water. **Given average water residence times in Schwatka Lake in the order of less than 0.2 to 0.3 h (Vol. 1), there is little if any potential for settling out of oocysts introduced into surface flows.**

Sedimentation rates of oocysts attached to organic-rich sediments are appreciably higher than for single oocysts; however, the very short residence time of surface water in the Yukon River and tributaries down river from Marsh Lake and through Schwatka Lake probably render negligible any oocyst (or cyst) removal by sedimenting out. **Overall, any oocysts (or *Giardia* cysts) that make their way into running water are likely to end up in water within the lower watershed, with little potential for removal through sedimentation or die-off.**

In developing a conceptual model for *Cryptosporidium* oocysts transport in watersheds, Park and Huck (2003) assumed a "die-off co-efficient" for oocysts of 0.004 to 0.012 oocysts per day (i.e. having a survival half-life, the time required for a 50% reduction in the number of viable cysts, of 125 days to 35 days), based on Robertson *et al.* (1992). For the City of Whitehorse source water areas, the die-off rates of oocysts are likely to far exceed transportation times from point-sources to the water intake point.

3.2.4 Contamination of Schwatka Lake by Chemical Substances

Concerns about chemical contamination tend to be more variable between communities than those of pathogen or turbidity-associated risks. The potential for introduction of chemical contaminants into the drinking water supply depends on the intensity and characteristics of especially industrial and commercial operations near the reservoir or on sub-watersheds.

Some of the areas of contamination within the City limits have been identified under the Yukon Governments Contaminated Sites Program. No contaminated sites, however, have been registered with the government in the area of the City limits that would potentially affect the drinking water supply, or to the south within the watershed (Ruth Hall, YTG; personal communication).

The widespread use of petroleum hydrocarbon products for transportation and heating represents the major source types for possible contaminant risks (Table 3-9).

Table 3-9: Identified Concerns for Chemical Contaminant Sources to Schwatka Lake (not prioritized)

- Major or chronic spills on or near roadways,
- Upstream spills (concern about potential lack of response time before spill reaches Schwatka Lake),
- Fuel spills from float planes,
- Recreation: RVs, ATVs, snowmobiles, power boats on or near Schwatka Lake and their impact on water quality,
- Stormwater runoff and impervious surfaces,
- Dust from the old Whitehorse Copper Mine tailings site being blown into the river and lake,
- Future mineral/mine developments,
- Road salt use on road network,
- MacRae Industrial Area uses,
- Use of creosote to treat rail ties/power poles in watershed,

3.2.5 Possible Sources of Chemicals to the Selkirk Aquifer

Possible sources of chemical contamination to the Selkirk Aquifer (Table 3-10) are similar in nature to those for surface waters; however, the extent of concerns is more spatially limited (to the eastern portion of the watershed, where the Selkirk Aquifer and its recharge area are located).

Table 3-10: Identified Concerns for Chemical Contaminant Sources to the Selkirk Aquifer (not prioritized)

- Domestic use herbicides, pesticides, fertilizers; inappropriate petroleum product disposal,
- Presence of gas station, fuel tanks, YECL substation near Selkirk well field,
- Major or chronic spills on or near roadways.
- Underground storage tanks, especially those used on residential properties for heating oil storage.

3.2.6 Possible Nutrient Inputs to Schwatka Lake

Nutrient inputs and possible eutrophication are the focus of many water quality and drinking water reservoir studies. This is because increased nutrient inputs associated with human activities may lead to both increased algal productivity of lakes, and to shifts in the characteristics or timing of algal species that dominate. Degraded reservoirs may experience an increase in the productivity and relative abundance of blue-green (cyanobacteria) or other potentially noxious algae. Nutrient inputs can shift not just algal productivity, but also the productivity and nature bacteria and other microbes in the water column or sediment.

Above all, excessive nutrient inputs can be associated with -

- increased taste and odour problems, and
- increased amounts of organic matter in the source supply that can lead to

eutrophic - Refers to a lake that is, literally, "old" in terms of its productivity of algae and other plant growth, due to the presence of nutrients required for such growth.

Eutrophication is the increase in primary productivity of a lake as a result of increase nutrient inputs. The extra algal biomass can result in taste and odour problems, both during algal blooms and afterwards when the dead algae decays.

enhanced formation of disinfection by-products after chlorination disinfection.

The overall issue of nutrient inputs to Schwatka Lake and the larger Yukon River watershed is of much less importance for drinking water quality than pathogen risks or turbidity. This is because Schwatka Lake exhibits a very short water residence time, has a maximum depth of only 6-8 m., and may be viewed more as an expanded river stretch than lake system (see Volume 1 of this study). Primary productivity is not likely to be nutrient limited, therefore, and the conditions do not exist for the seasonal stratification of the lake. Overall, Schwatka Lake – owing to its limnological characteristics – is probably less prone to eutrophication than reservoirs with a much longer water residence time. Seasonal limitations of sunlight in arctic and subarctic lake and river systems might reduce potential for eutrophication and noxious algal blooms relative to temperate and sub-tropical systems; however, the eutrophication of arctic lakes has been documented.

Possible nutrient sources are nonetheless identified in Table 3-11.

Table 3-11: Identified Concerns for Nutrient Sources to Schwatka Lake (not prioritized)

- Septic fields and country residential developments; developments on tributary streams,
- Agricultural parcels near the river and developments on Marsh Lake,
- Forestry/silviculture, firewood harvesting,
- Fertilizer use within or near the riparian zone; for example, at the Meadow Lakes Golf Course which straddles McRae Creek,
- General increase in human activities in the watershed, and
- Stormwater runoff and impervious surfaces.

3.2.7 Possible Nutrient Inputs to the Selkirk Aquifer

Nutrient inputs to the Selkirk Aquifer are a concern for one major reason: Excess nitrate additions to surface soils can lead to increased nitrate concentrations in drinking water derived from the local groundwater supply.

Excess fertilizer use or compost use can lead to increased nitrate in the ground-water supply.

Why is Nitrate in Drinking Water a Concern for Human Health?

Excess nitrate concentrations in drinking water supplies can be harmful to human health.

Methemoglobinemia (blue-baby syndrome), various cancers and birth defects have been suggested as being associated to exposure to elevated nitrate levels in drinking water (Townsend *et al.,* 2003)[1].

The epidemiological and toxicological case for the role of nitrate as a cancer-causing agent is still unclear. Where the issue of human health risks from nitrate has been discussed, however, prevention of groundwater contamination at the source is generally cited as the best available risk management strategy.

There is a Canadian Drinking Water Quality Guideline for nitrate, in recognition of the human health concerns.

Townsend, A.R. et al, 2003. Human health effects of a changing global nitrogen cycle. Front Ecol Environ *1(5): 240–246*

Table 3-12 identifies one major concern: the use of fertilizers in the Riverdale area.

Table 3-12: Identified Concerns for Nutrient Sources to the Selkirk Aquifer

- Fertilizer application in the Riverdale area.

3.2.8 Possible Sources of Turbidity and Organic Matter to Schwatka Lake

As discussed in Volume 1 of this study, elevated turbidity in drinking water supplies can undermine the effectiveness of disinfection, and thus increase the incidence of gastroenteritis and other illnesses, especially for unfiltered water supplies. Turbidity sources (Table 3-13) merit scrutiny even if the City of Whitehorse installs a water filtration plant in the future. Elevated turbidity imposes additional challenges for the operation, maintenance, and longevity of various filtration technologies. In addition, turbidity serves as an indicator variable for a wide variety of materials that can enter and cloud surface water: **Enhanced turbidity may be accompanied by enhanced erosion and wash-in of protozoan cysts, fecal matter, dissolved and colloidal organic matter, and nutrients.**

Table 3-13: Identified Concerns for Turbidity Sources to Schwatka Lake (not prioritized)

- Siltation in the catchment areas,
- Placer mines or other mining activity,
- Road crossings,
- Developments on tributary streams,
- Propeller wash in Schwatka Lake from power boat use in the summer,
- Forestry,
- De-vegetation due to residential and other development,
- Agricultural parcels near the river,
- Developments on Marsh Lake,
- Developments and activities along the Schwatka Lake lakeshore,
- Stormwater runoff and impervious surfaces,
- General increase in human activities in the watershed,
- Trail development and use,
- Long-term effects of climate change.

3.3 Risk Characterization and Prioritization

The preceding sections described possible sources of risk to human health based on potential for impacts to source water used for human consumption. This section characterizes and assesses the most significant of those. The sub-sections are not arranged accorded to the perceived priority of risks; rather, those risks that were evaluated using a more quantitative approach (i.e. hydrocarbon spills on the lake) are addressed immediately below, while possible risks assessed using a ranking approach are addressed in subsequent sections.

The previous section describes types of activities or land uses that may result in a possibility of risks to source waters. Section 3.3 attempts to better define the probability of such risks, and to identify higher versus lower priority issues in the watershed.

3.3.1 Risk Assessment of Petroleum Hydrocarbon Inputs to Schwatka Lake

Exposure Assessment

There exist activities on or around Schwatka Lake that could accidentally release petroleum hydrocarbons into the water.

The motor vessel MV Schwatka operates on Schwatka Lake as a tour boat, taking passengers between the dock at the northwest end of the lake to points up river from Miles Canyon. The MV Schwatka has a 300 L fuel tank that feeds its diesel engine. As a worst-case, it was assumed that the MV Schwatka could sink or otherwise encounter an accident that would result in loss of up to 300 L diesel to the surface of Schwatka Lake

Inukshuk Planning and Development (IP&D) in 1995 completed reports entitled *Schwatka Lake Aviation and Land Use Study: Background Documentation* and *Final Report.* The Background Documentation report lists five reported or documented spills between 1986 and 1993 in association with float plane bases on Schwatka Lake, all of

apparently low volumes (≤ 45 gallons). It was noted in the final report that up to that time only Yukon Energy had developed a spill contingency plan for fuel spills.

The IP&D reports also drew attention to problems at the time with fuel storage regimes, which increased the risks of accidental releases. Currently, the fuel tank on Lot 400 (leased to Black Sheep Aviation) is covered under a permit issued in 1998 by YTG Fire Marshall's office (Protective Services Branch, within the Dept. of Community Services). It is a doubled walled tank, with the interstitial space having been vacuum tested (hence, there is no need for a berm). A containment ring of absorbent matting was installed around the tank. A spill contingency plan is on file with the Fire Marshall's office.

The Inukshuk Planning and Development (1995) reports suggested that risks to the drinking water supply associated with operation of float plane operations was minimal, based on the assumption that volumes of accidentally released fuel would be small relative to the water mass in the reservoir, and that it was unlikely that a spill on the west side of the lake would impact the drinking water impact point on the east side, since the strong currents in the lake would tend to carry spilled materials over the YEC spillway, rather than allow cross-current diffusion and dispersion.

There is good anecdotal evidence that fuel spills may have only very limited potential for cross-lake transport; however, detailed studies of surface and subsurface currents in Schwatka Lake have never been undertaken. The western shore of the lake, where most fuelling, fuel storage and other commercial activities take place is close to the original river channel of the Yukon River prior to the construction of the hydroelectric dam in 1959. Ice along the western shore of the lake tends to break up earlier than along the eastern shore, further suggesting the presence of strong down-lake currents along the western shoreline.

There have typically been no more than 10-18 planes on the lake, owing to both economic demand and physical/space constraints, and it is unlikely that any future expansions would see more than 20 float planes using the lake.

Another scenario that merits consideration is the accidental release of aviation fuel from a floatplane due to a crash or sinking. While many of the float plane activities on

the lake are focussed around the western shore, float planes often taxi in the area of the lake near the drinking water intake prior to takeoff or after landing.

Tanker trucks and other land-based traffic on roadways close to Schwatka Lake represent another possible source of accidental fuel release to the reservoir. Finally, powered watercraft are a potential source of hydrocarbons to Schwatka Lake. Small-scale fuel spills would be expected, especially on the lake and on the adjacent shoreline of the boat launch and recreational area on the east side of Schwatka Lake. Two stroke engines also introduce partially uncombusted fuel as well as combustion by-products into surface waters.

A simple analysis of drinking water risks was conducted assuming as a worst case the accidental release of 1000 L of diesel or aviation gas. It was further assumed that none of the release was controlled through spill response measures.

The risks at the point of surface water intake were assessed, assuming no further dilution or loss of petroleum constituents in the treatment and water distribution system. As discussed below, risks are deemed herein to be unacceptable if the concentration of spill constituents at the intake point has a reasonable potential to reach or exceed Canadian Drinking Water Quality Guidelines.

The extent of exposure via drinking water ingestion is expected to be further mediated by the fate of hydrocarbon spills, once released to the water. The initial redistribution of a fuel spill on the surface of the water is controlled by the viscosity of the product and the surface tension of water. Low viscosity fuels can spread very rapidly, and the leading edge thins with the advancing outward dispersion. Further dispersion is controlled by the combined effects of meteorological and hydrological factors, and depends mainly on the power and direction of wind, waves, and currents. Wind-driven slick migration often dominates; however, in the case of Schwatka Lake, down lake currents might provide a greater relative influence.

Evaporation is the single most important weathering process in the first several days of a hydrocarbon spill. For light, refined products such as gasoline, evaporation will remove 100 percent of the spill within a very short time. Laboratory experiments show that more than 80% to 90% of most monoaromatic hydrocarbons (such as benzene and toluene) are lost via evaporation from seawater within the first 24 hours.

The downward movement of hydrocarbons into the water column is controlled first by the rate at which they dissolve into the water, followed by downward diffusion (spread). The limited solubility in water, coupled with limited rates of downward mixing and diffusion, are likely to be the most important limiting factors for the entry of hydrocarbons into the Schwatka Lake water intake pipe, which is located at a depth of 1.8 to 2.4 m below the water surface, depending on the lake level.

Unfortunately, the extent of dilution of a spill introduced at any given location on Schwatka Lake can not be quantitatively estimated based on the above-mentioned fate processes, since the current regime of the lake has never been studied. The risk characterization, therefore, is developed herein based on calculation of what dilution factors would be required to ensure that drinking water quality guidelines are not exceeded.

Effects Assessment

Common constituents of petroleum products such as motor gas or diesel are shown in Table 3-14, along with their respective Canadian Drinking Water Quality Guidelines or other estimates of 'safe' human health thresholds. These thresholds are based on chronic exposures and on health effects other than death. Hydrocarbon spills in or near the reservoir would be expected to result in a short-term exposure via drinking water at worst, over a period of 24 hours or less. Any hydrocarbon inputs to Schwatka Lake or an upriver entry point between the reservoir and Marsh Lake would be substantially transported by currents beyond the water intake point within 24 hours. The acceptable concentration threshold for an acute-type (short term) exposure to various hydrocarbon constituents is known to be much higher than for an ongoing chronic exposure.

Table 3-14: Some Petroleum Hydrocarbon Constituents of Concern

Substance	Canadian Drinking Water Quality Guideline (µg/L)	Approximate composition in commonly occurring mixtures (weight %)[12]
Benzene	5	Gasoline (1.9) Diesel (No. 2) Oil (0.029)
Ethylbenzene	≤2.4 (aesthetic)	Gasoline (1.9) Diesel (No. 2) Oil (0.18)
Toluene	≤ 24 (aesthetic)	Gasoline (8.1) Diesel (No. 2) Oil (0.068)
Xylenes	≤ 300 (aesthetic)	Gasoline (8.0) Diesel (No. 2) Oil (0.26)

Note that polycyclic aromatic hydrocarbons (PAHs) are also minor constituents of newly refined and used petroleum hydrocarbon mixtures. They are not considered here, however, due to their extremely limited water solubility relative to the mono-aromatics benzene, ethylbenzene, toluene, and xylenes. In addition, Canadian Drinking Water Quality Guidelines currently exist for only one of the PAHs: namely benzo[a]pyrene (CDWQG = 0.01 µg/L). Benzo[a]pyrene is among the least water soluble of the PAHs.

Risk Characterization

Assuming a hypothetical spill of 1,000 L gasoline or diesel, the risks can be quantified as follows:

$$\text{Risk Quotient (RQ)} = \frac{\text{Estimate of Exposure Magnitude}}{\text{Estimated Threshold of Effects}} \quad \textbf{(1)}$$

or

$$\text{RQ} = \frac{\text{Concentration at Point of Release x Dilution Factor}}{\text{Estimated Threshold of Effects (= CDWQG)}} \quad \textbf{(2)}$$

[12] Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), 1998. *Vol. 2 – Composition of Petroleum Mixtures*. 100 pages plus appendices.

It is further assumed that a risk quotient of ≤ 1 is represents an acceptable risk, whereas a risk quotient > 1 signifies the potential for unacceptable risks.

We are interested in the magnitude of dilution that would result in a risk quotient of 1 or lower. Therefore, equation 3 is re-arranged as follows:

$$\text{Dil. Factor} = \frac{\text{Concentration at Point of Release x RQ}}{\text{CDWQG}} \quad \textbf{(3)}$$

The concentration at the point of release in the water column is assumed to represent that fraction of the spill that dissolves in water and therefore can be transported downward to distance of approximately 2 metres, toward the drinking water intake. An upper estimate of the concentration at the point of release, therefore, is the solubility limit in water of individual hydrocarbon constituents. It is assumed that there is no potential for the introduction of free product into the water column below the surface, where light non-aqueous-phase liquids (LNAPLs) may be located near the initial spill location.

The expected aqueous solubility of the monoaromatic hydrocarbons of interest is as follows:

- Benzene: 1.79×10^6 µg/L at 25 °C.
- Ethylbenzene: 1.4×10^4 µg/L at 15 °C.
- Toluene: 5.26×10^5 µg/L at 25 °C.
- Xylenes(based on *p*-xylene): 1.62×10^5 µg/L at 25 °C.

A worst-case dilution factor is estimated for acceptable risks, therefore, assuming that spilled free-phase hydrocarbons reside on the lake surface directly above the drinking water intake pipe:

For benzene, for example –

$$\text{Dil. Factor (Benzene)} = \frac{1.79 \times 10^6\ \mu g/L\ \text{(Aq. Solubility)} \times 1.0\ \text{(RQ)}}{5\ \mu g/L\ \text{(CDWQG)}} \quad (4)$$

$$\text{Dil. Factor} = 358{,}000\ \text{(unitless)}$$

Based on similar calculations, the estimated worst-case dilution factors required to produce acceptable risks (RQ = 1) for the other substances in Table 3-13 are –

- Ethylbenzene: 5,800
- Toluene: 22,000
- Xylenes (based on *p*-xylene): 540

A required dilution factor for benzene of 358,000 between the point of dissolution of free product and the point of drinking water intake initially seems high. The rate of downward diffusion from the hydrocarbon-water intake pipe, however, is likely to be very slow relative to the rate of lateral plume transport from the south to north end of Schwatka Lake and over the dam spillway. As discussed in Volume 1, the active water storage capacity of Schwatka Lake is estimated to be in the range of 8-13 million m^3, while the peak daily inflow from the Yukon River is estimated at around 46 million m^3/day. Any buoyant mass of material is likely to be removed from Schwatka Lake in a day or less. A hydrocarbon spill with limited length relative to the direction of current flow in the lake would pass by the drinking water intake very rapidly. This would result in very limited potential for downward transport even if the spill's transportation pathway passed directly over top of the intake pipe. A decrease in concentration through the water column of six orders of magnitude or more based on limits to diffusion alone is highly conceivable.

During storms, downward transport of hydrocarbons from a spill area can be enhanced through surface agitation and the downward movement of fine droplets and larger globules of free product. This is likely to be countered, however, by the buoyancy of such hydrocarbon masses in lake water.

Because downward diffusion rates (or wind-driven downward movement of free product) over the top ~ 2 metres of lake water have not been quantitatively estimated, there remains some uncertainty that the major transport processes involved would

produce dilution rates following a spill that would render hydrocarbon risks in drinking water within an acceptable range. The Canadian Drinking Water Quality Guidelines, however, are based on acceptable chronic human exposures as opposed to a single acute exposure over a period of 24 hours or less. Human health protective threshold concentrations of benzene in drinking water based on a single, acute exposure are likely to be at least two to three orders of magnitude higher than chronic threshold estimates.

The potential for dilution along the down-lake transport pathway would provide additional reductions in risks to the drinking water supply based on hydrocarbon spills. Beyond the initial outward spread of spilled hydrocarbons on the water surface, the hydrocarbon concentrations at the water-air interface are expected to be much lower than the solubility limit since there in no immediate free-phase supply for rapid dissolution into the surrounding water, and since losses due to evaporation and sunlight-mediated breakdown tend to reduce concentrations.

In areas removed from the immediate spill area, therefore, concentrations at the lake surface are likely to be much lower than the solubility limit, and the concentrations deeper in the water would also be expected to be correspondingly lower.

Overall, it is concluded that the risk to the drinking water supply from a possible fuel spill is related less to the magnitude of the spill than the combined effects of the high velocity of down-lake transport and low rate of downward movement toward the drinking water intake pipe.

The available information suggests that the overall risks associated with hydrocarbon spills are very low.

Given some uncertainty, however, it should be appreciated that risks can be further reduced, regardless of their actual magnitude through –

- Prevention of hydrocarbon spills in the first place,
- Increasing the distance between the point of drinking water intake and the area of the watershed and Schwatka Lake in which a spill can be introduced, and/or
- Locating activities that might result in spills at a point where there is no potential for the current to carry the hydrocarbons toward the intake pipe (e.g., locating storage and fill areas down-current or cross-current, but not up-current).

What about Hydrocarbon Inputs from Outboard Motor Exhaust??

There is little question that two-stroke and to a lesser extent four-stroke engines used for boating and on-lake recreation are sources of combusted and partly combusted petroleum hydrocarbons to the water. However, the rate of input needs to be considered in addition to the fact that it occurs.

The November 25th, 2003, edition of the Whitehorse Star contained an article entitled "**Outboards pouring gas into Kenai River**":

The Kenai River, in Alaska, is the site of intense boating pressure during mid-summer, based on strong salmon runs. A study by the State of Alaska showed that up to 45,000 litres of fuel may be entering the Kenai each summer from outboard engine use. Fuel residues were detected throughout the water column in parts of the river, and in river sediment. Hydrocarbon levels in the water were high when boating activity in the river was high.

In spite of the detection of hydrocarbons in the river, it bears noting that "The pollution is still at a very low level and is not hurting fish eggs or larvae." Levels of hydrocarbons would need to be even higher to harm humans.

While Schwatka Lake sees considerable summer-time boating traffic, the activity level is still much lower than the Kenai River.

3.3.2 Assessment of Other Risks

Major activities and land uses that have a reasonable possibility of negatively affecting the drinking water supply were identified in Section 3.2. The larger list of concerns was collated based on feedback received during consultations, and from our understanding on the current status of the watershed.

A more concrete characterization of each of these is provided below, based on methods described in Section 3.1. Table 3-15 summarizes the risk characterization for each of these. A more detailed explanation of the rationale for the risk characterization rankings is provided in the text that follows the table.

Table 3-15: Summary of Drinking Water Risk Characterization

Source Type	A) Source Characteristics - Risk Index (1-4)[A]	B) Spatial Extent - Risk Index (1-4)[A]	C) Proximity to Water - Risk Index (1-4)[A]	Overall Risk Index Product = A x B x C
Possible Sources of (Human-borne) Pathogen to Schwatka Lake				
Agricultural parcels near the river/developments on Marsh Lake	4	1	3	12
Septic fields in country residential developments	3	3	2	18
Flooding of Marsh Lake waterfront properties (including septic fields)	4	2	4	24
Proposed commercial development at Schwatka Lake (Lot 401)	1	1	4	4
Swimming	1	1	4	4
Recreational activities around the reservoir	1	2	4	8
Possible Sources of (Human-borne) Pathogen to the Selkirk Aquifer				
Faecal material input from inadequate well-head protection	4	1	4	16
Breaks or leaks in sewer lines in Riverdale area	4	1	4	16
Possible Sources of (Animal-borne) Pathogens to Schwatka Lake				
Direct faecal inputs by beavers and other mammals	4	4	4	64
Use of Schwatka Lake by waterfowl and other birds	3	3	4	36
Deposition of faecal matter in lakeside and streamside areas (e.g. dog walking, human excretion)	2	2	3	18

Source Type	A) Source Characteristics - Risk Index (1-4)[A]	B) Spatial Extent - Risk Index (1-4)[A]	C) Proximity to Water - Risk Index (1-4)[A]	Overall Risk Index Product = A x B x C
Use and storage of livestock compost in the watershed	4	1	2	8
Swimming	1	1	4	4
Trail development and use	1	2	3	6
Residential, other developments on tributary streams	1	3	1	3
Possible Sources of Chemicals to Schwatka Lake				
Major or chronic spills on or near roadways	1	2	4	8
Upstream spills	1	2	3	6
Recreation: RVs, ATVs, snowmobiles, power boats	1	2	4	8
Floatplanes	1	1	4	4
Stormwater runoff	2	2	4	16
Whitehorse Copper Mine tailings site	1	3	2	6
Future mine developments	1-2	1-2	1-3	1-12
Use of road salt	1	2	4	8
MacRae Industrial Area uses	1	2	2	4
Use of creosote to treat rail ties	1	1	4	4
Potential pipeline ?	1	2	?	2?
Possible Sources of Chemicals to the Selkirk Aquifer				
Domestic use herbicides, pesticides, fertilizers; inappropriate petroleum product disposal	2	3	4	24
Presence of gas station, CYFN fuel tanks, YEC substation near Selkirk well field	2	2	4	16
Major or chronic spills on or near roadways.	2	1	4	8
Possible Nutrient Inputs to Schwatka Lake				
Septic fields and country residential developments	1	3	3	9
Agricultural parcels near the river	1	1	3	3
Forestry	1	1	2	2

Source Type	A) Source Characteristics - Risk Index (1-4)[A]	B) Spatial Extent - Risk Index (1-4)[A]	C) Proximity to Water - Risk Index (1-4)[A]	Overall Risk Index Product = A x B x C
General increase in human activities	1	4	4	16
Fertilizer use at the Meadow Lakes Golf Course which straddles McRae Creek	2	2	3	12
Stormwater runoff	1	4	4	8
Effects of climate change	?	?	?	?
Possible Nutrient Inputs to the Selkirk Aquifer				
Fertilizer application in the Riverdale area	2	3	4	24
Possible Sources of Turbidity and Organic Matter to Schwatka Lake				
Placer or mineral mining activity	2	1	4	8
Road crossings	1	2	4	8
Developments on tributary streams	1	3	4	12
Wave action from boats in Schwatka Lake	1	1	4	4
Forestry	2	1	2	4
De-vegetation during and following development	2	1	3	6
Agricultural parcels near river	2	1	4	8
Developments on Marsh Lake	1	2	4	8
Developments and activities along the Schwatka Lake lakeshore	2	4	4	32
Stormwater runoff and impervious surfaces	1	4	4	16
General increase in human activities in the watershed	2	4	2	16
Trail development and use	1	2	3	6
Climate change effects	?	?	?	?

Notes: A) See Table 3-3 for a description of risk index rankings

Rationale:

The relative risk indices tabulated are based on qualitative methods as described beginning on page 29. **The comparative risk rankings are intended above all to assist the City of Whitehorse with establishing priorities for source water**

protection in light of the characteristics of the watershed and human activities within and beyond city limits.

In general, risks to the drinking water supply associated with increased potential for the introduction and/or transportation through the watershed of human pathogens received a higher risk ranking than other watershed stressor types, such as chemical contamination and turbidity.

Risks to the drinking water supply associated with increased introduction and/or transportation through the watershed of human pathogens received a higher priority than other issues.

Some activities with the potential to be major, direct contributors or protistan parasite or bacterial and viral pathogen inputs into the watershed include –

- **Wildlife and waterfowl,**
- **Agriculture (livestock husbandry),**
- **Septic fields,**
- **Inputs of faecal matter in and around Schwatka Lake, and**
- **Breaks or leaks in sewer lines in the Riverdale area.**

Swimming within Schwatka Lake, or in the Yukon River to the south, has some limited potential to contribute pathogens to the surface source supply to the extent that swimmers, especially young children, might introduce faecal matter into the water while swimming. Additional mechanisms of disease transmission might include transfer of pathogens from open wounds and other infections**. The risk of pathogen introduction from swimming-related sources, however, is considered to be considerably lower than associated with the direct, potentially more frequent introduction of excrement. There is certainly potential for inputs of *Giardia* or *Cryptosporidium* cysts from infected humans while swimming, but this potential is much smaller than is associated with direct introduction into surface waters and adjacent soils by wildlife carriers.**

Swimming-related Issues

A search of the peer-reviewed and grey literature revealed very little scientific or epidemiological evidence for a link between water-borne disease outbreaks via drinking water and the use of the supply for swimming. One recent study is summarized on the next page.

Links Between Body-Contact Recreation and Drinking Water Quality

Swimming, boating, waterskiing, and other water recreation activities have often been banned or limited on drinking water reservoirs based on concerns about drinking water contamination.

There is little evidence that can be brought to bear when assessing the need for restrictions to body-contact recreation.

Stewart et al. (2002) recently published one of the few studies that directly assesses effects on drinking water quality of body-contact recreation. It has long been known that swimming and similar forms of recreation can result in detectable levels of human pathogens in water bodies, as well as disease outbreaks among the recreational community. Some of the disease organisms that have been implicated in swimming-related outbreaks include *Cryptosporidium parvum, E. coli* O157:H7*, Giardia lamblia, Shigella* and *Naegleria fowleri.*

The focus of most studies has been overwhelmingly on disease transmission between swimmers; for example in pools, water slides, and other and artificial settings.

Little is known about risks of disease transmission via drinking water. Stewart et al. (2002) developed a model-based risk assessment to assess possible public health consequences of body contact recreation in the water reservoir that serves the Metropolitan District of Southern California. This water body (Diamond Valley Lake) has a surface area of 1,800 ha. The estimated annual number of recreationist visits by individuals involved in boating, waterskiing, use of personal watercraft or other forms of body contact recreation was about 280,000.

Based on assumptions about the rate of pathogen input/person and survival times after release, Stewart et al (2002) predicted an annual risk of infection by *Cryptosporidium* in consumers of drinking water at up to 6 infections/10,000 consumers (a 17 fold increase in risk over the case where no body contact recreation was assumed).

For Schwatka Lake, the intensity of body contact recreation is far lower (by orders of magnitude) than modeled in the Stewart et al study, - much less than 280,000 recreational visits/year involving body contact recreation. The predicted per capita infection rates would be expected to be much lower as well.

Stewart, M.H., M. V. Yates, M. A. Anderson, C.P. Gerba, J.B. Rose, R. De Leon and R. L. Wolfe, 2002. Predicted Public Health Consequences of Body-Contact Recreation on a Potable Water Reservoir. AWWA Journal, 94(5): 84-97.

The Center for Disease Control (CDC) in the United States keeps statistics on the annual number of disease outbreaks in the United States among swimmers, who are more directly exposed to pathogens introduced into surface water. There are a large number of studies on bacterial, viral and pathogen incidence in swimming pools, hot tubs and recreational lake areas. None of these, however, have focused on associated risks to the local drinking water supply.

Swimmers exposed to compromised surface water typically suffer from a variety of gastrointestinal illnesses, which tend to 'appear' days to a few weeks after the initial exposure during swimming. Several studies have shown a positive association between disease contraction in swimmers and faecal bacterial indicator concentrations in samples from the water body. The CDC attributes swimming area pathogen introductions to the flowing major sources:

Point Source

- Sewage outflow

Non-point Source

- animal--urban/pastureland/forestland runoff
- human (localized and temporal which may be harder to detect)
    - ❖ swimmer to swimmer
    - ❖ untreated dumping -- pleasure craft, houseboats, septic tanks

Swimming in Schwatka Lake merits scrutiny in terms of risks to the drinking water supply; however, it bears remembering that swimmers themselves are more likely to experience health risks from water-borne diseases than down-stream consumers of disinfected drinking water. Possible future evidence of surface water contamination in Schwatka Lake would possibly result in a recreational water advisory against swimming activity before risks via ingestion of disinfected drinking water would be unacceptably high.

Health Canada (www.hc-sc.gc.ca/hecs-sesc/water/factsheets/recreational_water.htm) advises that individuals can assist with preventing the degradation of recreational waters through the proper disposal of pet droppings, and avoidance of practices (such as inappropriate food waste disposal) that attract animals and birds, which leave droppings, to lakeside areas.

Limited commercial development at Lot 401 on Schwatka Lake, as well as float plane operations, were ranked as having source characteristics with low risk indices, from the perspective of pathogen inputs.

This is based on the assumption that –

- Any release from sewage storage and treatment facilities, grey water, or of animal feces entrained in surface run-off at the proposed commercial development at the north end of Schwatka Lake will be lateral to or down current from the current drinking water intake point – not up current. This should be verified by current studies in the near future. Such an assumption would be invalid for commercial/tourist applications and operations farther south on the shoreline. These would need to be critically evaluated on a case-by-case basis if there was some potential for such operations. On the other hand, the current provisions in the OCP and zoning should prevent commercial developments farther south on the lake shore. Such restrictions should be maintained in light of the importance for drinking water protection.
- sewage disposal and treatment will take place in areas removed from the drinking water reservoir, and that there is not a dependence on onsite treatment or storage to ensure no inputs of untreated or inadequately treated wastewater or solids.

The current commercial operation, and even more so the current float plane docks, are identified as possible contributing factors to sediment (turbidity) and animal feces introductions into the drinking water supply – again, depending on the extent of cross-lake transfer, as opposed to rapid movement toward and over the spillway. This issue is addressed in the major recommendations (Chapter 4).

The relative risk indices assigned herein highlight the potential vulnerability of the Selkirk Aquifer and associated well field located within the Riverdale area of Whitehorse.

The groundwater-based drinking supply is located close to the surface in highly permeable soils, and there is little capacity for the adsorption or biodegradation of introduced substances (nutrients, pesticides, hydrocarbons, sewage) between their point of generation or use and the surface aquifer.

The groundwater supply is highly vulnerable to subsurface breaks or chronic leaks in sewage lines. The supply may be slightly less vulnerable to hydrocarbon contamination especially from leaking underground storage tanks, but there exists the potential for such contaminant sources to go undetected. Furthermore, the absence of wells in upgradient areas that can be used to monitor water quality means that

pathogen sources are likely to be integrated into the drinking water supply for a short period of time before the problem is detected.

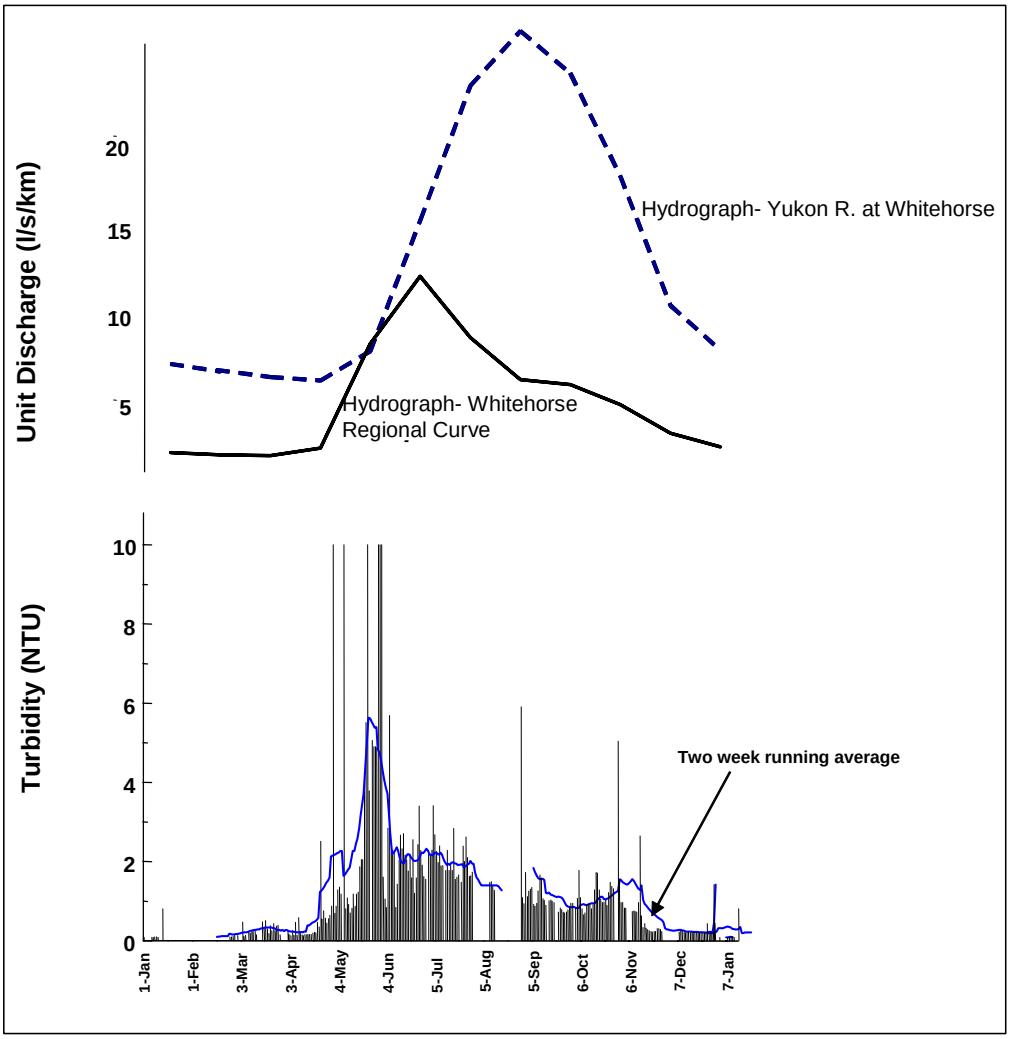
While turbidity in the Schwatka Lake supply is a major issue facing the City of Whitehorse, it was concluded that power boat use on the lake and the associated propeller wash and wave generation is not a major contributor to elevated summer-time turbidity of lake water. The seasonal timing of increased turbidity in 2002 corresponded with the spring freshet in local sub-watersheds. The seasonal timing of elevated turbidity is not consistent with expected timing of peak powerboat activity in July-August (Figure 3-4).

Roadways and other disturbances within the riparian zone are assigned higher risk indices owing to the increased potential for the input into the drinking water reservoir of both suspended solids and pathogens from especially faecal matter.

During public consultations, concern was expressed about the effects of the poorly vegetated tailings from the abandoned Whitehorse Copper Mine. The tailings pile is prone to dust generation during high winds. The available metal/metalloid concentration data for the Schwatka Lake supply, however, suggests that mine-related inputs to the drinking water supply do not currently pose any risk to human health. The mine site is afforded a low risk rating with regard to chemical (metal contamination) therefore. The extent to which poorly consolidated tailings contributes to turbidity problems in the watershed has not been assessed; however, Copper Creek

goes to ground before it enters Schwatka Lake, and this probably limits the extent to which sediments are transported into the lower watershed.

Figure 3-4: 2002 Trends in Surface Water Turbidity (Schwatka Lake Supply) in



Comparison with Yukon River and Local Sub-watershed Hydrographs.

The various sources of risk were ranked accorded to their perceived importance (Table 3-16). Only those activities with an overall risk index of 12 or greater are listed below. In addition, the different issues were assigned a risk ranking in recognition of the somewhat subjective nature of the numerical rankings, as follows: Very High (VH: 24-64 points); High (H: 12-23 points); Medium (6-11 points); Low (L: 1-5 points).

Table 3-16: Prioritization of Risks to the City's Drinking Water Supply.

Issue/Activity	Concern	Source Character-istics	Spatial Extent	Proximity to Water	Overall Risk Index	Risk Ranking
Direct faecal inputs by beavers and other mammals	**Protozoan inputs to Schwatka Lake**	4	4	4	64	**VH**
Use of Schwatka Lake by waterfowl and other birds	**Protozoan inputs to Schwatka Lake**	3	3	4	36	**VH**
Developments and activities along the Schwatka Lake lakeshore	**Turbidity and protozoan inputs to Schwatka Lake**	2	4	4	32	**VH**
Fertilizer application in the Riverdale area	**Nutrient Inputs to Selkirk Aquifer**	2	3	4	24	**VH**
Domestic use herbicides, pesticides, fertilizers; petroleum releases	**Chemical inputs to Selkirk Aquifer**	2	3	4	24	**VH**
Flooding of Marsh Lake waterfront properties	**Pathogen Inputs to Schwatka Lake**	4	2	4	24	**VH**
Septic fields in country residential developments	**Pathogen Inputs to Schwatka Lake**	3	3	2	18	**H**
Deposition of faecal matter in lakeside and streamside areas (e.g. dog walking, human excretion)	**Protozoan inputs to Schwatka Lake**	3	2	3	18	**H**
Presence of gas station, fuel tanks, etc. near Selkirk well field	**Chemical inputs to Selkirk Aquifer**	2	2	4	16	**H**
Faecal material input at the well-head points	**Pathogen inputs to Selkirk Aquifer**	4	1	4	16	**H**
Breaks or leaks in sewer lines in Riverdale area	**Pathogen inputs to Selkirk Aquifer**	4	1	4	16	**H**
Stormwater runoff	**Chemical inputs to Schwatka lake**	2	2	4	16	**H**
General increase in human activities	**Turbidity and Nutrient Inputs to Schwatka Lake**	1	4	4	16	**H**
Stormwater runoff and impervious surfaces	**Turbidity sources to Schwatka Lake**	1	4	4	16	**H**
Agricultural parcels near the river/developments on Marsh Lake	**Pathogen Inputs to Schwatka Lake**	4	1	3	12	**H**
Developments on tributary streams	**Turbidity sources to Schwatka Lake**	1	3	4	12	**H**
Fertilizer use within or near riparian zones	**Nutrient Sources to Schwatka Lake**	2	2	3	12	**H**

Rural residential developments and general increases of human activity in the watershed are listed as risk factors for drinking water quality; however, humans and human developments *per se* are not the issue. Rather, general population pressures and human developments especially within previously undeveloped areas of the watershed contribute to the following specific risk factors:

- Removal of vegetation and disturbing soils that otherwise serve to filter surface water flows;
- Direct disturbance of wetland and streambed sediments and channel form by ATVs, walking of humans, pets, and livestock;
- Creation of channels near drainage ditches, ephemeral and larger streams, rivers and lakes that increase the magnitude of sediment (and pathogen) transport in runoff;
- Deposition of pet, livestock or human feces in or near water courses;
- Construction of septic fields in seasonally saturated soils, or densification of neighborhoods utilizing disposal to ground sewerage systems;
- Dumping of garbage and other materials that attract birds and mammals;
- Road, driveway and parking lot construction, including stream crossings and increased extent of impervious surfaces that increase the energy of stormwater runoff and limit infiltration in favour of runoff.
- Excessive groundwater or surface water extraction that impairs the integrity of wetland or other plant ecosystems and impairs their ability to retain water, sediments, nutrients, and bacteria.
- Disturbance of areas of discontinuous permafrost.

4. RISK MANAGEMENT AND WATERSHED MANAGEMENT RECOMMENDATIONS

This chapter provides major recommendations for managing risks to Whitehorse drinking water supplies in light of the prioritized issues identified in Chapter 3.

Chapter 2 of this report discusses the basic components of a comprehensive, multi-barrier drinking water protection program. Among these are -

- source water protection;
- sanitary and contaminant surveys of source area and distribution systems to detect risks to health; and
- watershed or well-head protection plans.

The first and third of these components, in particular, are addressed in this City of Whitehorse Watershed Management Plan. The second component is addressed in part through recommendations for source water quality monitoring.

For each of these and the larger suite of basic components, important enabling mechanisms include:

- concrete regulatory and management strategies,
- monitoring,
- development of contingency plans,
- research and development,
- development and refinement of objectives, and
- public education and awareness.

These are also the major categories of tools available to undertake risk management of higher priority risks, as characterized in Section 3.3.

Some risk management strategies tend to be 'softer' management approaches, relying in large part on voluntary compliance and voluntary agreeme4nts to accomplish their objectives. A major advantage of such approaches is that they are often useful in accomplishing objectives that are resisted when tackled through 'command-and-

control' type approaches. A major disadvantage is the large degree of uncertainty associated with their effectiveness, as well as the ongoing requirement for catalyzing public interest lest the overall public awareness diminishes.

Conversely, important objectives are often addressed through use of regulatory compliance instruments such as bylaws and regulations, since these provide more concrete consequences for inappropriate behaviours and activities. A major disadvantage of these 'harder' approaches is the associated resources required to ensure compliance; i.e. through enforcement. This becomes particularly challenging when there is a need to manage human activities that may unfold in an entire watershed, and when the City may not have adequate jurisdictional responsibility to apply such an approach.

There are at least two major issues to consider in relation to the environmental risk assessment approach for shaping the Watershed Management Plan.

The first of these is that an evaluation of specific categories of potential risk might overlook the importance of cumulative effects of a wide variety of activities, especially those that are not deemed to be serious threats to source water quality if examined in isolation.

The second of these, related to the first issue, is that several aspects of watershed protection might best be engendered through a stewardship model. In particular, many of the principles for source water protection are already embraced in the Yukon River Corridor Plan (Chapter 2 of this report).

…many of the principles for source water protection are already embraced in the Yukon River Corridor Plan.

This section addresses possible risk management strategies with an emphasis on higher priority risks to the City of Whitehorse Drinking Water Supply, as identified in Chapter 3.

Risk management decisions are not always made solely on the basis of estimated risks. Risk assessment, along with an appreciation of the associated uncertainty and assumptions, is a good basis for prioritizing risk management initiatives and the allocation of resources. Risk management decisions, however, potentially embrace other considerations as well.

Some of these include –

- public perception,
- best management practices, and
- precedents for other decision frameworks.

Some risk management activities are undertaken simply because they are a way of further reducing risks regardless of the actual magnitude without too much monetary or other effort.

The following risk management solutions are based first on need as identified through the risk assessment, and second on activities that would further reduce risks to the drinking water supply as a part of best management practices.

The risk management solutions are provided in general form in Chapter 4. Chapter 5 critically evaluates the adequacy of current regulatory and management tools and regimes available to the City of Whitehorse, Yukon Territorial Government or Federal Government to address risk management needs.

What Broad Risk Management Issues Should be Considered as Part of the City's Watershed Management Plan ??

1) Prioritized risks to source waters

Source water protection requires action to address higher priority issues with a potential to adversely affect the quality of surface and groundwater supplies.

2) Importance of the cumulative impacts of many small scale activities

Dealing with issues on a case-by-case basis could result in overlooking an overall impairment of the ability of the watershed to provide clean, safe water.

The cumulative effects of many small-scale activities potentially is akin to "death by a thousand cuts".

Formalized regulatory measures are often poorly equipped to deal with the cumulative impacts.

3) The importance of environmental and community stewardship

If the possibility of cumulative effects on drinking water quality is part of the problem, then community-based environmental stewardship is a major part of the solution.

An engaged community increases the percentage of individuals who consistently make personal choices that enhance rather than threaten watershed processes that are important for the drinking water supply.

Watershed stewardship can, in itself, be viewed as another barrier for the protection of drinking water quality. Riparian zone protection may be weakened when a stewardship ethic is lacking among a significant portion of those who share a multi-use watershed.

A stewardship model for watershed management serves a much broader range of objectives in addition to source water protection. The same attitudes and strategies that protect drinking water supplies also protect and enhance fish and wildlife habitat, as well as the overall quality of life. The importance of stewardship within and around the City is clear from the recently developed Yukon River Corridor Plan, the City's Official Community Plan, the long-standing interests of local First Nations, and many other issues.

4.1 Specific Risk Management Options for the Whitehorse Watershed

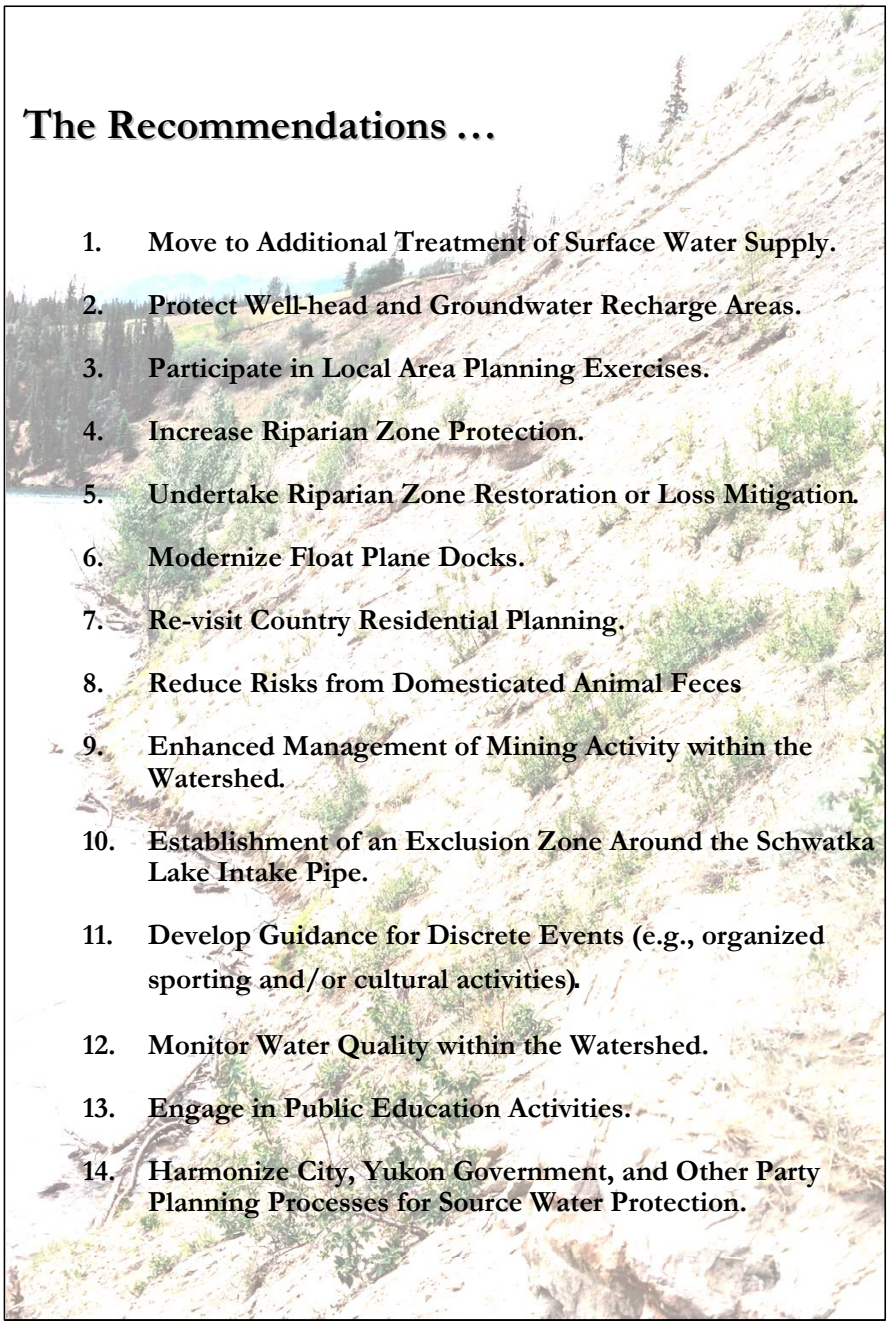
Table 3-15 lists issues that were estimated to represent potentially **very high (VH) or high (H) risks to source water quality** based on the currently available information.

These are summarized here:

The *Potential* Sources of Risk… Conclusions

Risk Potential	Source	Concern
V. HIGH	Direct fecal inputs by beavers and other	*Protozoa*
	Use of Schwatka Lake by waterfowl and other	*Protozoan*
	Fertilizer application in the Riverdale	*Nutrients*
	Domestic use herbicides, pesticides,	*Chemical*
	Marsh Lake waterfront developments in/near flood	*Pathogens*
	Septic fields in -country	*Pathogens*
	Depositing fecal matter in lakeside/streamside	*Protozoa*
	Presence of gas station (etc.) near Selkirk well	*Chemical*
	Faecal material input from poor -head	*Pathogens*
	Breaks or leaks in sewer lines in Riverdale	*Pathogens*
HIGH	Stormwater	*Chemicals*
	General increase in human	*Nutrients*
	Stormwater runoff and impervious	*Turbidity*
	General increase in human activities in the	*Turbidity*
	Agricultural parcels near the	*Pathogens*
	Developments on Marsh	*Pathogens*
	Developments on tributary	*Turbidity*
	Fertilizer use at the Meadow Lakes Golf	*Nutrients*
	…	…
LOW	Floatplanes on Schwatka	*Chemicals*

These issues, along with issues emerging from a stewardship approach or associated with the potential for cumulative effects, are addressed in the following specific detailed management options. **A summary of the major recommendations is provided below. Each is addressed in more detail in the following sections.**



4.1.1 Implementation of Additional Treatment

There are grounds for concern about the proximity of humans and animals to any streams that drain into Schwatka Lake or the Yukon River, even quite a distance upstream. Because of the very short residence time of water in the river system, it would likely take only a few hours to deliver a cloud of pathogens to the intake from upstream points. The highest risks to drinking water were assigned to potential sources of protozoan pathogens, including mammals and birds.

Planning for the Future:
Where to From Here?

Related to this Watershed Management Plan are deliberations by the City about the feasibility of (i) switching entirely to a groundwater source supply, and/or (ii) enhanced treatment.

The extent to which a precautionary approach is applied when considering actions for source water protection over the next half decade depends on possible future changes in source water and/or the level of treatment applied.

Changes in source water supply areas do not diminish the importance of source water protection, since -

- No treatment technology is absolutely 100% effective for removing chemical contaminants and pathogens in source water. A progressive deterioration of water quality over time will eventually render any treatment regime inadequate. In addition, capital and operating costs of treatment increase along with the need to restore as opposed to maintain water quality.
- Groundwater supplies benefit from the natural filtration afforded by native soils, but groundwater too can be contaminated by chemicals and certain types of disease-causing organisms such as viruses, where there is inadequate source water protection.
- Source water protection benefits not just drinking water consumers, but the entire ecosystem.

It is our understanding that the City is currently evaluating the feasibility of installing filtration treatment on the Schwatka Lake supply, which will directly reduce risks from protozoans in the final treated water. This is recognized as the most direct means of risk reduction from wildlife-borne pathogens, with greater certainty of effectiveness and a much higher degree of acceptability than other options such as the manipulation of wildlife populations or their habitat. The currently disseminated guidelines being considered for the draft Yukon Drinking Water Regulation (Chapter 5) may also compel the City to adopt a higher form of treatment, in light of seasonally high turbidity levels.

Recommendations…

Implementation of Additional Treatment

Why is this important?

The turbidity during the summer-time of Schwatka Lake is too high relative to the protection thresholds for an unfiltered water supply as recently established by the Federal-Provincial-Territorial Taskgroup on Drinking Water Protection. When combined with occasionally high summer-time coliform levels and the common detection of *Giardia* cysts in Schwatka Lake source water, this creates uncertainty about the adequacy of chlorination alone as a means of preventing water-borne outbreaks.

How can this be achieved?

There remain many options for resolving the current concerns about the elevated summer-time turbidity in Schwatka Lake, one of which is to build a filtration treatment plant, and another of which is to move away from the surface supply in favour of greater groundwater use. The evaluation of options is beyond the scope of the watershed management plan, however, with its vision and goals as described in Chapter 2.

4.1.2 Protection of Well-Head and Groundwater Recharge Areas, Especially Near the Riverdale Area Well-Field

The City needs a concrete well-head/re-charge area protection plan for the Selkirk aquifer and well-field within and up-gradient from the Riverdale area.

Identified sources of potential risk within Riverdale include-

- leaking underground storage tanks;
- small-scale hydrocarbon spills to surface soils;
- possible breaks or leaks in sewer lines (even smaller lines that serve individual households), and
- use of nitrate-containing fertilizers, animal or mixed-source compost, pesticides, herbicides, and other substances.

The portion of the aquifer that is recharged within and underlies the Chadburn Lake Park Reserve to the east of Schwatka Lake is protected to a large extent by the prohibition of residential, commercial or industrial developments, overnight camping, and many other activities. Unauthorized uses of the Park Reserve can be limited by a continued emphasis on education, augmented with enforcement. Enforcement in this area is likely to be challenging, given the size of the area and its extensive recreational use. **The presence of livestock such as horses and pets in the reserve should be better evaluated in the context of risks to groundwater and to Schwatka Lake.**

Recharge area protection in the Riverdale area is felt by us to be inadequate. The extraction well configuration does not currently include an upgradient monitoring well, data from which could be used to detect and respond to contaminant introductions. Further, no data are available to assess inputs of other than faecal coliforms or nutrients, including nitrates. In the absence of measures to limit domestic pesticide and herbicide use, a one-time screening of these substances in drinking water samples should be undertaken. For example, herbicides are applied extensively during the summer months to control dandelions and other broadleaf weeds in lawns. A one-time evaluation of inputs to the groundwater supply could be timed to coincide with peak usage.

Crosbie and Chow-Fraser (1999)[13] showed that concentrations of polycyclic aromatic hydrocarbons (PAHs) in 22 marshes in the Great Lakes Basin were correlated with percent urban development in the watershed, while metalochlor (a herbicide) was correlated with percent agricultural land use. This year, a small town in Alberta was compelled to seek alternative groundwater sources for drinking water, since the

[13] Crosbie, B. and P. Chow-Fraseer, 1999. Percentage land use in the watershed determines the water and sediment quality of 22 marshes in the Great Lakes Basin. Can J. Fush. Aquat. Sci. 56: 1781-1791.

primary source is now contaminated with herbicide residues, likely associated with herbicide application along a railway right-of-way.

There are a number of options for decreasing the vulnerability of the groundwater supply, which might be entertained in concert with the consideration of increased quantities of groundwater use for drinking water. The current extraction field undoubtedly draws water from both the Selkirk Aquifer, through the Chadburn/Hidden Lakes outwash deposit, and back from the Schwatka Lake/Yukon River supply. The enhanced movement of surface water through shoreline sand and gravel deposits likely results from the current extraction rates, but the portion of the groundwater supply drawn directly from the Selkirk Aquifer versus Schwatka Lake/Yukon River has not been determined.

The re-location of extraction wells within the Selkirk Aquifer to areas outside of the Riverdale area, farther south into the Chadburn Lake Park Reserve, is one possible means of limiting risks of contaminant inputs in the recharge area. It should be noted that only a small portion of developments in Riverdale are situated upgradient from the extraction wells. Some contaminants, therefore, have less potential to affect drinking water quality based on the current extraction wells, but may be important for either future viable source areas of the aquifer or for the overall integrity of the Yukon River ecosystem, which is the ultimate recipient of groundwater in the aquifer.

Especially over the shorter term, we recommend that the City engage residents of Riverdale in the issue of well-head and recharge area protection. This should include a public education campaign regarding fertilizer, pesticide and herbicide use and the conditions that could lead to groundwater contamination. The public education should emphasize the importance of residential heating oil underground storage tanks in light of the importance of the Selkirk Aquifer as a drinking water supply.

The probability of leakage or failure of underground sewage lines within the Riverdale area was not estimated by us. City staff should collate the relevant information, and an assessment of risks should be carried out.

Recommendations…

Protect Well-head and Groundwater Recharge Areas

Why is this important?

The groundwater supply lies below the Riverdale area, separated from surface inputs by only around 6 to 8 m of coarse, highly porous sand and gravels. Contamination in areas of groundwater recharge, or near the well-heads, could impair drinking water quality.

Contamination can come from:

- spill or leaks of contaminants onto the ground;
- releases from underground storage tanks, sewer lines and other structures;
- pesticide, herbicide, and fertilizer use.

How can this be achieved?

- Public education and discussion about aesthetic pesticide/herbicide uses;
- Identification of structures and facilities vulnerable to failure;
- Development of contingency plans for spills and leaks;
- Groundwater monitoring at the well head and elsewhere in the aquifer for chemical contaminants (e.g. petroleum hydrocarbons, pesticide residues);
- Study of the presence of enteric viruses in the groundwater supply;
- Re-location of extraction well network into Chadburn Lake Park Reserve, upgradient from possible influences.
- Respect the YTG Order (C.O. 1970-304), which prohibits land dispositions within the Chadburn Lake Park Reserve.

4.1.3 Participation in Local Area Planning Exercises

Possible risks to source waters based on activities upstream from the City of Whitehorse may be evaluated as part of the development of Local Area Plans (LAPs). The City and Yukon Government representatives should seek to provide input into such Local Area Planning processes, so that the plans are fully informed by the City of Whitehorse Watershed Management Plan. This is one area where the City might benefit from the pursuit of voluntary agreements with other working groups and agencies, given that these planning processes are otherwise beyond the City's control.

The quality of water entering the Yukon River at the outflow of Marsh Lake has a direct influence on source water quality in Schwatka Lake, especially given the short travel time of the river water from Marsh Lake to the dam at Schwatka Lake (less than 24 hours).

What Specific Activities Should be Better Managed During Land Development and Use?

1) **Removal of vegetation and soil disturbance that otherwise serves to modify surface water flows;**
2) **Direct disturbance of wetland and streambed sediments and channel form by ATV use, walking of humans, pets, and livestock;**
3) **Creation of channels near drainage ditches, ephemeral and larger streams, rivers and lakes that increase the magnitude of sediment (and pathogen) transport in runoff;**
4) **Deposition of pet, livestock or human feces in or near water courses;**
5) **Use of fertilizer, pesticides or other chemicals within the riparian zone;**
6) **Construction of septic fields in seasonally saturated soils (and in flood zones) or densification of neighborhoods utilizing disposal to ground sewerage systems;**
7) **Dumping of garbage and other materials that attract birds and mammals;**
8) **Road, driveway and parking lot construction, including stream crossings and increased extent of impervious surfaces that increase the energy of stormwater runoff and limit infiltration in favour of runoff;**
9) **Excessive groundwater or surface water extraction that impairs the integrity of wetland or other plant ecosystems and impairs their ability to retain water, sediments, nutrients, and bacteria;**
10) **Disturbance of areas of discontinuous permafrost (especially wetlands)**

Recommendations…

Participate in Local Area Planning Exercises

Why is this important?

- The quality of water entering the Yukon River at the outflow of Marsh Lake and other upstream areas has a direct influence on Schwatka Lake water quality;
- Foreshore development in upstream areas could result in either increased septic failures or in flooding of septic fields, possibly introducing pathogens into the watershed;
- Increased domestic and recreational activities close to the upstream shorelines could cumulatively cause water contamination.

How can this be achieved?

- By providing input into future Local Area Plans (e.g. through a voluntary agreement).
- By engaging in other regional planning processes, the City can encourage territorial and local governments to assist with the goals of the Whitehorse Watershed Management Plan;
- Ongoing monitoring of Yukon River water quality, at upstream locations.

A major concern for drinking water quality is recent trends in foreshore development on Marsh Lake that could either result in increased septic failures (for example, based on densification of residential developments) or result in flooding of septic fields during high water events. The construction of sewage disposal facilities within areas that are vulnerable to atypical flood events (for example, a 100 year flood) has direct implications for pathogen introduction into the City of Whitehorse drinking water supply.

4.1.4 Increased Riparian Zone Protection

The Marsh Lake waterfront is only one example of areas within the watershed that require a more detailed plan of action for riparian zone protection. **Enhanced riparian zone protection is needed in order to minimize risks associated with deposition of feces near water courses and the lakeshore, pathogen and nutrient inputs from residential and other septic fields, increased turbidity and pathogen delivery to Schwatka Lake associated with stormwater runoff, nutrient inputs from fertilizer use, or pesticide inputs.** As for the Marsh Lake waterfront, specific activities that need to be addressed are listed on the page 86.

Elevated turbidity of the surface water supply is likely to continue to pose challenges for the City. There is some evidence of inputs to the Yukon River mainstem of total dissolved solids and phosphate from the Cowley River/Wolf Creek watershed (see Chapter 3). In addition, there is visible evidence of streambed siltation in lower reaches of especially McRae Creek and Wolf Creek. Human activities within the sub-watersheds examined are probably contributing substantially to the amount of suspended sediments in the Yukon River and Schwatka Lake, although the data do not exist to evaluate this in more detail. **The seasonally variable suspended sediment loads in various parts of the watershed should be inventoried.**

The major risk management strategy for control of turbidity in a landscape setting is riparian zone protection, and – where justified – riparian zone restoration.

The major risk management strategy for control of turbidity in a landscape setting is riparian zone protection, and – where justified – riparian zone restoration. Soil-vegetation-atmosphere exchanges of water and energy (sunlight) are at the heart of the hydrological functioning of any watershed[14]. In keeping with a focus on watershed stewardship, the protection of riparian corridors serves to protect not "just" water quality, but also slope stability; retention of wilderness character and viewscapes; potential trail development areas; opportunities for quiet, passive recreation; and wildlife habitat/ travel corridors.

[14] Price, J.S. and J.M. Waddington, 2000. Advances in Canadian wetland hydrology and biogeochemistry. *Hydrol. Process* 14: 1579-1589.

Limited provisions currently exist for activity and development set-backs from streams, rivers and lakes within the watershed (Chapter 5). The *Federal Fisheries Act*, for example, includes limited provisions for riparian zone protection in consideration of fish habitat. The Federal Fisheries Act has not been used to set buffer zones through regulations, and probably will not be in the future. Letters of Advice typically issued by DFO Habitat Managers (by their very nature advisory and not prescriptive) do not include provisions for buffer zones, or require them as (poorly enforceable) conditions of Authorizations (A. von Finster, pers. com.). DFO prosecutions are pursued in the most egregious of offences; however, the mechanism for prosecution requires considerable expenditure of time and energy (harmful alteration of habitat is not a ticketable offence). Decisions to prosecute are carefully considered in the context of limited available DFO resources. Furthermore, several activities that potentially compromise the functional importance of the riparian zone may not obviously result in direct alteration of fisheries habitat.

Communities can achieve stream-side and lake-side setbacks through a combination of land owner education, land acquisition, and land use controls on new development. Set-backs, which are prescriptive buffer distances, should not be confused with riparian zones.

Some guidance on setbacks is provided in the City of Whitehorse Official Community Plan. Zoning bylaws and stewardship are likely to be a much more effective than Federal or Territorial regulations and policies in limited loss of the riparian zone. In particular, use of General Provisions modifications for existing and new zoning bylaws may establish an enhanced basis for riparian zone protection.

Provisions for setbacks established by various authorities for riparian zone protection tend to be somewhat arbitrary. Currently defined set-backs may not be adequate to limit movement of materials that contribute to turbidity or the enhanced transport of protozoan cysts/oocysts through the watershed. Some areas may require larger set-back areas than others, depending on the nature and scale of human activities, terrain slope and vegetation characteristics.

Set-backs for Riparian Zone Protection – *How Big is Big Enough?*

The Chagrin River Watershed Partners, Inc. (Ohio)[A] recommended channel-specific set-backs varying from about 8 to 100 m. **This group reviewed the literature information on the relationship between setback distance and either flooding risks, contaminant transport, or aquatic and terrestrial habitat protection.** The available information on contaminant transport was summarized as follows:

- Computer modeling of riparian systems shows that a 150 foot (approximately 50 m) riparian setback on a 3% slope reduced sediment transport by 90% (Wong & McCuen, 1981 in Divelbiss, 1994)[B].

- The effectiveness of riparian setbacks at removing sediments is directly related to their width. Most degradation of the aquatic benthic community from sediment deposition is prevented by riparian setbacks 30 m wide or greater. (Newbold et al., 1980 in Divelbiss, 1994)[B]

- Riparian setbacks greater than 15 m wide remove nitrate from agricultural drainage waters. (Jacobs & Gilliam, 1985)[C]

- A 150 foot (approximately 50 m) riparian setback is necessary to protect water quality from sedimentation and pollutants. In developing this number, 34 contaminant-specific studies were reviewed. These studies showed a 25 m setback necessary to remove 80% of sediments; a 60 m setback is necessary to remove 80% of suspended solids and nitrogen; and an 85 m setback is necessary to remove 80% of phosphorus. (Desbonnet et al., 1994)[D]

Based on this review, a minimum generic setback of 50 m (minimum buffer width from the water's edge, on each side) is required to achieve the City's source water protection objectives. This guidance may not adequately address highly sensitive areas of the watershed, however (areas where wetlands occur adjacent to streams and channels; low-lying land areas underlain by permafrost; steep terrain; or clayey soils).

[A] http://www.crwp.org/wrs.doc

[B] Divelbiss, Charles F., 1994. *A Review of Selected Functions of Riparian Buffer Zones and Widths Associated With Them.* Presented at the Rivers Without Boundaries Conference, American Rivers Management Society, Grand Junction, CO., April 21, 1994. Ohio DNR, Division of Natural Areas & Preserves, Columbus, OH.

[C] Jacobs. T.C. and J.W. Gilliam, 1985. Riparian Losses of Nitrate from Agricultural Drainage Waters. Journal of Environmental Quality 14:472-478.

[D] Desbonnet, Alan, Pamela Pogue, Virginia Lee, and Nicholas Wolff, 1994. *Vegetated Buffers in the Coastal Zone.* ISBN 0-938 412-37-x. Coastal Resource Center, Rhode Island Coastal Sea Grant, University of Rhode Island. Providence, Rhode Island.

Within British Columbia, the Streamside Protection Regulation (Section 12 of the Fish Protection Act of BC) establishes defined distances for setbacks ranging from 5 to 30 meters, depending on the parameters of the water body being protected. Agricultural riparian areas are currently exempt from the Streamside Protection Regulation. This is clearly inadequate in light of the available scientific information.

The effective width of set-backs has not been evaluated in any detail based on viral transport, either. **Adequate set-backs for preventing viral contamination are probably far greater than 50 m.**

A buffer limit review is important for ensuring the adequacy of buffer zones, and can be coupled with ongoing watershed monitoring programs.

The overall adequacy of setback distance and quality is likely to be directly influenced by factors listed in Table 4-1 (on page 93).

How would set-backs be established and what would they mean in terms of permitted uses?

Establishing formal set-back areas is only one part of increased riparian protection. Other components are listed on page 97. The set-backs described here would be established through the City's Zoning Bylaw. This bylaw already includes set-back areas beside lakes, creeks and rivers. These areas, presently 30 metres wide, are zoned "Environmental Protection". These areas are not intended to be "off-limits", but their use is limited because of their environmental sensitivity and because of the biological role they play in water quality protection. Normally, non-motorized trails, viewing decks and interpretive activities are permitted. With the preparation of environmental impact statements other developments such as utilities can be considered.

These setbacks would not apply to private land.

Evaluating the Expected Performance of the Riparian Zone for Source Water Protection – 10 Useful Criteria

The quality of the riparian buffer zone is also an important aspect to consider when developing land use controls. **The following ten performance criteria should be considered when designing effective stream buffers**:

Minimum total buffer width (50 m or more);

Three zone buffer system

- streamside zone protects integrity of stream ecosystem;
- middle zone provides distance between development and streamside zone;
- outer zone prevents encroachment and filters backyard runoff.

Maturity of the forested area that makes up the riparian zone;

Conditions where buffer can be crossed;

Conditions for buffer expansion or contraction;

Physical delineation requirements (e.g. – detailed mapping);

Integrating stormwater and stormwater management within the buffer;

Regular review of buffers and their performance;

Inspection and maintenance capabilities;

Ability of buffer zone vegetation to resist stress and recovery from minor disturbances.

Adapted from –
Stormwater Centre**,** Aquatic Buffers Fact Sheet: Buffer Zones
(http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool3_Buffers/BufferZones.htm)

Table 4-1. Factors Affecting Buffer Pollutant Removal Performance

Factors that Enhance Performance	Factors that Reduce Performance
Slopes less than 5%.	Slopes greater than 5%.
Overland flow paths over 100 m in length.	Contributing flow lengths < 50 m.
Groundwater far below surface (infiltration occurs even after extended precipitation).	Water table close to surface (infiltration ceases when soil becomes saturated at the surface).
Features that distribute stormwater flows over larger areas (e.g. wetlands, low relief topography).	Contact times between water and soils within riparian zone of less than 5 minutes.
Permeable, but not sandy soils.	Compacted soils.
Organic matter, humus, or mulch layer.	Snowmelt conditions, ice cover.
Active growing season (with longer duration annually).	Flows during non-growing season (and annual extent of non-growing seasons).
Size of runoff event is small (lower volume, lower energy).	Size of runoff event is atypically large; for example, runoff events for rainfalls that are a 1 in 2 year event, 1 in 10 year event, or more severe.
Entry runoff velocity less than 0.5 m/second.	Entry runoff velocity more than 1.5 m/second.
Swales that are routinely mowed (encouraging higher density of vegetative cover).	Sediment buildup at top of swale
Dense grass cover, six inches tall.	Tall grass, sparse vegetative cover.

Several factors within the Whitehorse watershed might reduce the performance of set-backs. These include –

- overly permeable soils (providing from easy conduits for sub-surface entry of poorly treated water to streams, the Yukon River, and Schwatka Lake),
- a very short growing season,
- high annual peak runoffs associated with snow melt,
- shallow rooted tree ecosystems,
- steep slopes, and
- presence of discontinuous permafrost.

Table 4-2 provides an example *watershed report card* modified from a typical report card that might be useful for prioritizing Yukon River sub-watersheds that merit additional riparian zone protection or restoration.

Table 4-2: Typical Watershed Report Card, Adapted for the Whitehorse WMP

1.	Percentage of watershed developed, adjusted for severity of clearing or conversion to poorly pervious surfaces (%).
2.	Total road density (km/km^2).
3.	Length of road as high sediment source (km of gravel and dirt road, as opposed to paved road).
4.	Total number of landslides (total numbers of point sources, road related, etc.) entering streams.
5.	Length of road on unstable slopes (km).
6.	Number of stream crossings.
7.	Length of stream with impaired functioning of riparian forest (km and %; assessed based on evidence of devegetated areas, erosion, and/or siltation of streams and streambeds.)
8.	Length of stream with disturbed stream channel (km and %); assessed based on loss of riffle or other natural habitat, excess sediment accumulation, signs of physical disturbance).

Regardless of the treatment technology implemented in the future for surface water supplies, continued monitoring of turbidity at specific sites within the watershed is important, since elevated turbidity is also a proxy for the potential entry into waterways of other particles as well, including pathogens.

A sediment source survey would provide an important foundation for riparian zone management in specific areas and sub-watersheds. In particular, a sediment source survey for the City's watershed is needed to identify areas requiring enhanced riparian zone protection. The sediment source survey is a reconnaissance-level inventory of significant contributors of fine-grained and coarse-textured sediment within the watershed. It can be completed using a combination of aerial photographs, road inventories, ground surveys, and water sampling events. The survey's purpose is to identify sediment point and non-point sources that have the potential to deliver significant suspended sediments (and turbidity) to downstream waters.

A program of ongoing monitoring of surface water quality within the watershed will greatly assist with the identification of turbidity, protozoan and coliform source areas, and allow an evaluation of the adequacy of set-back distances for any particular area of the watershed.

Given the importance of the riparian zone for source-water protection, it remains unclear whether there are adequate enforcement capabilities within the City staffing structure or through other jurisdictions to resolve inappropriate activities within the riparian zone. We define herein the factors to be considered when attempting to enhance the effectiveness of the riparian zone for water quality protection, with an emphasis on larger, more effective set-backs in comparison with the current guidance. However, there are several examples both within and beyond City limits where even minimum guidelines for riparian zone protection have not been followed. There are at least two examples of clearing and road construction virtually to the edge of the Yukon River along its western flank that have gone unchecked in recent years. Any policy instrument to encourage better riparian zone protection, especially in the sub-watersheds, will require a concrete plan for implementation and – where appropriate – enforcement. Because a substantial portion of the important sub-watersheds lie outside of City of Whitehorse jurisdiction, the Yukon Government has a major role to play. Several large (ca. 6 ha) rural residential areas lie south of the City limits along the Yukon River corridor. The City should seek voluntary agreements with responsible parties to foster goals of the watershed management plan.

Riparian zone protection on the eastern side of Schwatka Lake and the Yukon River within the Chadburn Lake Park Reserve is probably adequate at the present time, with some key exceptions. Picnic areas and the boat launch developed on the eastern shore of Schwatka Lake are areas where the riparian zone has been removed, and where

there is potential for direct wash-in of feces, sediment, and other materials deposited near to the lake shore.

Riparian zone protection in country residential and other developed areas to the west of the Yukon River needs greater scrutiny, however. In addition to this, the riparian zone along the major portion of the western shore of Schwatka Lake has already been lost. The vegetation has been replaced by a paved road and associated right-of-way along part of the shore, and by a gravel road and de-vegetated access areas farther to the south of this.

Within City limits, there are a few fee simple parcels or otherwise privately held lands where no provisions for riparian zone protection were included during land clearing and development. Some examples include residential properties located at the mouth of McRae Creek, the Cadet Camp parcel upstream on Wolf Creek, and the commercially zoned site at the northwestern end of Schwatka Lake, which is the base for the M.V. Schwatka. In these and a few other cases, the riparian zone has been partially or completely de-vegetated, and road works, buildings, septic fields, cleared areas, or other developments have taken place within close proximity to shoreline. In some instances, the activities may even occur at elevations lower than maximum flood elevations. Our understanding is that some of these fee simple or other historical developments have tended to fall outside of the guidance of the City's Official Community Plan (OCP), as well as various zoning bylaws. Such developments are not possible under the current policy guidance of the OCP (Chapter 5).

There are at least three implications of this. **First,** the City should seek with the Territorial Government an agreement that no additional land transactions will occur within City limits in the future that would be resistant to management approaches implemented by the City (see further discussion in Chapter 5). The Commissioner's Order which established the Chadburn Lake Park Reserve (C.O. 1970-304; pursuant to the Yukon *Lands Act*) withdraws the reserve area from disposition. This should continue to be respected.

Second, the Yukon Government – if serious about drinking water protection – should not approve land use activities or transactions in areas outside of City boundaries that are contrary to the spirit of the City of Whitehorse Watershed Management Plan. This might include land sales, approval of mining exploration and activities, forestry and firewood harvesting, and so on. In other words, the Yukon Government should designate the larger watershed that serves the drinking water, social, economic, and spiritual needs of City of Whitehorse residents as a *Community Watershed* with special provisions for interactive management similar to what has been established in Canadian provinces where the possibility for designation of community watersheds has been formally adopted.

Third, some areas where the riparian zone is already degraded may benefit from restoration activities. Failure to restore these areas could result in continued critical weaknesses in the overall multi-barrier approach. Riparian zone restoration will require a commitment to funding this initiative and to working with land holders to develop working agreements, to prepare details of site-specific restoration activities.

One way to ensure riparian zone integrity for areas that are not readily managed is through land acquisition by the City. This may or may not be a viable option, depending on the number of properties involved. If we were concerned only with foreshore properties on the Yukon River and Schwatka Lake, management control through land acquisition might be a viable option. **The entire watershed, including sub-watersheds, needs adequate riparian zone protection, if the maintenance of effective barriers at some points in the watershed is not to be undermined by critical weaknesses at other points.** Different management tools may be required, therefore. **Recommendations for enhanced riparian zone protection are provided on the next page.**

Specific actions proposed are intended to improve the City's ability to protect the riparian zone of the Yukon River down river from Marsh Lake, Schwatka Lake and sub-watersheds especially through managing land development activities within its control. In addition, the actions are intended to prevent new cases within and beyond the City's boundaries where loss of riparian zone effectiveness is difficult or impossible to manage. Issues of riparian zone restoration, where the vegetation and soil filtration capabilities have already been lost are addressed in section 4.1.5.

Some of the major aspects of riparian zone protection include –

- A generic increase in riparian set-backs through zoning provisions to a minimum of 50 metres on each side of streams, rivers, and lakes.
- The identification of more sensitive areas, through water quality monitoring, a sediment source inventory, development of a watershed report card, and consideration of local conditions that affect set-back performance.
- Ongoing evaluation of set-back performance for different catchments.
- Increased public education.
- Inventory of land parcels within and beyond the City limits where riparian zone protection has been neglected.
- Inventory of parcels within the riparian zone that should be considered for land acquisition by the City.
- Agreement with the Territory to establish a *Community Watershed* status or its equivalent for the watershed, both within and beyond the City limits.

Recommendations…

Increase Riparian Zone Protection

Why is this important?

The riparian zone is among the first set of barriers in the multi-barrier approach to drinking water protection! Enhanced riparian zone protection is needed to minimize risks associated with -

- Deposition of feces near watercourses and the lakeshore;
- Pathogen and nutrient inputs from residential areas and/or septic fields;
- Increased turbidity and pathogen delivery to Schwatka Lake from stormwater runoff;
- Nutrient inputs from fertilizer use; and
- Pesticide inputs.

How can this be achieved?

- Development of set-backs (min. of 50 metres) on each side of streams, rivers, and lakes,
- Through land acquisition and zoning controls on new developments;
- A sediment source survey to identify areas requiring enhanced riparian zone protection;
- Identification of sensitive areas and ongoing evaluation of set-back effectiveness;
- Respect for the YTG Order (C.O. 1970-304), which prohibits land dispositions within the Chadburn Lake Park Reserve.
- Landowner/public education;
- Voluntary agreements with responsible agencies for lands outside of the City's jurisdiction.

4.1.5 Riparian Zone Restoration and/or Mitigative Actions

The current road configuration on the east and west sides of Schwatka Lake go to the heart of riparian zone protection. It would be inconsistent to recommend significant additional effort be expended on riparian zone protection and the adequacy of set-backs without addressing the paved and unpaved, primarily un-maintained roadways established directly within the lake's riparian zone.

- **The approximately 1 km long section of paved road that runs along the western shore of Schwatka Lake at its north end provides an impervious surface with virtually no vegetated buffer zone on its shoreward side**. It provides an impervious surface and easy conduit for the direct runoff into the drinking water reservoir of pathogens from wildlife and domestic animals feces. While the roadway is mostly used seasonally by drivers who do not stop and are sight-seeing, the entire length of roadway leaves the northwest flank of the reservoir vulnerable to a wide range of human activities that are not readily scrutinized or enforced. Currently, there is little to prevent fuel and septage haulers, or those transporting dangerous goods from using this road. The road is also used to gain access to float plane docks situated farther south on the lake, as well as for access to a property established as a life estate lease, close to the shore of the lake.

- **Extending southward from the paved road is another stretch of dirt and gravel road that continues immediately adjacent to the western shoreline of Schwatka Lake.** Again, no vegetated buffer exists between the road and the drinking water reservoir. The dirt base of the road is likely to encourage sediment delivery directly to the lake. During a very brief site visit conducted in August, 2003, two separate piles of animal feces were found along the road. A clearing along this road has been used often for picnicking and partying, and there are the remnants of several fire pits.

- **At the north end of Schwatka Lake on its eastern shore, near the start of the Chadburn Lake Road, is a dirt road that is used by vehicles including four-wheel drives and ATVs to access a high bluff** directly overlooking Schwatka Lake at the point directly adjacent to the drinking water intake. Mountain biking, foot traffic, use of ATVs, vehicular traffic and indiscriminate tree cutting have removed a major portion of the vegetative cover in this area, including that on relatively steep unstable slopes. This is an area where people walk their pets, and observations of pet excreta are common in this area. The area is also strewn with litter. Overall, the use of this area for partying and a variety of other activities generally has not been in the spirit of watershed stewardship or drinking water protection and needs to be addressed. The only viable means of addressing may be

through strict enforcement regimes (and appropriate levels of staffing), since the road access is not a formally established or maintained one.

- **Farther south along the eastern shore of Schwatka Lake are developed picnic sites and the boat launch/day use area**. Especially in the case of the boat launch area, there is no vegetative buffer along the shore line, and soils tend to be highly disturbed and compacted. A gravel road extends to the boat launch and near the lake shore. This creates significant potential for the entrainment of sediment and other materials in surface runoff and direct entry into the lake.

- **Farther up river, it is still possible to gain vehicle access to the edge of Yukon River at the "Old Laundry Site",** now acknowledged as having historical value.

At least two riparian zone issues need to be addressed as part of the City's Watershed Management Plan:

First, all areas identified above represent significant impairment of the riparian zone, and its effectiveness in protecting water quality. There is simply no vegetative buffer between the roadways, disturbed soils on and adjacent to them, and the lake or river. It should be expected, therefore, that sediments and other materials deposits on or near roadbeds can be rapidly washed into the drinking water supply during rainfall events.

Second, there are significant challenges in managing the activities that take place in these areas, and that present risks due to pathogen or contaminant introductions into the drinking water supply. These roads have been used and will likely continue to be used in the future for inappropriate activities such as parties and garbage dumping (including vehicles/snowmobiles). These areas are not highly visible to the general public, which is important in terms of enforcement.

We considered an option for the closure and decommissioning of the portion of the roadway that runs along the western shore of Schwatka Lake, between the access point to the northern-most float plane docks to the point where the road swings away from the lake, up the hill toward Miles Canyon.

As mentioned above, the roadway leaves the reservoir highly vulnerable to a range of contaminant inputs such as associated with feces, urine, garbage, and spills and is not

accompanied by any buffer between the road surface and the lake. There are few credible ways of managing the risks associated with vehicular traffic, wildlife, domestic animals and humans using the road other than through public education (which does not work with wildlife) or nearly round-the-clock, year-round enforcement of new bylaws or policies. For human activities, public education would need to be virtually 100% effective in order to minimize associated risks to drinking water, given the close proximity of the roadway to the reservoir along with no potential for retardation of surface runoff.

The closure could be carried out in a way that facilitates the continued operation of the float plane base, albeit with an altered configuration (see below). Access to the viewpoint area to the south and Miles Canyon would be from the south.

Closure of the road would result in loss of access to the western shore of the lake for the purpose of canoe and kayak launching. This area has been used for limited periods each year during the spring, since the western shore of the lake becomes ice-free sooner than the eastern shore. Such loss of access represents an inconvenience, however, which may be justified in light of the risks associated with the access that the roadway offers coupled with the lack of any riparian zone buffer.

Consultation – What we heard

Issues/Concerns Raised

- Need for road closure has not been demonstrated.
- …and would result in negative economic impact, especially for tourism.
- Road closure might make the problem worse. Less vehicle travel could make these areas more attractive for recreation and uncontrolled activities such as over-night camping.
- Continued use of area by "responsible people" provides an "Eyes and Ears" warning system for inappropriate activities.
- Better facilities (toilet, garbage, parking), education, and enforcement are a sufficient means of dealing with the risk.

Based on public consultations and follow-up discussions, alternatives to closing Schwatka Lake road were considered. In particular, there was concern that the case for road closure was not compelling relative to the economic and other impacts that would result from loss of this route. In addition, people felt that such restrictions might not be necessary depending on the outcome of deliberations about either or both of a higher level of treatment of the drinking water, and the possibility of switching from the Schwatka Lake surface supply to total reliance on groundwater for the City's drinking water needs.

Options that should be more closely considered by the City include the following:

- **Eventual closure or re-routing away from shore** pending decisions over next 5 years regarding water intake changes (i.e. reduced reliance on the surface supply), as well as results from new water quality monitoring initiatives.
- **Remove one lane of traffic** and restrict access on narrower one-way route. Use the decommissioned lane for mitigative measures.
- **Creation of a barrier and/or change the road crown** to divert surface water away from water's edge (so that it is filtered by soil or wetlands prior to entering the lake).
- **Prohibit commercial traffic, transport of fuel, septage, dangerous goods.**

Of these, we feel that prohibition of traffic carrying bulk fuel, septage, or dangerous goods is a must.

In addition, continued use of the road will create many challenges for drinking water protection unless the decision is made to move away from Schwatka Lake as a drinking water source supply. In the absence of measures to reduce potential for introductions of various materials along the Schwatka Lake shoreline, the City should rapidly develop and implement short-term water quality monitoring strategies, and gain much-needed information on current regimes within Schwatka Lake.

The un-maintained roads along the eastern and western shoreline should be removed and the areas targeted for re-vegetation as part of riparian zone restoration. This will require an increased level of public support for protection of the Yukon River Corridor and the drinking water supply, which in turn will require increased public education (increased signage, workshops, seminars, and other forms of public education). These areas can continue to serve as walk-in recreation areas provided that people do not undermine riparian restoration efforts, and take the necessary precautions to strongly limit introductions of feces, other contaminants and sediments to the waterways. For pet owners, doggie bag dispensers should be made available, accompanied by an educational campaign on the links between animal feces and water-borne diseases. Garbage receptacles should also be available at strategic locations, along with portable toilets. Public education should be used to direct people to alternate, more appropriate areas for picnicking, hiking, pet walking, trail riding, and other activities. One advantage that the City has is a wealth of excellent recreational areas, many of these outside of the catchment area for the Schwatka Lake drinking water supply or the recharge area for the Selkirk Aquifer.

The US Laundry Site may require a different approach (a locked gate for, example), since it is recognized in the Yukon River Corridor Plan as a potential interpretive area, and may serve as a legitimate access point for river users, historians, and others.

The Yukon River Corridor Plan, in fact, recommended active development of the site:

> "Provision for boat launch sites shall be made at the approximate locations shown on Map 7 (supplementing proposed downtown riverfront sites). New sites are recommended especially at the American laundry site, the confluence of the Yukon River and Takhini River, and as part of any development that may occur on the east bank of the river north of the Kishwoot Island area."

Also, the US Laundry Site is presently used by one tourism operator (Gold Rush River Tours) who floats people downstream on wooden rafts (a re-creation of Klondike era river transportation). The operator helps by observing activities along the stretch of river between the Laundry Site and Schwatka Lake, and picks up garbage.

Many of those consulted agreed that there is strong public support for both source water protection and use of Schwatka Lake, the Yukon River and its environs for activities commonly equated with socio-economic well-being. Many of the residents of Whitehorse recognized that these two might conflict at times, but were not convinced of the need to strongly subordinate other uses for enhanced source water (and drinking water) protection. This is likely to cause some challenges for the City, since there will undoubtedly arise future interest in expanded tourism and other economic stimulation-type activities on or near Schwatka Lake and the Yukon River south of Marsh Lake. Each will have to be considered on its merits, but any lack of support for riparian zone integrity as a major component of the multi-barrier approach may leave the City with fewer objective criteria for deliberations about such applications.

Road closures and attempts to limit vehicular and ATV access are likely to meet with some public resistance. However, the current situation represents an impairment of the ability of the riparian zone to protect water quality. In addition, a major issue is the limited ability of the City to control human activities in these areas. The overall underlying logic is simple: Set-backs and riparian zone protection have been adopted in principal as a means of managing residential and other developments for watershed protection.

Deliberations about road closures and riparian restoration should include as a minimum –

- Re-establishment of vegetated buffer zones that have been seriously compromised where this is feasible.
- Efforts to decrease poorly controlled human activities that result in unacceptable risks to the drinking water supply, such uncontrolled pet defecation and disturbance of vegetation.
- Prohibition of commercial traffic, transport of fuel, septage, dangerous goods along foreshore roads.
- Increased public education.

Recommendations…

Riparian Zone Restoration and Loss Mitigaton

Why is this important?

There are both maintained and un-maintained roadways beside Schwatka Lake and the Yukon River, which have little to no buffer (riparian zone) remaining. Many activities in these areas are hard to monitor or regulate.

This may lead to contamination via-

- Sediment transport (turbidity);
- Pathogen wash-in (animal and human feces along roadway);
- Chemicals (vehicle exhaust, leaks, spills);
- Other sources (e.g. garbage disposal).

How can this be achieved?

Restore the riparian zone (vegetated area) or compensate for its loss by –

- Removal of un-maintained roads along sensitive foreshore areas;
- Refine options for the Schwatka Lake Road. Options to be considered may include –
  - Eventual closure or re-routing away from the foreshore, pending decisions over next 5 years about water intake changes (i.e. reduced reliance on surface supply) and results from new water quality monitoring studies,
  - Creation of a barrier and/or change the road crown to divert surface runoff way from water's edge (so that it is filtered by soil and/or wetlands prior to entering lake),
  - Prohibit commercial truck traffic, transport of fuel, septage, dangerous goods,
  - Remove one lane of traffic and restrict access on a narrower one-way route. Use the decommissioned lane for mitigative measures.
- Increase public education and enforcement;
- Educate the public about pet feces and the need to 'pick up' after pets.

4.1.6 Modifying Float Plane Facilities

Even in the absence of closing the road, there may be merits to the consolidation and better management of float plane docks, re-fueling and other support services toward the north end of Schwatka Lake. Such a facility should, in particular, be designed to facilitate more consistent enforcement of bylaws, regulations, and other policy directives. Many of the recommendations in the 1995 float plane study have yet to be implemented, and these should be re-visited.

Docks (and planes) are scattered along the western shore of Schwatka Lake. This potentially creates a few challenges for source water protection:

- Local access ramps provide direct conduits for the runoff of sediments and other materials into Schwatka Lake;
- Without permanent sewage facilities and service, there is a greater concern about deposition of human feces along the shore of Schwatka Lake;
- Without permanent garbage facilities and service, there is a greater concern about the disposal of garbage near and within the reservoir;
- Some provisions are in place for fueling and fuel storage or handling, but adherence to best management practices is difficult to enforce for operations scattered along the western shore;
- Approved parking facilities do not exist, either for day-trips for fly-outs lasting greater than one day.

Situations that facilitate the rapid transport into the surface water supply of sediments, nutrients, chemicals, and/or pathogens should be avoided where possible and mitigated if already present.

As a result of stakeholder discussions, two major issues were identified:

1. **From a planning perspective, float planes operating on Schwatka Lake might be divided into two groups**. The major portion is probably small plane operators where the primary 'cargo' is passengers with or without small amounts of personal or camping gear. Some consideration should be given to larger planes, however, capable of hauling larger payloads. In particular, the question arose whether any float planes operating on or immediately up river from Schwatka Lake might be carrying dangerous goods or other sources of contaminants. This latter case deserves special scrutiny from a source water protection perspective.
2. Float plane operators expressed a concern that the width of the lake is too small to accommodate more consolidated operations, and **consolidation of operations would result in crowded and unsafe operating conditions**, potentially resulting in direct threats to human lives. Safety issues are of particular concern during windy days.

The risk assessment herein identifies fueling and accidental spillage of hydrocarbons to be only of moderate concern. **However, amalgamation of the float plane facilities would allow for implementation of best management practices for fuel storage and handling, as well as the handling of human sanitary and solid waste.** Also, this would decrease traffic on the road and access to the lake shore further south (even if road is not decommissioned). In the absence of better information on water currents in Schwatka Lake, the amalgamation of facilities to the north is expected to limit any potential for cross-lake movement of released materials toward the drinking water intake point on the east side of the lake near the dam.

Consultation – What we heard

Issues/Concerns Raised

- The need for amalgamation of float plane operations has not been demonstrated.
- The current distribution of docks up the lake shore provides an "Eyes and Ears" warning system for inappropriate activities.
- Amalgamation at a single location near the spillway will not work because there is not enough room to safely taxi.
- Better facilities (toilet, garbage, parking), education, and enforcement are a sufficient means of dealing with the risk.

This issue is intimately tied to the issue of riparian zone restoration and possible future reconfiguration or closure of the road along Schwatka Lake (Section 4.1.5). **As for the issues associated with current road configurations, the guiding principal is that - situations that facilitate the rapid transport into the surface water supply of sediments, nutrients, chemicals, and/or pathogens should be avoided where possible and mitigated if already present.** Access routes to float plane docks should be evaluated in light of this.

Following initial discussions regarding the possible feasibility of amalgamating float plane operations into a unified facility for which best management practices can be implemented and maintained, the following options were considered in more detail:

- Postpone implementing recommendations for consolidation pending a more detailed investigation of possible configurations, with a focus on safety;
- Decrease the size of the proposed 'exclusion zone' around the current water intake pipe from 100 metres to 50 metres, to allow more room for taxiing and maneuvering;

- Postpone implementing recommendations of consolidation pending the availability of water quality data for sites along the foreshore, and evidence that this portion of the lake may serve as a source of fecal matter, sediment, *etc.* into the drinking water supply;
- Postpone implementing recommendations of consolidation pending a decision by the City regarding a possible abandonment of the use of Schwatka Lake as a drinking water source (i.e., toward a 100% use of groundwater from the adjacent aquifer);
- Continue use of individual docks, but based on re-locations to a slightly more concentrated area near the north end of the lake (i.e., more closely lateral to as opposed to up-current from the intake pipe);
- Continue use of individual docks in their present location, but with improved toilet and garbage facilities, as well as the installation of stormwater control structures at access points to re-direct surface flows away from the foreshore.

This issue, like the issues surrounding the roadway along the Schwatka Lake western foreshore, is expected to evolve through several early iterations of watershed management planning for source water protection.

What about potential developments at the MV Schwatka site?

One issue that is partially related to the consideration of a modified float plane base is the potential additional commercial development on the adjacent lot to the north (Lot 401). This lot is zoned CW – Commercial Waterfront (City of Whitehorse Zoning Bylaw 97-42). As stated earlier (p. 70), commercial developments at this location at the northwest corner of Schwatka Lake were ranked as having a low risk index from potential pathogen inputs, in spite of the short (straight-line) distance to the drinking water intake pipe. The main reason for this conclusion about low risk potential is that the commercial development would be located at a point along the lake shore that is cross-channel from the intake pipe, rather than up-current from it. In the absence of detailed knowledge about current regimes in Schwatka Lake, it is important to remember that the lake is configured more as a widening of the river and that the hydro-electric dam is constructed as a "run of the river" facility. Therefore, any cross-lake transport of contaminants is considered to be very unlikely from this location. Finally, it is recognized that the Yukon Environmental and Socio-Economic Assessment Act will provide an adequate framework for a critical evaluation and management decision for any specific proposals that may be put forward.

As a minimum, and in light of the four major goals that guide the Whitehorse WMP action plans, the following recommendations are made with respect to floatplane facilities:

- Undertake a focused study (e.g., by an appropriately experienced air transportation consultant) of possible configurations of float plane docks and associated infrastructure, with a focus on critical evaluation of transportation safety issues;
- In the interim, implement improvements to parking and loading areas, garbage and sewage facilities and surface runoff control structures;
- Immediately implement a water quality monitoring program, and coliform or turbidity source assessment, sufficient to detect effects (if any) on source water quality from current lakeshore activities (See also section 4.1.12); and
- Undertake a study of currents in Schwatka Lake to examine magnitude of expected movement of materials between various foreshore locations and the drinking water intake pipe.

Recommendations…

Modify Float Plane Dock Configuration

Why is this important?

Like the roadway itself, the staging areas for the existing docks are within the riparian zone, with no remaining vegetation between the activities there and the lake.

Activities such as fuel handling, sewerage, or garbage handling are very difficult to monitor and manage at present.

Any re-configuration, however, needs to consider transportation safety issues first and foremost.

How can this be achieved?

Over the shorter term -

- Initiate a focused study on possible re-configuration strategies and their safety implications;
- Implement improvements to parking/loading areas, garbage and sewage facilities, and create surface runoff controls based on current dock locations;
- Implement a water quality monitoring program of sufficient resolution to assess possible foreshore inputs; and
- Initiate a study of water currents in Schwatka Lake, to assess interaction potential between foreshore sediment or other inputs and the drinking water intake pipe.

4.1.7 Re-visit Country Residential Planning

Planning processes for country residential developments should be re-visited in the context of source water protection, including riparian zone protection and groundwater protection. The *Official Community Plan* and other regulatory/policy documents provide some guidance on watershed protection; however, more detailed guidance is needed.

The implementation of routine monitoring studies of surface and groundwater quality and quantity is recommended as the major enabling tool. This tool is needed for the subsequent evaluation of the effectiveness of current practices for the development and management of country residential and rural residential areas. Some information is available on groundwater-related issues in rural-residential areas; however, no studies have been completed on the effects of the City's country residential areas on surface water quality or quantity. Extensive groundwater studies have been undertaken of the Wolf Creek area (see Volume 1); however, these studies did not examine possible effects on surface water supplies or quality. While we argue for the need for more detailed guidance on watershed management measures in existing and new country residential areas, we believe that such guidance should be refined after a surface water quality assessment and sediment source assessment is available to assess the extent and nature of possible impacts to the watershed, if any.

Specific mechanisms for the better management of country residential and rural residential developments are discussed as part of riparian zone protection, above.

Where rural development areas are beyond the City limits but within the watershed designated for protection, the City should seek voluntary agreements with responsible agencies and individuals to further the watershed protection goals.

Recommendations…

Re-visit Country Residential Planning

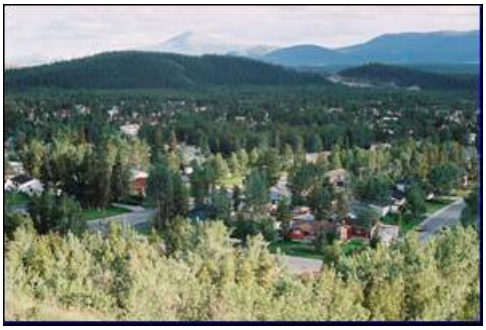
Why is this important?

Residential planning processes need to reflect emerging understanding about source water protection, including both surface water and groundwater protection.

How can this be achieved?

In addition to those issues addressed under Riparian Zone Protection, subdivision planning should include -

- Minimizing stream crossings and impervious surfaces near surface water;
- Implementation of routine monitoring studies of surface and groundwater quality and quantity;
- Using monitoring results to diagnose and address problem areas;
- Seek voluntary agreements with parties in areas beyond City limits.



4.1.8 Reducing Risks from Domesticated Animal Feces

Animal feces are a possible direct source of primarily protozoan pathogens to surface waters within the watershed that contribute to the source water supply. The risks associated with feces from domesticated animals and livestock increases with decreased distance from actively flowing surface water. The risks also increase with decreased effectiveness of the riparian zone.

Beyond areas of Schwatka Lake shoreline, it is difficult to define appropriate areas of inclusion or exclusion from pets – either on or off leash. This is because the overall watershed is so extensively developed, that there is potential for introduction of excrement from dogs or other species throughout the vast majority of the watershed. Wolf Creek campsite is one area were better attention to the control of pet feces could be achieved through installation of doggie bag dispensers and educational signs, perhaps in concert with enhanced enforcement through bylaws.

We provide two specific recommendations for risk management:

- Include in public education initiatives the concern about pet feces within the watershed;

- Consider (through bylaw) defining specific zones where picking up after pets is required, and providing doggie bag dispensers and garbage receptacles. One such area should be the boat launch and picnic areas on the eastern shore of Schwatka Lake.

Recommendations…

Reduce Risks from Domesticated Animal Feces

Why is this important?

Animal feces are a possible direct source of protozoan pathogens to surface waters within the watershed.

How can this be achieved?

- Educate the public about the concerns from pet feces within the watershed;
- Define specific zones where picking up after pets is required;
- Provide doggie bag dispensers and garbage receptacles.

4.1.9 Enhanced Management of Mining Activity within the Watershed

Metals released from the abandoned Whitehorse Copper Mine do not appear to affect drinking water quality based on the available drinking water quality data (Vol. 1 of this WMP). On the other hand, this mine and possible future mining activity within the watershed may be contrary to the vision and goals of the overall Watershed Management Plan (Chapter 2).

The following issues were identified when considering mining:

- Mining has a high potential to alter site hydrology over relatively large areas and impair the riparian zone in areas higher up in catchments, thus resulting in increased sediment transport (and turbidity).
- Figure 3-2 (p. 38) shows a map of current land-uses in the watershed and sub-watersheds identified as important source water areas of the City's drinking water supply. Mining claims occupy a major portion of these watersheds, in fact far more than agriculture, forestry and all other land uses combined. It is appreciated that few of the claim areas will be developed, and even fewer will be developed at any given time (in fact, there is no active mining activity presently); however, the large-scale extent of the claims creates uncertainty about the future status of important watershed areas.
- Of particular concern are areas outside of City limits (adequate provisions likely exist to guide such developments if they fell within City limits);
- Some members of the public expressed concern about possible effects on the watershed from the current status of the tailings pile at the abandoned Whitehorse Copper Mine, which have not been stabilized against wind and water erosion;
- Finally, the Whitehorse WMP 'watershed' covers a land area of approximately 22,000 km^2 within a land base for the entire Yukon of 483,450 km^2. The watershed, therefore, represents only about 4.5% of the total land base in the Yukon, but supplies drinking water for about 62% of the Yukon's population.

There are several key regulatory tools that cover mining activities in the Yukon (fewer checks and balances are available for managing exploration and claims staking in sub-watershed areas beyond the city limits). Among these are the Yukon Waters Act, which governs water licences and the Yukon Environmental Assessment Act (EAA), soon to become the Yukon Environmental and Socio-economic Assessment Act (YESAA). Both of these processes typically allow for participation by the City in project proposals.

In the case of the Waters Act, however, there is a possibility of missing projects for which a water extraction or discharge permit is not required (e.g. gravel extraction operations), and the process does not adequately consider cumulative effects. In the case of environmental assessment processes, project scrutiny is catalyzed as a pre-requisite to project approval and before the start of a project. Cumulative effects assessments are still challenging for practitioners under Federal and territorial environmental assessment frameworks, however. In addition, there tends to be inadequate follow-up and monitoring of projects once approved, through to their closure and decommissioning.

Above all, source water protection may require a higher standard of project development, operation, and site restoration than protection of fisheries or other natural resources, and this needs to be explicitly recognized for major industrial activities within the Whitehorse watershed.

Given that the activities and land areas of interest are outside of the primary control of the City, a proposed mechanism for minimizing adverse impacts on source water quality from mining activities is an enhanced participation in currently established management, planning and permitting processes. Ultimately, it is in the City's interest to maintain a very active participation in Yukon government and regional planning processes. There are at least two specific options: Increased focus on the issue by City staff, and engaging YTG and others through voluntary, cooperative agreements to encourage a high priority is given to the City's watershed protection goals. **These are discussed in more detail in Section 4.1.14.**

Recommendations…

Enhanced Management of Mining Activities

Why is this important?

An examination of the map in Figure 3-2 (page 38) shows that mineral claims comprise a very large portion of the watershed identified for the purpose of Whitehorse source water protection. In fact, future mining activities potentially cover a much larger portion of the City's source water areas than forestry, agriculture and all other land uses combined.

Also, much of this area is outside of the City limits but within important sub-watersheds such as the Wolf Creek, Cowley River and MacRae Creek catchments

How can this be achieved?

- Building on current YTG management structures (e.g.- based on environmental assessments and land use applications), the City should increase its direct participation in Yukon government and regional permitting and planning processes. The City should consider securing targeted, voluntary agreements with YTG.

4.1.10 Establishment of an Exclusion Zone Around the Schwatka Lake Intake Pipe

Three types of activities were considered with regard to a possible protection zone around the intake pipe:

- swimming and associated recreational activity;
- use of boats, including motorized boats and vessels; and
- taxiing of float planes during take-off or landing.

Given the current state of knowledge, we were unable to objectively define a protection zone around the drinking water intake pipe based on pathogen risk-reduction considerations. **The rapid movement of water through Schwatka Lake, and even along the Yukon River from Marsh Lake, means that water transit times toward the north end of Schwatka Lake are much shorter than required for the inactivation of the vast majority of water-borne pathogens**. A protection zone defined based on expected *Giardia* cyst or *Cryptosporidium* oocyst inactivation times, therefore, would extend up river beyond Schwatka Lake and would likely encompass portions of Marsh Lake. Furthermore, the magnitude of inputs of pathogens from swimming and wading are likely to be minor relative to water-borne pathogen introduction from wildlife carriers that routinely defecate directly into source waters.

A log-boom around the intake would limit potential for clogging of the intake by partially floating debris, such as dead heads.

The adoption of a protection zone for motor boats and float planes might not be a high priority in light of our perceptions about risks from petroleum hydrocarbon releases. Establishment of a protection zone might be considered, however, to further reduce any possibility of the dumping of potentially contaminating materials to the lakebed near the point of intake. In an era when infrastructure managers especially in the United States are spending considerable resources to examine risks from terrorism, an exclusion zone may be appropriate if only because it might make it easier to detect an intentional release of toxicants into the drinking water supply at the point of intake.

Regardless, the establishment of an exclusion zone with a radius of 50 metres around the Schwatka Lake intake pipe is recommended. The exclusion zone toward the shoreline in a northerly and easterly direction is constrained to less than 50 metres by the presence of an existing parking lot, fish ladder, and other activities, so the absolute distance of the edge of the exclusion zone from the pipe will need to be variable to accommodate this. An extension of the exclusion zone onto the land to include the bluffs overlooking the lake on the eastern side would help to prevent

future dumping of vehicles, snowmobiles, garbage and other potentially contaminating materials into the lake – as was observed during the winter of 2002. Such an exclusion zone would also address concerns about riparian zone degradation and increased sedimentation owing to physical disturbances along the steep, exposed slope.

Recommendations…

Establishment of an Exclusion Zone Around the Schwatka Lake Intake Pipe
(including the adjacent land)

Why is this important?

An exclusion zone helps to protect against the possible sinking or dumping of snowmobiles, airplanes, boats, and other debris near the end of the intake pipe. The exclusion zone, therefore, minimizes risk of temporary loss of the water supply and costs of recovery.

An exclusion zone also allows for the detection of individuals near the intake pipe who may harbour malicious intent.

Finally, the posted exclusion zone is intended as a reminder to those on or near Schwatka Lake that many people depend on the water source for their health.

How can this be Achieved?

The exclusion zone would be posted on the land and water. The exclusion area could be indicated on water by an anchored log float, and on land by appropriate signs.

Such an exclusion zone may require approval from Transport Canada under the *Navigable Waters Protection Act.*

4.1.11 Develop Guidance for Organized Sporting and Cultural Events on and Around Schwatka Lake

As part of the development of the draft WMP, considerable discussion revolved around discrete, organized events on the watershed (especially on Schwatka Lake). In the past, such activities have included organized snowmobile races, motor boat races, dog mushing races, concerts and cultural gatherings. Although such events are often of limited duration, they are often very intense.

Organized events on the watershed may comprise a special, discrete risk category depending on the specific activities, and checks and balances used in consideration of source water protection goals. Some concerns, depending on how such events are organized, might include deposits of human and dog feces and urine, inappropriate garbage disposal and fuel spills. Activities in the winter-time bring a unique set of concerns, since the activities unfold directly over top of the drinking water supply.

Organized events on the watershed may comprise a special, discrete risk category

It should be noted that in most past cases, the organizers have voluntarily worked with City staff, Yukon Environmental Health personnel and others to develop appropriate event plans for human health protection. However, it appears that there is a management gap wherein there is no formal requirement for event organizers and sponsors to address source water protection concerns. In particular, there appears to be no permit required from Yukon Environmental Health for special events, other than in association with on-site food and liquor services.

Section 6(1) of the "Regulations Respecting Public Health" states –

> "No person shall create, establish or maintain a condition injurious to health or which is or is likely to become a public nuisance in or on any …watercourse."

In addition, Section 27 if the same regulation states –

> "Every outdoor toilet shall b (a) located at least 100 feet downstream from any well or the inlet of any water pipe drawing water for human consumption or ablution".

Section 28 states –

> "…a health officer may prohibit the establishment , operation or maintenance of any outside toilet at a place where, in his opinion, such toilet is likely to endanger public health."

While some provisions may exist for minimizing potential for direct inputs of human excreta into the drinking water supply, it is unclear whether the provisions adequately address all major potential risks to source water for discrete events.

In light of the above, it is recommended that the appropriate YTG legislation be critically reviewed and, if required, amended in order that all special and major discrete events be required to have a permit issued by the Environmental Health office.

4.1.12 Water Quality Monitoring within the Watershed

Only through the design and implementation of an expanded monitoring program will the managers of drinking water supplies develop greater confidence that multi-barrier approaches are effective in reducing risks to source water quality.

The majority of municipalities in Canada that rely on an unfiltered surface water supply have implemented a water quality monitoring program which includes sampling at important points in the watershed. **Only through the design and implementation of an expanded monitoring program will the managers of drinking water supplies develop greater confidence that multi-barrier approaches are effective in reducing risks to source water quality.** Monitoring within the watershed is also a necessary foundation for ongoing adaptive management of source water quality.

We urge the City to work with the Yukon Government toward the establishment of a funded, long-term water quality monitoring program based on the sampling and analysis of the larger watershed including major tributaries and areas of potential concern.

It is noted that much of the watershed is beyond city limits, and much of the land use is outside of the jurisdictional control of the City. Therefore, the Yukon Government needs to be an active partner in watershed monitoring in support of a multi-barrier approach to drinking water protection.

A possible surface water quality monitoring program would include an evaluation of –

- Turbidity, colour, pH, hardness, total dissolved solids (TDS), total suspended solids, electrical conductivity, dissolved oxygen;
- Nutrients and major anions;
- Total and faecal coliforms;
- Protozoan pathogens;
- Metals, cations (at a lower frequency).

Some points within the watershed that should be considered for routine monitoring include –

- South end of Schwatka Lake;
- Southeast side of Schwatka Lake, near boat launch;
- Points along the western side of Schwatka Lake, reflective of inputs from roadways and other developed areas;
- Hidden Lakes;
- Chadburn Lake;
- Yukon River at Marsh Lake outflow;
- Mirers Creek just upstream from confluence with Yukon R.;
- Cowley Creek just upstream from confluence with Wolf Creek;
- Wolf Creek just upstream from confluence with Yukon R.;
- Mary Lake sub-watershed at confluence with Wolf Creek (or at a viable sampling point upstream, based on presence of active flows);
- McCrae Creek just upstream from confluence with Yukon R.;
- McCrae Creek in the vicinity of the golf course;
- Basalt Creek just upstream from confluence with Yukon R.;
- Copper Creek just upstream from the point where it goes to ground;
- Canyon Creek just upstream from the point where it goes to ground; and
- McLean Creek just upstream from the point where it goes to ground.

Evidence of elevated levels of sediment and/or contaminant inputs at major tributaries can be used to further narrow areas of concern and to direct more detailed sampling toward tributaries that are major sediment, nutrient, or pathogen contributors to mainstream flows.

Because of the seasonal variability of watershed processes, **sampling at least three times/year will provide a better indication of spatial and long-term variations in water quality and contaminant inputs**; i.e. –

- Spring freshet: mid-May
- Summer-time conditions: mid-August
- Fall-time conditions, prior to freeze-up: mid-October

An estimated level-of-effort for annual monitoring, therefore, is approximately 20-25 sample locations x 3 sampling periods, for up to 75 individual samples each year.

Additional sampling would be needed to diagnose and apply corrective action to potential contaminant and sediment source areas.

4.1.13 Public Education

The ongoing commitment of resources to expanded public education is seen as a major component of risk management solutions. The City should develop a curriculum and communications strategy to further the objective and goals of the Watershed Management Plan. Informational signs should be provided at watershed access points (e.g., along the roadway along the western side of Schwatka Lake) and in the vicinity of the Selkirk aquifer. There already exist signs that inform the public about the watershed, particularly at the road and trail access point to the Chadburn Lake Park Reserve. Additional signs could be installed at other major access points within the larger watershed, however, and in specific areas discussed in the preceding sections.

Another key component of public education is greater dissemination of information regarding the state of the City's water quality, including:

- General information on the water distribution system;
- Water quality tests (parameters tested, frequency, location, results)
- Disinfection Process (what type, location etc.)
- System safeguards

This information should be available through the City of Whitehorse's web page where it can be updated regularly.

Enhanced public education should include, as a minimum -

- Broad public dissemination of the City's Watershed Management Plan, through the development and distribution of fact sheets and briefs, including media briefs and contributed articles.

- Establishment of additional educational signs within the Chadburn Lake Park Reserve, at access and major stopping- points on the western shore of Schwatka Lake, and along sub-watersheds (at the Wolf Creek Campground and Miles Canyon, for example).

- Development of curriculum materials that can be used in schools.

- Establish a dedicated watershed protection liaison officer to talk with community groups, and to interact with recreational and other users in the watershed – educating them on the key issues.

- Work with groups with a shared vision; for example, the Yukon River Inter Tribal Watershed Council.

4.1.14 Harmonizing City, Yukon Government, and Regional Planning for Source Water Protection

The consulting team expressed concern about the apparently fragmented approach within and beyond the City boundaries within various arms of the Yukon government. In particular, promotion of agriculture or forestry, facilitation of mining through claim staking and development, or promotion of residential development may at times be in conflict with government objectives for drinking water and aquatic protection. The YTG needs to better consider whether the intent to make land available to Yukoners especially for residential and resource use purposes is in conflict at times with watershed and source water protection goals.

The inclusion in new safe drinking water legislation of a more harmonized approach between ministries with a major role in resource use and landscape level processes should be encouraged. Draft principles for the new legislation are currently deficient in this regard. The need for better harmonization and communication between Yukon government entities is underscored by the fact that the City of Whitehorse itself has limited if any legal jurisdiction over activities and some land uses within city limits, and virtually no legal jurisdiction over activities and land uses beyond the city limits, but still well within the area targeted for source water protection.

YTG has established several land-use planning committees, as follows:

- **Land Application Review Committee (LARC):** LARC reviews all applications for acquiring or changing land tenure. The committee meets once a month. Membership includes the Land Claims and Implementation Secretariat, Forest Planning, Aviation, Environment, Tourism, Water Resources, Building Safety, Community Services, Heritage, Agriculture, Mining Recorder, Lands and Granular Resources, Land Use, **City of Whitehorse**, and Environmental Health. Applications are also sent to First Nations, Yukon Electric, Yukon Energy and Department of Fisheries and Oceans.
- **Mining Advisory Committee (MAC):** MAC provides technical and interest-based reviews and consultation on Mining Land Use Operating Plan Approvals on mineral claims under the Quartz Mining Land Use Regulations of the Quartz Mining Act. Committee members consist of YTG Departments, Environment Canada, Department of Fisheries and Oceans, First Nations, RRC's, YCS, CPAWS and community associations where applicable.
- **Land Use Advisory Committee (LAUC):** This committee, overseen by Energy Mines and Resources, reviews land use and quarry permit applications and comments on relevant environmental, cultural and competing land use factors, which may have an effect on applications. The LAUC is chaired by the Manager of Land Use and includes the following members: Water Resources, Lands Dispositions, Forest Resources, NROs, Environmental Assessment, Highways, Tourism, Lands Inspectors, Federal Government: DFO, DOE, First Nations, CPAWS, YCS.
- **Yukon Environmental Review Committee (YERC).** This is a multi-stake holder committee (First Nations, Environment Canada, DFO, YTG etc.). The YERC is chaired by the Manager of ECO's Environmental Assessment Unit. Established to facilitate the assessment of major projects and disseminate environmental assessment information and forum to review and participate on national initiatives.
- **Oil and Gas Interdepartmental Working Group (OGIWG):** This committee, chaired by Energy Mines and Resources Oil and Gas Branch, reviews oil and gas related issues (disposition/nomination process). Working Group chaired by EMR Oil and Gas Branch.

Note that the City of Whitehorse appears to have formal representation only on LARC. In light of issues raised in Section 4.1.9, and based on the vision and goals of the watershed management plan, the City should seek a more active representation in land-use planning through these and other committees and groups. This will also likely require additional staffing support.

Based on its membership on LARC, the City receives information on two stages of land use application referrals. Applications within City limits are received from the YTG Lands Branch are sent to the City Planning Department well in advance of when they will be reviewed at the LARC committee meeting. The City also receives copies of all land applications submitted in the Yukon, including ones for areas that are outside of the City limits but may fall within the sub-watersheds that drain into the Yukon River between the Marsh Lake outflow and Schwatka Lake.

The City should seek early notification for applications not just within City limits but also for areas within the watershed, as defined for the purpose of this WMP.

Overall, a preferred approach for source water protection would be designation of the watershed as a "community watershed" with special significance for the residents of Whitehorse. Such a designation is supported in the legislative frameworks in some provinces (e.g. in Nova Scotia and British Columbia) but not in the Yukon at the present time. Special status recognition would allow the City to have more direct control over source water protection, and of the land-uses that need to be managed for maintaining drinking water quality.

Although the Yukon has not developed any enabling mechanisms for whole watershed designation or protection in recognition of drinking water needs, some of the recent regional planning mechanisms may serve the same purpose. In particular, Chapter 14 of the Ta'an Kwach'an Final Agreement and Self Government Agreement establishes provisions for broader regional management of the Yukon River watershed:

> "14.6.2 A working group in respect of the Yukon River Watershed shall be established and the specific provision in respect thereof are set out in Schedule A – Yukon River Watershed Management Working Group, …"

Specifically the Working Group will make recommendations on –

- Public awareness and appreciation of the Water, including respect for the traditional and current use of the Water by Yukon Indian People and respect for the historical and current use of the Water by others;
- Responsible residential, commercial, recreational and other uses of the Water and shoreline lands bordering the Water;
- Coordination and facilitation of the efforts of Government, Yukon First Nations and communities in or downstream from the Area, to maintain or improve the health of the Water and related shorelines; and
- The protection and enhancement of Freshwater Fish and Salmon and their habitat.

Of particular interest relative to the vision and goals of this WMP is the role of the Yukon River Watershed Management Working Group in coordination and facilitation of watershed protection.

Reference is made in several sections of Chapter 4 to voluntary agreements. The City is encouraged to collaboratively draft and adopt a series of voluntary agreements with responsible agencies and individuals for those cases where important activities might take place within the watershed that affects source water quality, but outside of City limits. As discussed above, there are already mechanisms in place that allow some of the City's concerns to be assessed as part of various planning processes; however, the formalization of voluntary watershed protection agreements would place the issue of drinking water protection front and centre, and give it a priority that has been lacking up to the present time. One form of voluntary agreement might be specific Memoranda of Understanding, between the City's Mayor and Council and other responsible agencies. One tool within such voluntary agreements might be the use of Best Management Practices, in light of the need for riparian zone protection and – in some cases – restoration.

4.2 Other Risk Management Options That Were Considered

We were tasked with evaluating several specific options for inclusion in a watershed-based drinking water management plan. These included –

- establishing a protection zone around the Schwatka Lake drinking water intake pipe (see section 4.1.10, above);
- increasing the depth of the intake pipe;
- initiating a land acquisition program to assist with watershed and reservoir protection;
- limiting or prohibiting certain recreational uses or developments;
- limiting or prohibiting certain residential, commercial or industrial developments; and
- decommissioning roadways (see section 4.1.5, above).

There is little risk management value in changes to the present depth (~ 2 m) or location of the Schwatka Lake intake pipe. The lake has a maximum depth of 6 to 8 m

over much of the lake[15] and is likely to be well mixed throughout. An intake depth of 2 m is probably sufficient to minimize petroleum hydrocarbon inputs from a spilled floating mass at the lake surface.

A few specific industrial, commercial or residential operations and proposals are likely to draw a large amount of local interest; however, the simple reality is that the portion of the watershed especially to the west of the Yukon River is already highly developed, and the conditions in some cases exist for altered surface runoff as well as the introduction of sediments, nutrients, and pathogens into tributary streams and then into Schwatka Lake. **Recommendations for riparian zone protection and routine water quality monitoring, therefore, are a major component of the watershed management plan.**

Ideally, historically established land-holdings should be the subject of riparian zone restoration and specific measures to minimize risks of pathogen, contaminant, nutrient and sediment inputs to the water supply via surface and groundwater flows. Land acquisition might be used in the more severe cases where there is evidence of risks from these establishments to the drinking water supply. In some cases, voluntary agreements between land holders and the City may be sufficient to resolve historical problems.

Developments along the shoreline of the Yukon River between the Marsh Lake outflow and the YEC dam, including Schwatka Lake, merit special consideration. **In focusing on these areas, however, interested parties should not lose sight of the fact that the transport of surface water and materials throughout the entire watershed can be very rapid at times, and cumulative risks of drinking water contamination need to be considered over areas well beyond Schwatka Lake and the Yukon River proper.**

The eastern shore of Schwatka Lake and the Yukon River, and portions of the western shore, are protected from further development by the Chadburn Lake Park Reserve. Similarly, the City of Whitehorse Official Community Plan specifies an area of greenbelt on the western shore of Schwatka Lake, south of the current float plane docks, to just south of the McRae Industrial Area.

On the shore of Schwatka Lake, the risks to drinking water quality are expected to decrease the closer an operation is to the spillway. This would limit any cross-lake movement of introduced materials to the drinking water intake point. In light of this, we have recommended a further investigation of amalgamating

[15] A temperature profile was obtained by the City on October 21, 2003, from an area of the lake near the intake pipe with a depth of 15.8 m. The temperature was around 5.3 ^{o}C from the lakebed to a depth of 5 m below the surface and then increased over the top 5 m to 6 ^{o}C at the surface.

plane operations to the north, in facilities designed to incorporate best management practices for fuel storage and handling, sanitary and solid waste.

In addition to general considerations for the drinking water supply based on major commercial, industrial or domestic activity type, the degree of risks is expected to be a function of the design and operational specifics of each development. General guidance on development provided within the Watershed Management Plan may not be sufficient to ensure that any specific activity is undertaken in a way that is environmentally sustainable and minimizes risks to the drinking water supply.

One management framework specifically designed to enable management decisions on a case-by-case basis is the Canadian Environmental Assessment Act (CEAA) federally, and the Yukon Environmental Assessment Act territorially. **A requirement to conduct environmental assessments (including historical, socioeconomic and environmental aspects) of proposed new developments could in some instances provide City and Yukon government managers with the appropriate critical evaluation of possible mitigable and non-mitigable impacts associated with a project.** With an environmental assessment, there is also the ability to specify ongoing monitoring requirements to ensure that the projected outcomes are in line with the realized outcomes. The City of Whitehorse Watershed Management Plan has a role to play in informing individual project environmental assessments. In particular, the Watershed Management Plan establishes overarching principles for evaluation of the acceptability of various project outcomes.

4.3 Knowledge Gaps

The following knowledge gaps were identified during the preparation of the Watershed Management Plan:

- Water current regime in Schwatka Lake,
- Source inventory of suspended particulates (and turbidity) to the Yukon River/Schwatka Lake upstream of the Marsh Lake outflow,
- Detailed characteristics of the Selkirk Aquifer, especially in terms of configuration of and possible inter-communication between different vertical groundwater zones,
- Specific identity of faecal and total coliform bacteria routinely measured in the surface water supply (as human-derived, cattle, avian, or other wildlife coliforms),
- Viability of protozoan cysts and oocysts in Schwatka Lake.

5. REGULATORY AND MANAGEMENT TOOLS

This section describes the regulatory or other tools needed to implement the specific risk management and watershed management recommendations provided in Chapter 4. Existing regulatory documents, guidelines, bylaws, and other policy documents are listed in Appendix A of *Volume 1: Background/Status Report*. Sixty-one documents are listed and briefly summarized.

Two recent additions to this list are discussed below:

Ref 62) Yukon Health and Social Services, (draft) *Bulk Delivery of Drinking Water - Guidelines for Regulation*, August 2003.

The *Bulk Delivery Guidelines* apply to trucked water in quantities larger than 20,000 litres per month. The guidelines are of relevance to many of the residents of Whitehorse and surrounding areas who are supplied with trucked water.

Another recent addition to this set of documents is a set of guidelines recently released by the Yukon Health and Social Services Ministry as a foundation for the future development of a new drinking water protection act:

Ref 63) Yukon Health and Social Services, (draft) *Public Drinking Water Systems - Guidelines for Regulation*, August 2003.

The Yukon Government is considering a new regulation for drinking water protection, and has produced a set of guidelines that provide insights into provisions that may be included in the regulation once developed and finally adopted. The overall intent is to establish a multi-barrier approach, as is being undertaken in other Canadian provinces. The guidelines, and eventually the regulation will –

- Define responsible parties for each aspect of the drinking water system,
- Provide criteria for the protection, operation and maintenance of drinking water systems, and
- Enable enforcement by a Health Officer to ensure that appropriate practices are followed.

The guidelines are evaluated below based on their value in assisting with fulfilling regulators' needs for protecting City of Whitehorse source water areas.

New features of the proposed regulation include empowering health officers to require the preparation of a source water protection plan. This is similar to provision of British Columbia's new Drinking Water Act. This will not influence the City of Whitehorse, since the City embarked on the preparation of a Watershed Management Plan, which includes a source water protection plan, prior to the proposed change in the Yukon Government regulation.

Proposed changes also include addition of prescriptive measures for drinking water well-head protection and well site location relative to possible contaminant sources.

Section 38.(1) of the guidelines require owners of public drinking water systems based on a surface water source to install chemically assisted filtration and disinfection or an equivalent treatment technology. The City of Whitehorse is currently investigating the addition of a filtration treatment plant.

Overall, changes in drinking water protection regimes within the Yukon – based on the draft guidelines currently available - may not be adequate for achieving their goal of drinking water protection, especially in the context of multi-barrier approaches. Despite potentially requiring the development of source water protection plans, these guidelines do not recognize nor deal with the fact that many surface water supplies originate from watersheds that fall under more than one jurisdiction, and are multiple use watersheds.

The guidance document is very short on discussions about how to resolve non-compliance. Under the guidelines, enforcement is vested with the Health Officer, who can prescribe remedial actions provided that there is a suspected or known risk to public health and safety. It remains to be seen what situations will trigger compliance actions, especially in source areas outside of the influence of owners of public drinking water systems.

There seems to be no mechanism for catalyzing action by Health Officers or others in order to ensure protection against cumulative and progressive deterioration of the watershed through pressures on the riparian zone, or based on various human activities that individually may be low risk but collectively may substantially increase risks to the drinking water supply.

It was noted earlier, that the Federal Fisheries Act is inadequate for riparian zone protection, since habitat loss is not a ticketable offence, and because the effort required to pursue the enforcement of all but the most severe cases of riparian zone degradation tends to divert very limited staffing resources from other important issues.

A parallel issue for management effectiveness is anticipated for the many situations where there may be a need for the intervention of a Health Officer to address the deterioration of barriers to drinking water contamination in headwater areas of the watershed.

Above all, the guidelines do not create the conditions for the harmonization of relevant YTG legislation and policy. Policies for agricultural development, mining claims, road development, forestry, and residential development outside of city boundaries, therefore, may continue to be at odds with drinking water protection goals. The Yukon approach is different from that being considered in Quebec, and – to a lesser extent in Ontario – where harmonization under one regulation of all issues that potentially influence source water quality is a major objective. **It is recommended in the preceding chapter that the City pursue with the Yukon government a community watershed designation, wherein more control over a wide range of issues is vested with a multi-stakeholder group specifically assembled to support the Watershed Management Plan.** As stated previously, there is currently no formal mechanism in the Yukon that would accommodate such a request.

The guidelines specify monitoring, along with the proposed suite of substances to be monitored, but it appears that the monitoring requirement is at the point of use or ingestion, not within source areas of the watershed. The general impression from the guidelines is that source areas are more restrictively defined to include the immediate area of source water or groundwater from which drinking water may be drawn, not the larger watershed. The reference to "source-to-tap" may be a bit of a misnomer, therefore. **The multiple use nature of the City of Whitehorse Watershed and other factors suggest a need for monitoring surface and groundwater quality in source areas within sub-watersheds, not just at or near the intake points.**

Finally, it is unclear whether increased resources would be available for enabling the drinking water guidance, specifically with regard to sampling and analysis in the larger water, and engineering assessment.

5.1 Specific Regulatory Tools

Risk management and watershed management recommendations for the City of Whitehorse drinking water supply are provided in Section 4.1. Specific regulatory tools that might assist with implementation of each of these recommendations are discussed below, along with possible gaps and solutions:

5.1.1 Increased Riparian Zone Protection

The City of Whitehorse *Official Community Plan*, (Ref 28 in *Volume 1*) supports the Watershed Management Plan, and designates riparian zones adjacent to Schwatka Lake and the Yukon River as either greenbelt or outdoor recreation areas. The OCP, however, is generic in nature and needs to be supplemented and augmented by more concrete guidance.

The OCP is guided by a Vision Statement that includes "Environmental Stewardship," and "Maintain and Enhance the Quality of Life" among seven guiding principles.

Chapter 4 of the OCP addresses "The Natural Environment". In particular, specific polices under this heading adequately address future developments, grading and tree harvesting on steep and unstable slopes. Policy 5 of Section 4.1 requires that –

> "The clay cliffs in the immediate area of the Yukon River shall be considered environmentally sensitive, and other than carefully planned trails shall be kept free from development"

Section 4.2 discusses "Natural Open Space" designations, which identify areas within the City requiring further study, or are subject to geological hazards or are environmentally sensitive. Riparian zone protection in the watershed is enabled in part through recognition of these areas as Natural Open Space. The OCP polices, however, provide allowance for mineral exploration and extraction in highly mineralized areas of land designated as Natural Open Space, subject to other regulatory requirements, including Environmental Assessment Legislation and the Yukon Waters Act. These regulatory requirements may not adequately address riparian zone effectiveness for source water protection. The vision and goals of the WMP suggest that drinking water and associated watershed protection goals should be the major consideration when evaluating mineral exploration and extraction opportunities.

Policies adopted for protecting "Wildlife and Environmentally Sensitive Areas" (Section 4.3 of the OCP) establish a "30-m riparian set-back along both sides of all rivers, streams, lakes and wetlands, year-round or seasonal", which "may be increased for areas identified in conservation studies as having a high capability for wildlife habitat.

An OCP policy in Section 4.4 (the Yukon River Corridor) states that - "Any new development within 100 m of the Yukon River or any other stream/wetland shall be subject to site-specific examination, with special considerations for desirable set-backs. This applies to all lands along the Yukon River Corridor where new land uses are considered."

This provision does not address historically established land holdings within the riparian zone.

In light of potential risks to drinking water quality, we recommend that the minimum set-back be increased to 50 metres, and that provisions be adopted for a possible further increase in width based on effectiveness of the riparian zone to trap and/or pathogens, nutrients, contaminants, and sediments in surface and shallow subsurface flows. A 50 metre minimum buffer width in the watershed that provides source water should be included in the zoning bylaw. Note that this is a proposed change relative to Policies 4.3.2 and 4.3.3 of the City's Official Community Plan.

When establishing General Provisions for Zoning Bylaws, the quality of the buffer and adjacent zones should be afforded as much importance as set-back widths. Ten performance criteria to consider are provided in Section 4.1.4 of this report. We also recommend the regular re-evaluation of set-back restrictions for specific areas and sub-watersheds in light of new information on water quality and sediment sources areas, and the completion at intervals (of three years or less) of sub-watershed report cards (Table 4-2 provides an example).

The prior existence of already established home sites within riparian setbacks is recognized in the OCP, with a policy that "any significant expansion of these non-conforming uses shall not be encouraged". **The OCP and other management tools fall short in providing any foundation for riparian zone restoration, especially along already established home sites as well as maintained and un-maintained road networks.**

The Yukon Government *Agriculture for the 90s: A Yukon Policy* (1991) provides some guidance on riparian zone protection adjacent to agricultural lands. Similarly, DIAND (1999) Forest Resources *Timber Harvest Planning and Operating Guidebook* provides some guidance for riparian zone protection on forested lands. In both cases, the mechanisms for monitoring and enforcement are poorly defined.

The *Federal Fisheries Act* supports a limited potential for ensuring regulatory compliance of agricultural, forestry, mining, residential, industrial and other activities with a potential to affect fisheries habitat within and beyond Whitehorse City Limits; however, the effectiveness of this tool is limited by the capacity of Federal Fisheries staff to monitor activities and seek prosecution under the Act. In addition, a major portion of the riparian zone as defined for the purpose of source water protection might not meet a legal definition of relevance to fish habitat protection under the act.

Overall, there are major portions of the watershed where existing regulatory instruments and resources are insufficient relative to the vision and goals of the Watershed Management Plan, as described in Chapter 2.

Amendments to the General Provisions of zoning bylaws should be made, as discussed above. **Ultimately it may be possible to provide greater levels of protection beyond the enhanced generic guidance for sensitive areas. The supporting information does not exist yet, but monitoring information should have as one of its objectives the development of area-specific guidance for riparian zone protection, naming each major creek in the Schwatka Lake watershed and the Yukon River upstream of Schwatka Lake.** Different zone widths should be developed for different activities, i.e. construction of structures or roads, construction of walking trails, animal husbandry, and any disturbance including brush clearing, drilling of wells, and earth removal.

It was noted earlier, that prescriptive definitions of set-back distances may not address site-specific differences in effectiveness of set-backs. It was further suggested that an ongoing monitoring program would help better define management needs in specific sub-watersheds. It would be preferable, therefore, to develop goals that are adjustable as new information emerges, rather than rigidly codifying values within the bylaw. A 50 m set-back, however, is regarded as being a minimum threshold for riparian zone effectiveness.

5.1.2 Faecal Contamination –

Defecation by pets or livestock has the potential to introduce feces, and pathogens, into Schwatka Lake or tributary streams. The existing Public Health Bylaw (Ref 32), the Animal Control Bylaw (Ref 38), and the above-recommended amendments to General Provisions for zoning bylaws will accomplish improved attention to dog feces recovery, with proper enforcement.

Amendments to the bylaws are recommended, to establish areas where more restrictive requirements for recovering pet excrement apply, along with appropriate fines or other forms of enforcement.

5.1.3 Float Plane Dock Modernization –

Major reconfiguration of float plane docks should not be considered prior to an analysis of safety concerns. Pending new developments, the strategic objectives can be achieved through modifications to the "Schwatka Lake Waterfront Policy" (ref. 31). The *Policy* allows the removal of any docks "…that present a hazard to the public or the environment as determined by the Development Officer."

Section 4.6 of the Official Community Plan (Schwatka Lake) states that – "Dock owners are encouraged to consolidate into a single activity node for floatplanes on the west side of the Lake. This may include a marina, and a docking facility for pleasure boats."

The modernization of developments on the western shore of Schwatka Lake can potentially resolve potential risks to drinking water quality (primarily associated with increased pathogen and sediment inputs owing to loss of riparian zone protection) and provide major benefits as well. Consolidation of activities within an appropriately structured centre can enhance public awareness about the sensitivity of the drinking water supply and assist with stewardship efforts. The City has an opportunity to work with proponents of a consolidated float plane and dock facility, to ensure that details of development plans –

- Resolve historical issues regarding possible pathogen, contaminant, nutrient or sediment input into Schwatka Lake,
- Eliminate through appropriate design any risks from contaminant and pathogen inputs to Schwatka Lake, either chronically or based on failures,
- Include provisions for an educational and stewardship centre for the overall watershed, including Schwatka Lake.

5.1.4 Groundwater Recharge Area Protection –

In the recharge area, part of which is occupied by Riverdale, there is a need to minimize the possibility of contaminating the Selkirk Aquifer with herbicides, pesticides, and fertilizers. Recharge area protection also requires the further phase out underground storage tanks, and avoidance of hydrocarbon releases from gas stations. The well-head protection plan should identify the potential for groundwater contamination from leaky and failed sewer lines, and develop appropriate emergency response plans for various release scenarios.

Existing applicable bylaws are the *Public Health Bylaw* (Ref 32) and the *Solid Waste Bylaw* (Ref 37). However, we recommend that the 1998 City of Whitehorse *Zoning Bylaw* (Ref. 30) be modified to define the specific groundwater recharge area(s) to be protected, in a revised zoning bylaw. The OCP is very limited in its policy development for groundwater protection, and this is an area where improvements could be made during subsequent revisions to the OCP.

5.1.5 General –

In addition to existing and new City bylaws, existing YTG and federal guidelines and regulations should continue to be used to preserve water quality. For example, the *Fisheries Act*, in maintaining water quality and habitat for fish, will also maintain drinking water quality.

A high degree of source water protection is afforded by the Commissioner's Order 1970-304, which established the Chadburn Lake Park Reserve. This Yukon government regulation, passed under the *Lands Act*, withdraws the area of the reserve from disposition. Compliance with this regulation will significantly contribute to the ongoing implementation of a multi-barrier approach to drinking water safety.

Another powerful tool is the draft *Yukon Environmental and Socio-Economic Assessment Act*, (Ref. 56), expected to come into effect in late 2004. This Act will govern the assessment and approval of projects, and should be brought to bear on projects that could impact drinking water quality in the Schwatka Lake watershed. It was noted in Section 4.2 that use of an environmental screening at the present time under the *Canadian Environmental Assessment Act* (CEAA) would provide a more rational basis of decisions by the City and Council on individual developments. Once adopted, the *Yukon Environmental and Socio-Economic Assessment Act* will serve the same purpose.

6. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

This Watershed Management Plan will assist the City with adopting a "source-to-tap" approach to drinking water protection, often referred to as a multi-barrier approach. It includes recommendations for practical source water protection strategies in light of –

i) the current higher priority risks to the City's drinking water supply,

ii) the importance of stewardship approaches for watershed protection, and

iii) the recognized importance of wide-scale cumulative effects throughout the watershed on drinking water quality.

The Watershed Management Plan primarily covers the Yukon River Corridor downstream of the Yukon River bridge at Marsh Lake to the outlet from Schwatka Lake at the Yukon Energy Corporation dam, and the sub-watersheds entering the Yukon River between that point and the Schwatka Lake outflow.

This plan complements the vision and guidance provided in the City's Official Community Plan (2002) and the Yukon River Corridor Plan (1999).

The vision of the WMP is captured in the following statements:

> *"The watershed of the Yukon River, its sub-watersheds and lakes in the Whitehorse region, and the groundwater aquifers they are connected to, are essential to the health of the community. Governance of these resources shall focus above all on the protection of source water quality.*
>
> *In addition, watershed management strategies and initiatives shall recognize the value of the watershed for social, cultural and economic activities, as well as the integral role of these activities in sustainable communities. Strategies and initiatives shall embrace only those activities that are compatible with and enhance, source water protection.*
>
> *Watershed management is a shared responsibility and brings with it a commitment to collaborative management."*

Four major goals were established to assist with the realization of this vision. These address: (i) Raw Water Quality Goals, (ii) Riparian Zone Protection and Buffer Zones, (iii) Recharge Area Protection, and (iv) Stormwater Management. These goals reflect our concern about the many, often small-scale but cumulative threats to hydrological, hydrogeological and ecosystem functioning throughout the watershed.

Two issues dominate our discussions about potential risks to the City's drinking water sources: pathogen risks, and sedimentation leading to turbidity and other problems in Schwatka Lake. Risks from chemical contamination or nutrient inputs are of a lower concern, with some notable exceptions. The relative risks of specific types of land uses and activities within the watershed were evaluated based on the type of possible release into the environment, proximity to surface water (or the Selkirk groundwater aquifer), and spatial extent.

The land uses and activities were evaluated within the following eight potential risk categories:

1. **Contamination of Schwatka Lake by primarily human-borne pathogens,**
2. **Contamination of Selkirk Aquifer by primarily human-borne pathogens,**
3. **Contamination of Schwatka Lake by primarily animal-borne pathogens (*Cryptosporidium, Giardia*, other protozoans),**
4. **Contamination Schwatka Lake by chemical substances,**
5. **Contamination of Selkirk Aquifer by chemical substances,**
6. **Nutrient inputs to Schwatka Lake,**
7. **Nutrient inputs to the Selkirk Aquifer, and**
8. **Elevated turbidity and/or dissolved organic matter in Schwatka Lake.**

Higher priority issues include the following: -

- Direct faecal inputs by mammals
- Use of Schwatka Lake by waterfowl and other birds
- Developments and activities along the Schwatka Lake lakeshore
- Fertilizer application in the Riverdale area
- Domestic use herbicides, pesticides, fertilizers, etc.
- Flooding of Marsh Lake waterfront properties
- Septic fields in country residential developments
- Feces in lakeside and streamside areas
- Presence of gas station, fuel tanks, other activities near Selkirk well field
- Breaks/leaks in Riverdale area sewage lines
- Stormwater runoff
- General increase in human activities
- Agricultural parcels near the river; Developments on Marsh Lake
- Developments on tributary streams

Recommendations for watershed and source water area protection consider the prioritized risks, importance of stewardship approaches (as embraced in the Official Community Plan and Yukon River Corridor Plan), and concern about cumulative effects of many small-scale activities that may not be important when examined individually, but which can contribute cumulatively to long-term progressive deterioration of source water protection areas.

Detailed watershed management options are provided in Chapter 4, under the following major categories:

- Implementation of Additional Treatment,
- Protection of Well-head and Groundwater Recharge Areas,
- Participation in Local Area Planning Exercises,
- Increased Protection of the Riparian Zone,
- Riparian Zone Restoration and/or Mitigative Actions,

- Modifying Float Plane Facilities,
- Re-visit Country Residential Planning,
- Reducing Risks from Domesticated Animal Feces,
- Enhanced Management of Mining Activity within the Watershed,
- Establishing an Exclusion Zone Around the Schwatka Lake Intake Pipe,
- Develop Guidance for Organized Sporting and Cultural Events on and Around Schwatka Lake,
- Water Quality Monitoring Within the Watershed,
- Public Education, and
- Harmonizing City and Yukon Government, and Regional Planning for Source Water Protection.

Instalment of a filtration treatment plant for the Schwatka Lake supply is briefly discussed as a viable method for addressing two of the highest priority risks: inputs of pathogens associated with water-borne human illnesses by (i) mammals, and (ii) birds on or near the reservoir. This is not evaluated in detail, however, since guidance on treatment technologies at the intake is beyond the scope of the WMP, which focuses on barriers to drinking water impairment within the watershed above the intake.

Prior to the development of the Watershed Management Plan, there existed a management void in the protection of groundwater quality beneath the Riverdale area. The Selkirk Aquifer is located about 6 to 8 m below the ground surface in highly permeable sand and gravel. This makes the source supply vulnerable to chronic inputs of pesticides, herbicides, or nutrients from fertilizer use. The groundwater is also vulnerable to petroleum hydrocarbon leaks or sewerage line leaks within the southern portion of Riverdale. The detailed evaluation of potential for contaminant releases, development of spill release contingency plans, and public education will help to minimize risks.

Several specific sites and activities have been the focal point of concerns about the integrity of the Schwatka Lake drinking water supply. The rapid movement of water (and theoretically of pathogens, sediments, and contaminants) introduced into the Yukon River and Schwatka Lake downriver from Marsh Lake, and in virtually all the sub-watersheds that drain into them suggests that risks to water quality need to be evaluated and managed throughout the watershed. A major, recurring theme in the Watershed Management Plan, therefore, is the importance of riparian zone protection,

and also restoration in some cases. This is consistent with guidance provided in the City's Official Community Plan and Yukon River Corridor Plan; however, additional protection measures are required based on a specific evaluation of set-back effectiveness for limiting protistan, viral and contaminant inputs into the drinking water supply.

There are many facets of effective riparian zone protection. Specific recommendations include the generic increase in setback distances on both sides of lakes, rivers, streams and wetlands to 50 metres from the current 30 metres. Set-back effectiveness is also affected by the quality of the buffer zone as well.

Another recurring theme in the Watershed Management Plan is the importance of an ongoing water quality monitoring program. The monitoring of surface water quality (and sediment loads) at key points within the watershed will provide basic information needed to assess the need for further enhancements to land-use restrictions and set-backs within specific sub-watersheds. The availability of water quality and sediment source data from at least one round of study would greatly assist in prioritizing decisions about weak links in the City's multi-barrier protection strategy. Routine, long-term monitoring provides the best measure of effectiveness of the Watershed Management Plan in achieving its overall objectives.

The City's Official Community Plan and an enhanced Zoning Bylaw are effective guidebooks for future developments in the watershed. These do not address several specific situations that currently exist, but which are in contravention of the spirit and intent of the OCP and this WMP. Chapters 4 and 5 discuss property acquisitions, entry into voluntary agreements, and public education as the major tools available for redressing the past loss of set-backs and the associated value of the riparian zone in minimizing pathogen and sediment inputs. In some cases, land acquisition may be a viable alternative for the City; however, this needs to be carefully considered based on the number of land holdings throughout the watershed that are deemed to be non-compliant with the spirit and intent of source water protection measures.

A public education campaign about watershed functioning and water quality issues will be important for virtually all of the above-listed watershed/source water management options. Implicit in this is an understanding of the central role of community-based environmental stewardship. Some members of the public may balk at some of the recommendations regarding activities on Schwatka Lake. However, many of the recommended options described in Chapter 4 were shaped by a concern that many undesirable activities around Schwatka Lake are difficult if not impossible to prevent through policing and enforcement. Public education and promotion of watershed stewardship are the most viable means for encouraging consistent, appropriate and responsible human actions, as opposed to those that increase risks to the watershed and drinking water supply.

7. APPROACH TO IMPLEMENTATION

Through the development of this Watershed Management Plan it became apparent that many of the recommendations could not be considered in isolation of other related projects.

The most obvious of these is the work underway to more fully delineate the nature of the groundwater aquifers under the Riverdale area. A better understanding of these aquifers (quantity, quality, interconnectedness, etc.) may allow a decision as to whether or not the City should switch to using groundwater to supply all of its drinking water needs. A concern was raised during public consultation that since this possibility has not been discounted, it may be hard to justify implementing recommendations that involve large expenditures and/or that would have major impacts on the use of the watershed for other purposes such as commerce or recreation.

Another concern that was raised is that although the Plan does a good job of identifying risks in a general sense, more site-specific work to pinpoint the sources of possible contaminants is required prior to some of the recommendations being implemented. The best example of this is the western shoreline of the lake adjacent to the Schwatka Lake Road. Many questioned the degree to which this non-vegetated area is a significant source of contamination. The lack of 'physical proof' (such as water quality testing immediately off-shore) coupled with the lack of information about the currents in the lake (recognized as an information gap by the consultants) again points to the need for a cautious approach prior to implementing recommendations that carry a high financial or social cost.

In light of the above, and recognizing that other City of Whitehorse initiatives (such as the Strategic Plan and the annual capital budgeting process) also play a role in determining planning priorities, the Watershed Management Plan is accepted by Council to help guide land planning decisions, but may not necessarily be implemented exactly per the consultant's recommendations. Specific projects arising from the recommendations will be identified annually in the appropriate Department's work plan.

The following section provides information on how (and under what conditions) each recommendation (underlined) should be implemented:

<u>Move to Additional Treatment of Surface Water Supply</u>

- As the Plan notes, potential additional treatment options are being considered. This is identified in the 2004-2006 Strategic Plan as one of the organizational improvement targets.

Protect Well-head and Groundwater Recharge Areas

- As outlined in the Plan, a number of projects should be carried out to help protect the well-head and groundwater recharge areas. These include public education, identification of structures and facilities vulnerable to failure, and consideration of relocating the extraction wells up-gradient of possible contamination – for example in the Chadburn Lake Park Reserve. These projects should be implemented in accordance with the proposed schedule (see section 7.1).

Participate in local area planning exercises

- Such planning exercises are driven by the Yukon Government. Participation in the preparation of such plans will therefore depend on that government's priorities and schedule. Participation in these exercises is not expected to require substantial City resources.

Increase Riparian Zone Protection

- A key implementation tool is the establishment of 50 metre setbacks. This should be done through an amendment to the Zoning Bylaw to zone such setbacks as "Environmental Protection".

- An expanded water quality testing program (itself a recommendation) and a study to determine site-specific sources of sediment to the watershed should help identify areas that may require additional protection measures. These projects should be implemented in accordance with the proposed schedule (see section 7.1).

Undertake Riparian Zone Restoration or Loss Mitigation

- Some areas can be restored without impacting use of the watershed by commercial operators and identified recreational groups. This refers to informal access areas and 'party spots', which may be closed and reclaimed not only for watershed protection concerns, but for reasons of public safety, fire hazard and site degradation generally. Such work would be carried out upon approval of the project(s) in the annual budget.

- Major riparian zone restoration projects which would involve closing or altering the Schwatka Lake Road should not be carried out until:
    1. Water quality tests provide a more solid indication of the western shore as being a source of contamination
    2. The water current(s) through Schwatka Lake are better understood.
    3. A decision is made not to switch to using only groundwater.

Modernize Float Plane Docks

- A key recommendation in the plan is that a focused study should be done to look at possible dock reconfiguration strategies, particularly in relation to the concerns that have been raised about the safety and feasibility of such a facility. An amalgamation of docks to a single site at the northwest corner of the lake should not be considered until:
    1. Such a focused study is completed.
    2. Water quality tests provide a more solid indication of the western shore as being a source of contamination.
    3. The water current(s) through Schwatka Lake are better understood.
    4. A decision is made not to switch to using only groundwater.

- In the short term, a number of improvements can be made to parking/loading areas, garbage collection and sewage facilities. The Schwatka Lake Waterfront Policy should be revised and should allow for the replacement or moving of the more southern docks to locations further north, provided that safety is not compromised.

Re-visit Country Residential Planning

- There is no single, 'stand-alone' action for this recommendation. Ongoing planning for country residential areas (and for rural residential areas outside city limits) should attempt to minimize stream crossings and ensure a thorough consideration of downstream water quality concerns. Progress would also be achieved through implementing other related recommendations, such as the proposed water quality monitoring program (see below) to help identify sources of contamination.

Reduce Risks from Domesticated Animal Feces

- This recommendation would be implemented through greater public education and through installing doggie bag dispensers at locations along the lakeshore. These projects should be implemented in accordance with the proposed schedule (see section 7.1).

Enhanced Management of Mining Activity within the Watershed

- The first step in implementing this recommendation would be to play a more active role in reviewing proposed mining projects that may impact the City's watershed. If necessary, formal arrangements to ensure the City is included in such reviews would be sought.

Establishment of an Exclusion Zone Around the Schwatka Lake Intake Pipe

- This recommendation should be implemented by erecting a fence and signage at the area of the intake. Additional buoys would be considered if agreeable to Yukon Energy Corporation.

Develop Guidance for Discrete Events (e.g., organized sporting and/or cultural activities)

- Implementation of this recommendation would be primarily an 'administrative exercise'. The first step would be clarification as to which level of government (and which department) has the appropriate authority to require that permits be issued for the staging of discrete events; to ensure that water quality concerns can be addressed. This clarification should be sought through a legal review of the applicability of various related laws and bylaws, such as the Regulations Respecting Public Health.

Monitor Water Quality within the Watershed

- The plan recommends collecting water quality data at a number of locations upstream of the intake pipe, to help identify sources of contamination. This should begin immediately.

Engage in Public Education Activities

- The plan recommends a number of themes for public education about our watershed. This has already begun with a series of seven articles in the Yukon News in the summer, 2004 and should continue through signage, brochures and mail-outs.

Harmonize City, Yukon Government, and Other Party Planning Processes for Source Water Protection

- The first step in implementing this recommendation should be for the City to play a more active role in reviewing proposed projects that may impact the City's watershed. If necessary, formal arrangements to ensure the City is included in such reviews would be sought.

7.1 Scheduling

The following preliminary schedule is proposed to help prioritize the initial implementation of the plan. This primarily focuses on capital projects. Ongoing "administrative" projects, such as working with other agencies to improve the City's input to project review processes, are not included.

2005:

- Public education – signage, brochures, mail-outs etc.;
- Water quality monitoring – initiate an expanded water testing program;
- Well-head protection – Preliminary feasibility study on relocation of wells to the Chadburn Lake Park Reserve;
- Intake exclusion zone – erect signage and fencing at the intake;
- Determine what short-term improvements should be made along the Schwatka Lake Road (i.e. improved garbage and sewage facilities, parking options)
- Revise the Schwatka Lake Waterfront Policy
- Alternate water supply – continue work to better delineate the nature of the Selkirk Aquifer(s).

2006:

- Continue public education program
- Carry out a study to identify site-specific sources of sediment;
- Continue water quality monitoring program;
- Revise the zoning bylaw to increase the riparian setback where required;
- Identify locations where doggie-bag dispensers should be installed;
- Legal review of legislation related to the permitting of discrete events on Schwatka Lake;
- Initiate a focussed study to look at possible reconfiguration strategies for an amalgamated float plane base.

2007:

- Continue public education program;
- Well-head protection – identification of structures and facilities vulnerable to failure;
- Groundwater monitoring at the well-head in Riverdale;
- Testing for the presence of enteric viruses in the groundwater;
- Carry out a study to better understand the currents in Schwatka Lake

7.2 Estimated Implementation Costs

The Recommendations	*How can this be achieved?*	*Potential Costs - Rough Estimates*
1. Move to Additional Treatment of Surface Water Supply	Filtration or other treatment plant…	Beyond the scope of the Watershed Management Plan to estimate this.
2. Protect Well-head and Groundwater Recharge Areas	Public Education and discussion…	$1,000 for mail-out.
	Identification of structures and facilities vulnerable to failure.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
	Develop contingency plans for spills and leaks.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
	Groundwater monitoring at the well-head…	Monitoring est. at ca. $300/event/location
	Study of the presence of enteric viruses…	One-time sample = $1,000.
	Possible re-location of extraction well network into Chadburn Lake Park Reserve. (long term possibility, pending current study on groundwater supply).	Total study and relocation costs would exceed $500,000. Costs considered highly speculative, pending preliminary design phase.
	Respect the YTG Order, which prohibits land dispositions within the Chadburn Lake Park Reserve.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).

The Recommendations	*How can this be achieved?*	*Potential Costs - Rough Estimates*
3. Participate in local area planning exercises.	Provide input into such plans as they are developed.	Would likely use existing staff resources – (per dedicated Watershed Protection Liaison Officer).
	Ongoing monitoring of Yukon River water quality.	See Monitoring Water Quality, below.
4. Increase Riparian Zone Protection	Development of setbacks.	Would likely use existing staff resources – (per dedicated Watershed Protection Liaison Officer).
	Land acquisition and zoning control.	No specific parcels have been identified yet. Zoning (or traffic) control would likely use existing staff resources – (per the dedicated Watershed Protection Liaison Officer).
	A sediment source survey could identify areas requiring enhanced protection.	Lab expenses and field equipment estimated at ~$3,000. (turbidity meter, filters, etc.) Alternately, work could be contracted out (at a cost of ~$3,200 to ~6,000).
	Respect the YTG Order (C.O. 1970-304), which prohibits land dispositions within the Chadburn Lake Park Reserve.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
	Landowner/public education	$1,000 for mail-out.

The Recommendations	*How can this be achieved?*	*Potential Costs - Rough Estimates*
5. Undertake Riparian Zone Restoration or Loss Mitigation	Removal of un-maintained roads along sensitive foreshore areas.	Add soil, scarify, seed and plant; block access. Allow $7,500 per site (speculative estimate pending preliminary design, sixes of sites etc.).
	Creation of a barrier and/or change the road crown.	$10,000/ha (speculative estimate pending preliminary design).
	Prohibit commercial truck traffic.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer). Also may require signage.
	Increase public education and enforcement. Educate public about pet feces.	$2,000/yr for signage and leaflets. The hiring of one or two summer students as Watershed Information Officers could allow for educational delivery at sites around the watershed. Allocate $3,200 to $6,000 per temporary hire.
6. Modernize Float Plane Docks	Initiate a focused study on possible re-configuration.	$25,000
	Implement improvements to parking/loading areas.	$50,000
	Implement a water quality monitoring program.	See Monitoring Water Quality, below.
	Initiate a study of water currents in Schwatka Lake.	$20,000

The Recommendations	*How can this be achieved?*	*Potential Costs - Rough Estimates*
7. Re-visit Country Residential Planning	Ongoing planning to minimize stream crossings and ensure a thorough consideration of downstream water quality concerns.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
	Implementation of routine monitoring studies of surface and groundwater quality.	See Monitoring Water Quality, below.
	Seek voluntary agreements with parties in areas beyond City limits.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
8. Reduce Risks from Domesticated Animal Feces	Educate the public.	$1,000 for brochures or mail-out.
	Define specific zones where picking up after pets is required.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
	Provide doggie bag dispensers and garbage receptacles.	$4,000 (?)
9. Enhanced Management of Mining Activity within the Watershed	Build on current review processes and YTG management structures.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
10. Establishment of an Exclusion Zone around the Schwatka Lake Intake Pipe	Installation of fencing and buoys	$5000 for fencing; and $500 to supplement existing YEC buoys.
11. Develop Guidance for Discrete Events (e.g. organized sporting and/or cultural activities)	Build on current review processes. Legal clarification may be required.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).

The Recommendations	*How can this be achieved?*	*Potential Costs - Rough Estimates*
12. Monitor Water Quality within the Watershed	Implement an expanded monitoring program; Sampling of various parameters at a number of locations in the watershed.	Assume 15+ sites monitored annually x 3 times/yr = 45 water samples @ $350/sample; plus cost of sampling, interpretation of results etc -- allow $25,000 annually.
13. Engage in Public Education Activities	Broad public dissemination of information.	$1,000 for reproductions.
	Establish additional educational signs.	(cost included under (5))
	Development of curriculum materials for schools.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
	Establish a dedicated Watershed Protection Liaison Officer.	$70,000 / year.
	Work with groups with a shared vision.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).
14. Harmonize City, Yukon Government, and Other Party Planning Processes for Surface Water Protection	Build on current review processes and other agency management structures.	Requires adequate staff resources -- (per dedicated Watershed Protection Liaison Officer).