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EXECUTIVE SUMMARY

The Bridgewater Public Service Commission (PSC) initiated on June 19, 2000 a land use study to be conducted on the Petite Riviere Watershed, above Hebb Lake Dam. This area is also the water supply area for the Town of Bridgewater and a portion of it is designated a Protected Watershed Area (PWA). This implies regulatory controls to limit land use activities however, these controls are difficult to enforce. The study intended to identify historical and current land use activities which may be affecting or have the potential to affect the present water quality.

The geology of the area has led to past gold mining activity and many of the old shafts remain open and water filled. Two areas in particular are located on land owned by the PSC and include the Quigley Shaft area and the Bluff Shaft. The physical hazards posed to any person walking through these two areas should be addressed immediately. Temporary remediation would involve marking the sites with hazard signage and investigating a more permanent solution.

Another geology related problem is the occurrence of sulphidic shales and slates in the upper watershed area and their past excavation. The past land disturbance may be contributing to low pH and acid mine drainage in the area of Wildcat Brook. Further investigation is recommended in this area.

Current land use problems exist with regard to forestry practices such as clear-cutting in the area of Frederick Brook. Recommended buffer zones to prevent erosion are not recognized and the siltation of the brook and the western end of Minamkeak Lake may be the result. Enforcement of the PWA regulations is difficult and the required permits are not obtained. Further investigation is recommended. Agricultural practices are not a present concern but the use of pesticides, herbicides and liquid manures should be monitored.

Mineral exploration and development in the watershed should be discouraged due to the potential for contamination of the water supply from heavy metals and chemicals used in gold extraction processes. It is easier to prevent a problem such as this than to try to deal with the irreparable damage which could result. The water supply will benefit many people as a long-term resource if properly managed and mining benefits fewer people and is a much shorter-term resource.

Having the Milipsigate Lake area "Withdrawn from Lands Available for Exploration", through the Department of Natural Resources may better provide for watershed protection. Also, the presence of the endangered Atlantic Whitefish in the Lakes area may well qualify the Lakes as "Protected Wilderness Areas". Both of these options should be further investigated in the interest of protecting the water supply.

INTRODUCTION

Background

The Public Service Commission (PSC) of the Town of Bridgewater, Lunenburg County initiated on June 19, 2000 a land use study to be conducted on the Petite Riviere Watershed, above Hebb Lake Dam. This upper portion of the Petite Riviere Watershed provides the town's water supply, in particular Hebb, Milipsigate (also known as Leipsigate) and Minamkeak Lakes. The lakes and lands surrounding them are designated Protected Watershed Areas (PWA).

The historical and current land use activities in the area affect the water quality and health of adjacent lakes and streams. Also, the area has a varied and active history and mixed land ownership. A steering committee therefore represented the various stakeholders having an interest in and personal knowledge of the area and also guided the objectives of the study.

Land use in the watershed has historically included the mining of gold. In particular, an area north and south of Milipsigate Lake beginning in the southwest and in proximity to both shorelines. Although actual mining ceased in 1949 with the closure of the Queen's Mine, nonintrusive exploration has continued to date.

Focus of Report

The main objective of this study is to identify potential water quality problems as they relate to land use, with an emphasis on past and present gold mining activity. Initially, there was concern regarding abandoned mine shafts having been used as waste dumps for chemicals. Also, the potential hazard liabilities regarding open shafts and pits were to be addressed.

This report hopes to summarize the findings of the authors and has been completed by the study team with guidance from Neiff Joseph, Consultant, Harland Wyand, Town Engineer and Tim Hiltz, Water Technician, PSC. Neiff Joseph contributed the history portion and Tim Hiltz was consulted on a regular basis with regard to the analysis of the watershed and with regard to water quality.

The following main elements are included:

- a physical description of the watershed including the designated PWA areas
- a land use description, historical and current
- problems identified regarding watershed protection
- the reclamation of abandoned mines so as to reduce physical hazards and liability
- the mineral claims staking process as an option for watershed protection
- recommendations to the Steering Committee regarding land use and present and future watershed protection

Scope of Study

The scope of this historical and current land use study includes the following:

- a review of historic records of land use (gold mining in particular)
- collection of existing studies of the watershed area (Two sources used extensively were the Water Resources Management Strategy Study Design by the Lunenburg County District Planning Commission and A Cumulative Effect Assessment of the Petite Riviere Watershed by Saide Sayah)
- discussions with personnel from various regulatory departments as well as local property owners
- site visits of abandoned shafts and pits
- a water sampling program
- an assessment of all collected information

WATERSHED DESCRIPTION

Hydrogeological Setting

The designated water supply (Hebb Lake watershed) for the Town of Bridgewater is a 110 km² area located west and southwest of the town (Figure 1). It is drained to the Atlantic Ocean by the Petite Riviere from an eastern point of Hebb Lake. Water flow from Minamkeak Lake was also directed to this point in 1939 by road and embankment upgrades to the south end of this lake, which prevented previous flow (Sayah 1999). The three lakes Hebb, Milipsigate and Minamkeak are fed by Wildcat, Birch and Frederick Brooks respectively. Water flow and lake levels are controlled by the Bridgewater PSC by a number of dams and water is drawn by a pumping station at the eastern, discharge area of Hebb Lake: A 100 series highway (103) borders and bounds the water supply area to the southeast, adjacent to Hebb Lake.

Surficial geology (Figure 2) includes drumlins in the northwestern water supply area which support the agricultural land uses and are composed of glacially deposited mounds of till. Shallow, discontinuous till covers a large portion of the area and supports a forest ground cover. Bedrock is exposed throughout an equally large area and mostly underlies the lakes. The watershed area lies on the Meguma Group of bedrock consisting of the Halifax and Goldenville formations (Figure 3). The Goldenville formation underlying the lakes consists of black, grey and greenish grey quartzite layered with beds of bluish and greenish grey slates (Sangster, 1990). To the north and northwest the Halifax formation overlies the Goldenville and consists of black, grey and green slate and argillite.

An anticlinal dome runs northwest through the area and gold deposits have been found concentrated in a quartz fissure vein paralleling the anticline on the south side of

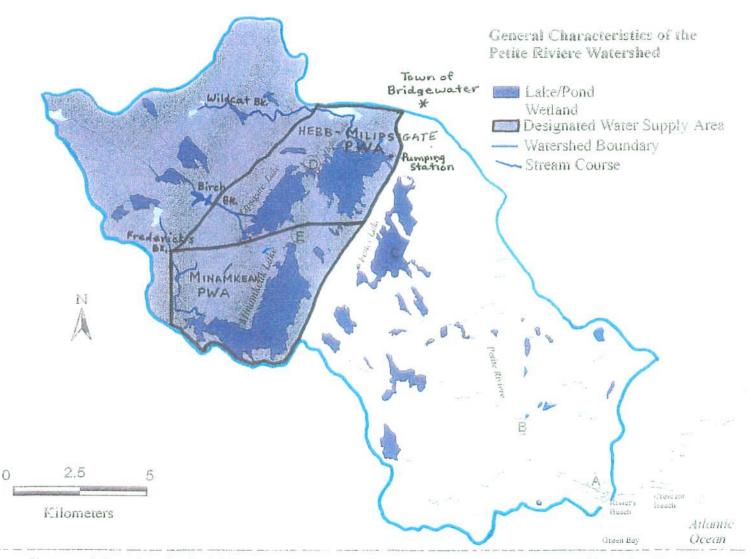


Figure 1 - Characteristics of the Petite Riviere Watershed. Source: Nova Scotia 1:50000 topographic series; 21 A/7, 21 A/8. (Sayah, 1999: copied and modified with permission)

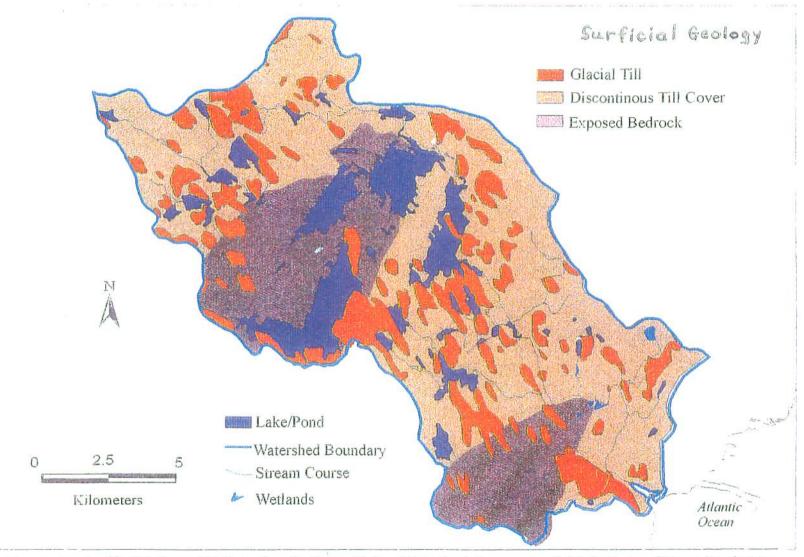
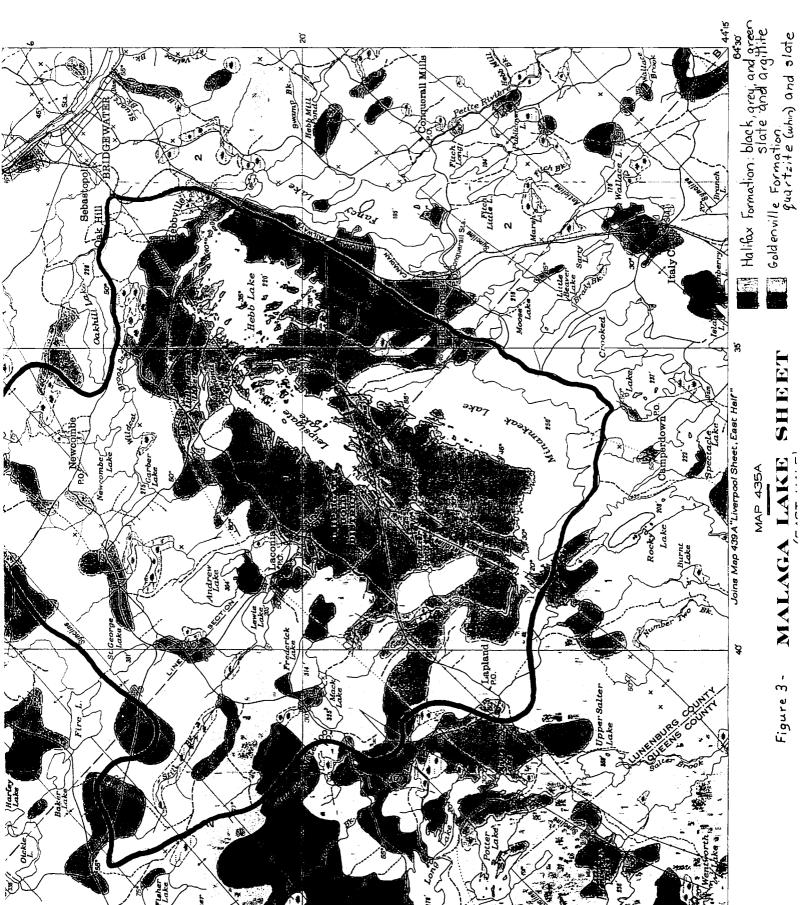


Figure 2 - Aquifer Media and Ratings for the Petite Riviere Watershed. Source: Surficial Geology of Nova Scotia Map 92-3, NS Department of Natural Resources Mines and Energy Branches, Halifax, Nova Scotia, 1992. (Sayah, 1999: copied and modified with permission)



MALAGA LAKE

the lake. Gold mineralization has also been found in faults subparallel to the fold axes (Sangster, 1990) and in crosscutting veins and angulars (shoots off the main quartz vein). The slate is commonly found to be sulphidic with abundant pyrite, pyrrohotite and arsenopyrite (Sangster, 1990) which, when exposed to the atmosphere and water, contributes to acid mine drainage.

The watershed has a number of wetland areas scattered throughout (Figure 1). A wetland area is a basin that collects and holds runoff water by absorption. Wetland areas delay the discharge of runoff into streams and rivers. When filled to absorption capacity, they will begin to gradually discharge the water into the groundwater table or the closest streams or watercourses. The wetland can also filter out certain types of pollutants contained in runoff water such as organic matter, and dissolved metals such as arsenic are absorbed by marsh plants (Ripley, 1996). The wetlands are a constant source concerning the recharge of the groundwater.

Groundwater is an underground reservoir of water available for plant growth and also for sustaining the water levels in lakes, ponds and streams (Lunenburg County, 1980). Groundwater also has the ability to moderate the impacts of acid rain (Environment Canada, 1995) and can be affected by contaminants seeping into it. This may in turn pollute water bodies downstream. Dissolved material may diffuse through it or be carried along by it. Chemical changes can occur from reactions with neighboring rock and from solutes reacting with each other. Groundwater moves through fractures and cracks in the bedrock and, although specific hydrological data was not available in this regard, flow is determined by the connections within the fracture systems. The groundwater table surrounding the Lakes' area is fairly shallow (Sayah, 1999) and storage capacity is not known. It is believed that extensive past mining activities may have altered subsurface (groundwater) flow, particularly around the area of Milipsigate Lake. Previously impermeable bedrock may have been made permeable by the excavation of shafts, adits (tunnels) and rises and by the drilling and blasting practices of the time. This is also based on continual reference to fractured and weak rock zones encountered and referenced in assessment reports at the Mines and Energy Branch of the Department of Natural Resources. The interconnection of the groundwater table with the Lakes is not known but may be determined from further hydrologic study. Saide Sayah (1999) produced a Drastic Aquifer Vulnerability Index. It shows the potential for pollution of the groundwater aquifer to be high in the Lakes area, particularly between the three Lakes (Figure 4).

Lakes also have the ability to store and release water gradually. The Lakes of Hebb, Milipsigate and Minamkeak are partially groundwater fed. During dry periods turbidity and color from runoff is reduced and groundwater recharge helps to clarify the lake water

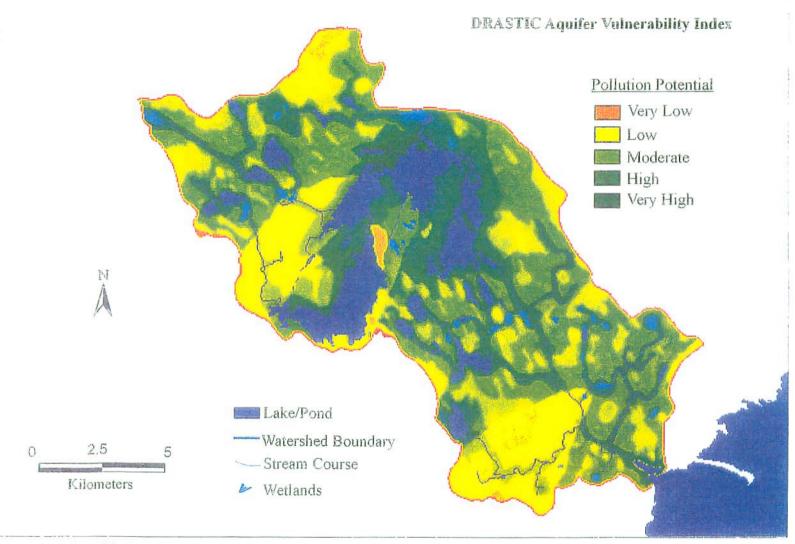


Figure 4- Modified DRASTIC Aquifer Vulnerability Index. based on topography, soil media, aquifer media, and depth to the watertable. Layers were overlayed and pixels added together using the Idrisi OVERLAY module (Sayah, 1999: copied and modified with permission)

(Hiltz, 2000). The Lakes discharge to the Petite Riviere and the majority of water flow is overland due to the nature of the relatively impermeable bedrock underlying the area (Sayah, 1999). Close monitoring should follow any activities suspected of causing ground disturbance or discharge of any liquid effluents having the potential to contaminate the ground or surface water.

Designated Areas

The designated water supply for the Town of Bridgewater occurs as two separate designations being Hebb-Milipsigate Lakes and Minamkeak Lake. These three lakes are the largest bodies of water in the watershed, having a total area of approximately 110km² of catchment.

Hebb and Milipsigate Lakes designated water area regulations, which were approved by the Minister of the Environment on Wednesday, June 17, 1964, are stated below.

- No person shall place, deposit, discharge or allow to remain therein any material of kind that may impair the quality of the water.
- No person shall bathe, wash, or otherwise impair the quality of the water.

The penalties for a violation of these regulations are up to \$500 a day.

The regulations for the Minamkeak Lake Protected Water Area were proclaimed on September 1, 1975. These regulations were revoked and revised on April 22, 1981 and approved by the Minister of the Environment.

The regulations of the Minamkeak Lake Protected water area are summarized below:

- Any activity that causes soil erosion resulting in sedimentation of any watercourse can be halted, by the Minister until suitable corrective action is taken by the person or persons responsible. Any person who proposes to undertake any mining, forestry, or construction activity for any purpose shall notify the Department of Environment and/or the PSC of Bridgewater.
- The operation of pits, quarries, or mines shall not be allowed unless approval from the Minister is received. The owners of any of these operations have to comply with the pit and quarry regulations.
- No person shall, or shall allow the deposit or release of oils, petroleum products, toxic chemicals, pest control products, garbage, litter, solid or liquid waste or effluent, or any other deleterious material into a watercourse within the protected water area.
- No person shall store, handle or transport gasoline, oil, or petroleum and associated products within the protected water area. This does not apply to normal household purposes.
- No person or Municipality shall establish any form of dump or waste disposal site within the designated Protected water area.

- No person shall be allowed the use of chemical or biological pest control products or programs before obtaining the approval from the Minister and notifying the Department of Environment and the PSC of Bridgewater. This does not include normal household uses.
- No person shall alter the natural features or movement of water in any watercourse without a permit from the Minister.
- No person shall wash, or use soap or detergents in any watercourse. Swimming is permitted unless otherwise regulated or prohibited by the Nova Scotia Department of Health.
- No person shall install an on-site sewage disposal system within the designated area until approval has been received from the Nova Scotia Department of Health.

The Water Act (section 17) permits the protection of watershed lands throughout Nova Scotia. The penalties for violation of the regulations for Minamkeak Lake Protected area are outlined in sub-section (4), section 17 of the Nova Scotia Water Act, Revised Statutes of Nova Scotia, 1967:

Every person who violates or fails to observe an order of the Minister made pursuant to subsection (2) shall be guilty of an offence and liable on summary conviction to a penalty not exceeding fifty dollars and in default of payment thereof to a term of imprisonment not exceeding thirty days.

The regulations for Minamkeak Lake Protected area are simply a listing of requirements, which are already law throughout the Province of Nova Scotia.

HISTORICAL LAND USE

History of Gold Mining in the Public Service Commission of the Town of Bridgewater Watershed Area from 1878 to present - Neiff Joseph, Author

About 500 million years ago during the Cambrian and Ordocian Period the continental drift shaped the earlier form of Nova Scotia and North Africa. Shale from Africa containing gold was subjected to great pressure and heat and quartz was formed with the gold concentrated in the quartz rock.

About 200 million years ago the continents formed mainly as they are today during the Treassic Period and small pieces of Africa remained in North America. The iron deposits in Labrador and Northern Quebec are one such area as cypress trees have been recovered from the French mine by Iron Ore of Canada. Scientists have established that they are the same species as old fossil trees in the North African desert. Another piece of Africa was known as Meguma containing the gold bearing rocks in Nova Scotia. In this formation the gold is mostly found in quartz veins between balsat rock layers near Anticlines.

In the 1878 as the legend goes Fletcher Croft's grandmother, Mrs. Sarah Weagle got lost in the area of the German and Queens mines looking for her cows. When she finally found her cows she noticed great large white rocks (quartz). As the word spread about the white rocks Lewis and John Labrador, native Mic Mac Indians living in the area, began prospecting for gold and found a lead of Quartz rock coming from the main fissure vein. They sold their claims to Tom Moore who formed the Mic Mac Mining Company and so serious professional mining of the gold began.

The Mic Mac Mining Company bought up adjacent properties and in the early 1900's a group of Boston promoters capitalized a new company with all the shares taken up for a total of \$1,500,000.00. A new shaft (Jackpot) was sunk to a depth of 280 feet and mining took place until 1908 when water flooded the mine. In the 1970's or 1980's a group of spectators talked of pumping out the shaft but failed as the water volume was too great for the pumps. They wanted the Town of Bridgewater to put in a hydro line and sub station so they could bring in 1000 gallon a minute electrical pumps but the town refused (rightly in my opinion as the pollution from the water in the old mine shafts would have gone directly into the watershed and most notably Hebb's Lake). So ended the last attempt to pump out the Mic Mac and Jackpot Mines.

In 1946, after consuming all the easily available wood in the Molega Mines area, Olands Limited, a beer brewery, moved the Queen's Mines operation to the Leipsigate Lake area and sank the Queen's shaft to a depth of 250 feet. They then tunneled to the fissure vein near where the old Gilmore and Crowe Mines were located and then further out and under South Mud Lake. They spent over one and a half million dollars but due to mismanagement (so the locals say) the mines closed in 1949 and all underground mining ceased in the area. Of great interest was the large ball mill that the Queen's Mine set up and the gold was obtained by an amalgam of Mercury and water later to be recovered by an electrolysis process. This produced about 85% of the available gold and the remainder's particles were recovered by using a cyanide process that was and still is in use in Gold Mining around the world.

In the summer of 1949 after the Queen's mine had ceased operation but before Mr. Irving Hebb had removed the building, three teenagers, Neiff Joseph, the late Bernard Keating and Larry Haines went to the dam between Manamkeah Lake and Leipsigate Lake on a fishing trip. After fishing for a time we decided to check out the

mine site and we became acquainted with the Queen's mine. I picked up an old mining report in the trash and was fascinated by the Geological Report of the Queen's mine. I took the report home but always remembered that the gold was extracted by the use of Cyanide. I forgot about this until I saw the TV news and newspaper reports of a large cyanide spill into the Danube River in Romania by a gold mine. The result was that the destruction of the fish and habitat in the Danube River over a 60 mile stretch of the river. The court case is in the early stages and it appears that damages will be over 1 billion dollars. Also, there was another cyanide spill in Spain around the same time. I was curious to know what happened to the cyanide used at the Queen's mine in the 1940's and whether it got into the Bridgewater water supply. After a submission to the P.S.C. it was decided to do a study of the mine shafts to see if there were any hazardous chemicals there especially cyanide and or mercury. To date none has been identified.

In the watershed area there were around eight (8) major mining operations, being:

- (1) the old German Shaft (between Leipsigate and Manamkeah Lakes).
- (2) the Crowe Shaft (between Leipsigate and Manamkeah Lakes) and South Mud Lake.
- (3) the Gilmore Shaft (between Leipsigate and Manamkeah Lakes) and South Mud Lake.
- (4) the Queen's Shaft (between Leipsigate and Manamkeah Lakes) and South Mud Lake.
- (5) the Pelham Exploration area (on P.S.C. land near Birch Cove on Leipsigate Lake).
- (6) the Aulenback Shaft (near the Western end of Leipsigate Lake).
- (7) the Oakes Pit (near Caribou Lake) west of Leipsigate Lake.
- (8) the Mic Mac Mine and three adjacent shafts in the Hebb's Lake area of Mines Road

 No. 1, which was the largest mining operation to date.

In the 1930's stock promoters proposed to reopen the German mine. Shares were sold and a little work was done on the old shaft. A watchman was hired and he lived for

a time in the old cookhouse but after the local population of Laconia, Lapland,
Camperdown and Hebb's Cross brought all the shares they had money for, the whole
operation folded without producing any gold. All that the locals had were worthless
share certificates but no chance of ever recovering their investment.

At the time of the Mic Mac Mining Operations in the early 1900s a 50 ton cyanide mill was in operation and both the Mic Mac Mine and the Gilmore, Crowe, and German Mines were operated under the Mic Mac Mining Company. In 1946 the Queen's Mines operated a large ball mill for gold extraction. To date no trace of any residual cyanide has been found in the Watershed nor was any Mercury found. Cyanide is water soluble so if it was left in the area it has long since gone away by leaching, evaporation and straight run-off into the lakes and marshes. Mercury on the other hand, was extremely valuable and was reused over and over in the extraction process. Hopefully it was too valuable to waste and was taken to another mining site.

The mining area was populated by miners and their families from the 1900 to the 1950's. There were about 25 dwellings at the Mic Mac Mines as well as stores, and a school where the late Arthur Croft taught school. The area near the Queen's mines had approximately 15 dwellings for the miners as well as two large houses for the mine manager and the pit boss. There was also a school that operated for a number of years as well as a large cookhouse. These buildings were transported to Bridgewater in the early 1950's and set up at various locations around the town by Mr. Irving Hebb, who purchased most of the assets from the bankrupt company. The mine manager, Mr. Charles Johnson continued to live on the property, prospecting the area and maintaining the mining claims for the Olands family.

In the early 1930's Mr. Warner Bickle and Mr. Lyle Hopkins, civil engineers, arrived from Saskatchewan and formed the Acadia Construction Company. One of their first jobs was to pave the street of Bridgewater with a "Tar" "Mac" material to produce a MacAdam surface. This consisted of crushed stone and tar, laid over larger crushed stone and then rolled with a "Steam Roller" to compact all the materials together. The rock crusher was set up at the Gilmore - German Mine site at Leipsigate property and the waste rocks, which contained minute quantities of gold along with some quartz stone that was omitted from the refining process, was crushed for use in the paving operation. So goes the story that "THE STREETS OF BRIDGEWATER WERE PAVED WITH GOLD" (partially true).

In 1956 a large forest fire destroyed the timber and many of the mining artifacts in the watershed area. The fire was deliberately set, as were two additional fires, one in the Lockeport area, Shelburne County, and one in the Hunt's Point area, Queens County. I interviewed Mr. Wilbert Veinot of Lapland hearing his knowledge of the mining area. He stated that in the 1930's a promoter sold shares in a mining venture (the re-opening of the old German mine) to a number of people in the Lapland-Laconia-Waterloo area. They proposed to clear Manamkeah Brook and run a small steam boat from the old Bridge on the Lapland-Laconia Road to the mine site to carry in the necessary mining equipment and supplies but the promotion folded without any work being done and every one lost their money. Mr. Wilbert Veinot states that as a senior member of the local fire department in 1956 he had a crew of men fighting the forest fire burning in the watershed area and they came upon numerous mining shafts (shallow but still very dangerous) which made fighting the fire very hazardous. The fire consumed some of the old mine buildings on its march to Bridgewater. Many buildings were destroyed at the old Foundation Martimes, site of the barge construction for the D-Day

landing in France in World War II. Also, Mr. Willed Wile's house and barn were destroyed on Dufferin Street, Bridgewater, and the fire finally stopped at the south end of the Duck Pond in the Judge Owens Town Park.

The watershed area was also used extensively for logging and a large water mill was located on the run between Leipsigate and Hebb's Lake in the early 1800's. The mill was owned by Nicholas Hebb, ancestor of most of the Hebb's living in the area today. Logging was done in the winter by double bitted axes, swede saws and the logs were yarded on the lakes by horses and transported over the ice and winter roads to the mill site at Hebb's Lake run. It has been told to me by the old people that the Town of Bridgewater enforced a ruling that all draft animals wore a leather diaper to catch the manure so as not to pollute the watershed. I note that this was not enforced on the local moose, bear and deer population because of non compliance.

Also, a dam was constructed on Hebb's Lake and a canal was cut to Fancy's Lake and a small hydro electric power generating plant was installed at Weagle Dam. This necessitated the maintaining of numerous flood control dams in the watershed, most of which are still being used to the benefit of our Town water supply. There also was a large dam and power generating plant built on the Petite River at Conquerall Mills, the remains of which are still evident. The P.S.C. sold their electric distribution and generating plants to the Nova Scotia Power Commission in the 1970's and then generating plants were shut down and sold to an American, Mr. Merrill. Mr. Merrill hired Rex Hebb, the former operator of the generating plants, to dismantle the two plants and they were transported to New Hampshire, U.S.A., where they were reassembled by the same Rex Hebb on a small river and have been producing electric power ever since. It has been reported the that power generating operation returns a tidy profit of

approximately \$35,000.00 yearly to Mr. Merrill. I wonder at the logic of selling the generating plants as a new small generator and dam were constructed at Morgan Falls, New Germany, on the LaHave River, in the past 5 years and it produces power at peak time and is very profitable. The profit from our former generating plants paid for the construction and upkeep of all the control dams and roadways in the watershed. Now this expense comes directly out of the water cost to the rate payers of the Town of Bridgewater.

REPORT OF THE GEOLOGICAL SURVEY OF 1904

Mr. E. R. Faribault, Geologist for the Canadian Geological Survey, in his report for the year 1904, devoted considerable attention to the Leipsigate Gold Mining District.

After pointing out that certain of the veins in the district are more or less irregular, his report says:

"One fissure vein, however, the Leipsigate, owing to its permanency and size and the uniformity of its ore values, has made the district famous. In many respects it is probably the most typical true fissure vein in the Province, and gives promise of being one of the best producers. It is situated in the most southerly part of the district, some 1,200 feet south of the lake, and has been traced for 9,000 feet, of which 4,350 feet have already been opened in three different sections. Extensive and profitable mining has been done on the Micmac property since 1897."

On the permanency of the ore-shoots the report of Mr. Faribault says:

"The recurrence of the ore-shoots in regular and close succession and the uniformity of the ore values have thus been proved in actual practice at the Micmac mine, to the depth of over 650 feet. Such favorable conditions are,

perhaps, not met with in any other known fissure vein in the Province."

VALUE OF QUARTZ

The total average value of the quartz from the Micmac and Leipsigate mines, including the tailings, is over \$10.00 per ton.

Micmac Property (1900 - 1908)

15 stamp mill Boilers, capacity 300 H.P. Large Black Rock crusher 50 H.P. Hoist (Mundy) with 2-ton skip 50 H.P. engine Air Compressor, 850 cubic ft. capacity 5 smaller duplex sinking pumps 250 gallon station pump 9 air drills and a complete equipment of tools, piping, etc. Foreman's house Superintendent's house Mill building **50 - TON CYANIDE PLANT** Cook house Shaft house & black smith shop Store house Office building Two stables Assay Office completely equipped Small water power, 35 H.P.

Leipsigate Property (1900 - 1908)

Worthington electric turbine station pump, 10 stamp mill 12 H.P. Hoist capacity 200 gallons against 250-foot head Air Compressor, 200 cubic ft. capacity Mill building and shaft house Boilers, capacity 75 H.P. Mill building and shaft house Cook House 1 Sturtevant roll jaw rock crusher Two 30 H.P. engines Store house One 35 Kilowatt generator Superintendent's house McKiernan air drills, tools, piping, etc. Magazine 100 gallon Worthington electric sinking pump Stable

Queens Mine Leipsigate Property (1946 - 1949)

Large rock crusher and Bail Mill

CYANIDE MILL attached to Ball Mill

Cook house

for extraction of Gold Mine Managers house

MERCURY AMALGUM MILL attached to Ball Mill for extraction of Gold

Two 200 Horsepower double skip Hoist Elevators
1000 foot tramway from Hoist Shaft to Ball Mill
Two 500 gallon per minute dewatering pumps
500 mega watt diesel light plant
Two 1000 cubic feet per minute diesel air compressors
Air drills, jack keys, piping, etc. for mine tunnelling
operation

Superintendents house
School house
15 small dwellings per
miners
Magazine for Blasting
Power & T.N.T.
Milling building attached
to Ball Mill

TREATMENT OF ORE

The ore, which is free milling and therefore easy to treat and crush, is treated by stamping at the Company's stamp mills at the mines, which gives about 75 percent extraction of the values therein. The tailings are then treated at the Company's cyanide plant, the extraction from which is about 85 percent of gold, and the success attained by the investment of private capital have lately awakened interest on the part of outside capital in general, and now American capital and American engineers are continually taking up and developing numerous promising mines throughout the Province that for years have been permitted to drag along under unskillful management, if not to lie dormant altogether. The cyanide process has been brought into use by these western engineers and they are rapidly pushing the development of the properties, so that Nova Scotia within the next few years is undoubtedly destined to take a high place among the gold producing countries of the world.

After operating profitably for approximately 5 years the mine flooded beyond the capacity of the existing pumps and the entire operation was shut down, not for a lack of gold but because of the flooding of the mine with water. The Micmac mine, the most modern gold mine in Nova Scotia at that time, never reopened and lies dormant to this day.

CURRENT LAND USE

Current land use assessment has been based on extensive research by Saide Sayah in his report titled A Cumulative Effect Assessment of the Petite Riviere Watershed (1999).

Agriculture is a dominant land use in the water supply area (Figure 5). It is practiced within the watershed boundary but outside of the Hebb-Milipsigate Lake, and Minamkeak Lake protected watershed areas. It mostly consists of hay fields scattered throughout and pasture land, mostly to the north in the upper reaches of the watershed. These areas do have some effect on the water quality by way of bacterial contaminants and siltation but do not pose a significant detrimental effect on the water supply. Chlorine treatment usually renders the potential problem abstract (Lunenburg County, 1980). The use of liquid manures in particular can contribute to contamination by allowing bacteria more mobility through runoff. Herbicide and pesticide use is a concern receiving more attention lately but is limited to a few areas (Sayah, 1999). A U-pick strawberry operation is located north of Newcombe Lake and small rotational crops (corn) are also grown in the vicinity. The largest identified farms are two beef cattle operations, one north of Newcombe Lake and one west of the boundary between the two PWA's. Both are outside of the PWA (areas). A mid-size pig farming operation is located west of Minamkeak Lake and is also outside the protected area.

Forestry operations in the watershed have been identified and pose one of the greatest potential threats to the fresh water resource (Lunenburg County, 1980). The soil erosion from roads and skidding trails and the areas that have been clear cut cause the soils to become unstable and result in siltation and sedimentation of the streams and lakes due to accelerated erosion. The clear-cut areas affect the rate and quantity of runoff water. Also, the buffering zones from the treed areas are eliminated. A tree canopy slows snow melting in the spring season which helps recharge the groundwater table as well as lakes and streams at a more constant rate keeping the level of water higher for longer and reducing the risk of flooding (Lunenburg County, 1980). Forestry lots are owned and cleared by both large companies and private owners. The overlapping of cleared areas and water bodies is apparent throughout the watershed (Sayah, 1999). This is a problem when the recommended guidelines, designed to protect the environment, are not respected and adhered to. A number of small Christmas tree lots occur in the upper portion of the watershed and this is not a concern at present, however, this land use should be monitored as pesticide and herbicide use is not known. Pesticides are not easily broken down and can remain for a long time in freshwater systems. Herbicides can cause

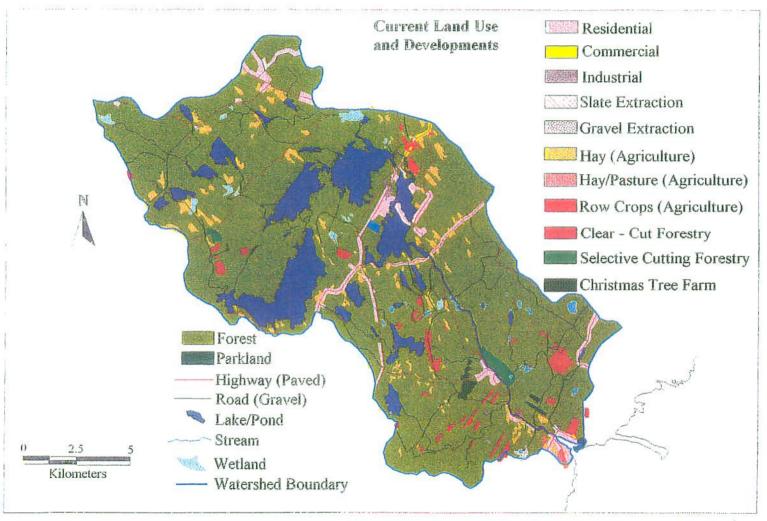


Figure 5 - Current Land Use and Activities (1999).

(Sayah, 1999: copied and modified with permission)

massive algae and littoral plant kills when misused. This further leads to high bacterial decomposition and anaerobic conditions. Herbicides are also used to control hardwood regrowth in commercial clear cuts. Due to the methods used to apply herbicides on large-scale areas, this may be a concern if it is being practiced within the watershed (Hiltz, 2000).

Residential development in the area is concentrated in the northern, upper portion of the watershed along Pleasant River and Auburndale Roads and is quite sparse following other main roads within the protected areas. Some development is also apparent south of Minamkeak Lake and in an eastern area where Hebb Lake discharges. Although septic fields related to this source may contaminate ground and surface water, this is not known to be a problem in the watershed. The effects of pesticide and fertilizer use for gardening are not an identified problem either and would not be expected to outweigh those effects from the agricultural land use category.

Industrial development was not identified as an issue in the watershed except for one operation, Lapland Quarry, owned by Dexter's Construction. This operation excavates bluestone which is used for road construction. It is located close to Birch Brook, just outside the Hebb-Milipsigate PWA. A number of holding ponds allow for drainage control and reuse of wash water and pH in these ponds ranged from 7.6 to 8.5 (see Appendix). One large, deep pond located farther from the brook was contained within slate bedrock (acidic water is indicated). A concern could be the escape of this water during high precipitation, flood conditions, however, this has not been documented in the 15 or more years of this site's operation. An abandoned shale pit located less than one kilometer from the northern entrance to Lapland Road (The Old Wildcat Brook Quarry) was found to have at least two remaining ponds on the property. The pH of these ponds ranged from 2.7 to 3.8 and, again flood conditions and release of this acidic water should be a concern. A fish kill was noted in Wildcat Brook in 1997 but is undocumented. It was attributed to the low pH of waters draining into the brook following a dry period and then excessive rain (Hiltz, 2000).

Mineral exploration has continued in this area since the prescribed regulations were amended to the Minamkeak Lake PWA (1981). The regulations allow for exploration provided approval has been obtained from the NS Department of Mines and Energy for activities involving no surface damage. For those activities involving surface damage, approval must be obtained from the NS Department of the Environment (Mineral Resources Act). Notification of activity to the Bridgewater PSC is described as a choice made by the company to notify the PSC and/or the NSDOE. It would appear the PSC may not necessarily be part of the decision making process. A request for access to land exploration was made to the PSC in 1985 on behalf of Meguma Gold Corp. Ltd. and

Coxheath Gold Holdings (Whitelaw, 1985). The request was in the capacity of land access to PSC lands, not approval for the activity.

Further to the surface program, in 1986 Coxheath proceeded with underground exploration by the dewatering of the Queen's shaft (MacPherson, 1986). MacPherson states "higher than anticipated costs for obtaining environmental approvals were offset by the elimination of the settling pond and obtaining less expensive rentals". David Allen, P.B.T. Construction and Excavation Ltd. (1985) describes the dewatering as follows: "The water was pumped from the shaft and sprayed, to aerate the water, into low lying areas approximately 400 ft. from the shaft." Other exploration activities in the area include numerous remote-sensing surveys such as an Airborne Magnetic Survey done by Coxheath in 1987 (NTS Index, Report 91-2) and many various rock geochemical surveys. A geochemical survey by Whitelaw in 1985 determined the content of the slates in waste dumps to the north of Milipsigate Lake to contain up to 10 % sulfides, at Birch Brook Lead some slates are high in pyrite and at the Garfinkel workings, arsenopyrite is obvious. Although much exploration activity may be considered non-intrusive, the release of mine water onto sulphidic waste rock may lead to acid mine drainage (to be discussed later).

Dewatering of shafts may cause groundwater movement and ultimately resuspend or redissolve contaminants which were previously in a stable, non-contaminating state. Contamination may also occur when holding ponds fail, releasing effluents to the environment (Ripley, 1996). The ultimate goal of most preliminary study is to determine the development potential of the mineral (gold) as a resource. Also, exploration is closely related to economic climate and the demand for the mineral. Mineral development (as discussed later) may introduce a large range of environmental problems over which the PSC may have little control with regard to watershed protection. Recent assessment reports at the Department of Natural Resources, Mines and Energy Branch show a decline in exploration in the area of Milipsigate Lake in recent years. A large mineral claim in this area has been allowed to expire. It is recommended that the PSC discourage mineral exploration within the watershed as a guard against future mineral development or pursue the staking of this claim themselves to protect the water quality of this area.

WATERSHED PROTECTION ISSUES

Abandoned Mineshafts

Numerous site visits to the watershed revealed a large area of land disturbance. The most noticeable effect of the past mining activity are the open pits, shafts and trenches left, in most cases, just as they were abandoned more than 50 years ago. Environmental protection standards were not considered when most of the operations occurred. Also,

many waste rock piles, tailings piles, some cement structures and wooden debris remain. It is difficult to imagine the extent of the underground workings accompanying some of the now, water filled holes.

One group of shafts, the Micmac and Jackpot, centered 300 m from the southeastern shore of Milipsigate Lake were backfilled in 1934 to 1936 possibly by the Meguma Belt Mines Company, the last to work in this area (Henneck, 2000). There is now some collapse evident at the Jackpot shaft. The Micmac was, in it's time, one of the three largest gold mining operations in the province (Henneck, 2000). Shaft locations with respect to Milipsigate Lake may be seen on a large-scale map at the Bridgewater PSC office. Photos of selected pits and shafts are included as Figures 6 to 14.

Figure 6: Aulenback Property – wooden debris and remains (now Carol Rhodenizer)

Figure 7: Aulenback Property - stamping mill

Figure 8: Aulenback Shaft

Figure 9: Bluff Shaft - on PSC property

Figure 10: Queen's Shaft - stamping mill

Figure 11: Micmac Shaft area – tailings pile (crushed and treated rock)

Figure 12: Quigley Shaft – on PSC property near Aulenback Shaft

Figure 13: Unnamed Shaft – on Mines Rd. close to Queen's Shaft

Figure 14: same as 13

The Aulenbach Property was a medium sized operation at which cement structures and wooden debris may still be seen. This area is one with a large number of pits, shafts and trenches and many are located on property belonging to the PSC. An adjacent landowner has provided hazard signage and taped off dangerous areas with the help of the department of Natural Resources to reduce hazard liability and reportedly throws boughs and branches into the shafts also.

The Bluff Shaft is also located on PSC property and was one of the earliest and smallest operations with the mining being done by hand. This shaft is located close to the edge of Milipsigate Lake and at the base of a 12-foot escarpment which makes it quite unnoticeable to the unwary hiker.

Several years ago, the Municipality of the District of Lunenburg capped with cement two dangerous shafts, the Queen's and the Old German. They are located close to the Mines Road No. 1 which provided for easy public access and a high degree of hazard.

A number of unnamed shafts also located close to the Mines Road No. 1 are not located on PSC property but do pose a hazard due to their accessibility. These are in the area of the Zink and Old German shafts and one is marked by orange tape tied to a tree. This particular shaft is recognized with a partial truck body sticking out of the top.

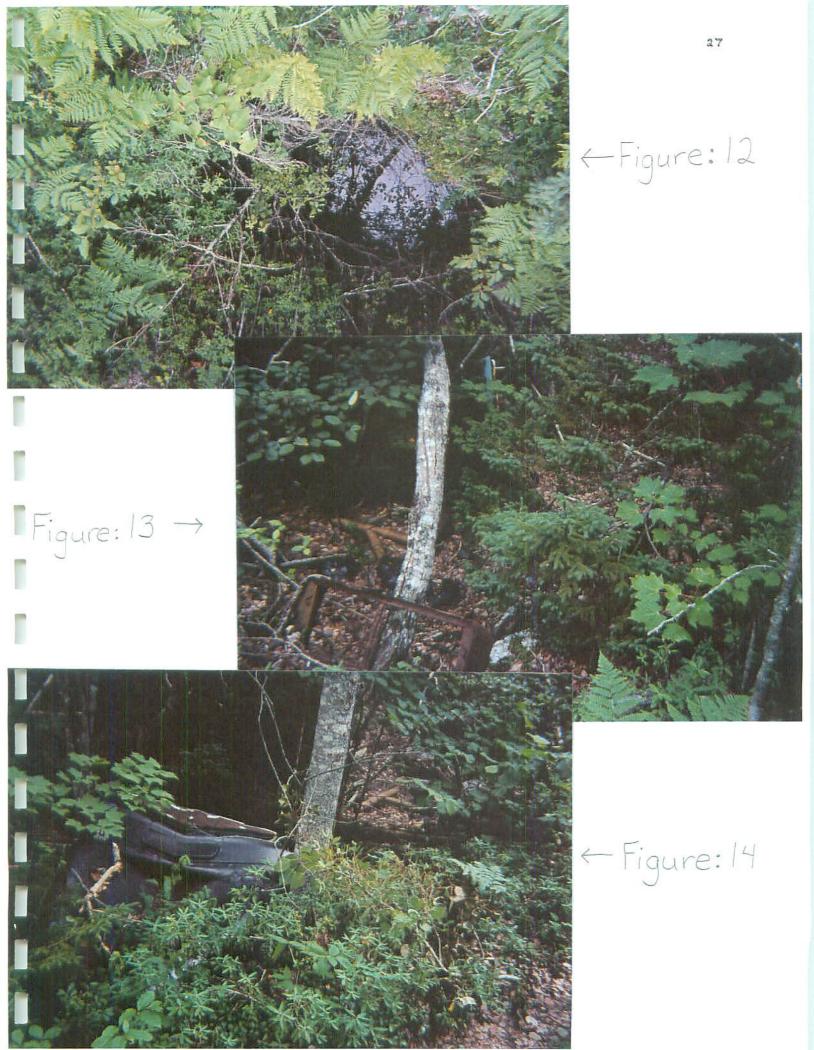
Many of these sites are potentially dangerous to anyone who is unaware of them.











Most are water filled and there is no indication of their depth. The physical hazards are sometimes increased by the instability of the sides and therefore the inability to escape. Some are covered by a layer of branches and leaves falsely indicating a stable surface. Physical evidence of waste dumping was also identified on a number of the properties, in particular those with easy road access.

The shafts that have been identified with hazard signs by either private property owners or the Department of Natural Resources include those on the following properties:

- Carol Rhodenizer located with respect to Aulenback Property
- Ivan Weagle with respect to Micmac and Meguma Belt Mines' Shafts
- Crown Land with respect to Queen's Shaft and Rose Lead

Present Environmental Protection Regulations try to ensure the return of excavated lands to their original state or at least to an aesthetically pleasing and productive one. Although the existing pits, holes and trenches are not aesthetically pleasing, the sites have naturally regenerated to a state supporting plant and animal life and to a degree of the former state before disturbance.

Due to legal liabilities from injury, it is recommended that the PSC identifies dangerous shafts on their property and marks them off with tape and posts hazard signs. These signs are available from the Department of Natural Resources, Bridgewater office. Further remediation should be considered after evaluating the methods presented in the reclamation chapter and after a physical inspection of the dangerous shafts previously presented.

Acid Mine Drainage

Acid mine drainage is drainage with a pH of 2.0 to 4.5 resulting from mines and mine wastes (American Geological Institute, 1983). The bedrock composition of the watershed area is high in metallic, sulphidic components, particularly pyrite and arsenopyrite in some areas. The sulphates from these rocks dissolve to produce sulfuric acid and metal hydroxide precipitates when exposed to oxygen and water (rain and snow). The results are the leaching of metals from the rock and a reduced pH of the water (Ripley, 1996).

Acid mine drainage does occur in nature but is accelerated by mining. The waste rock produced from mining is the primary source of potential contamination and may be effective for centuries (Ripley, 1996). The metals of concern are those having the potential to be toxic such as arsenic, lead and cadmium. A major metal involved (although nontoxic) is almost always iron because it occurs in pyrite and pyrrhotite and is left behind in waste rock and tailings (Ripley, 1996). Heavy rains following dry periods or spring loading (after rapid snowmelt) may cause spikes of contamination and the material may be carried in solution, in suspension, and as attached to sediments.

Suspended loads and sediments may settle out in ponds or lakes and some residuals may be taken up and exchanged by organisms. Marsh plants such as cattails absorb dissolved metals.

Arsenic in particular is taken up by plants through the phosphorous pathway (Ripley, 1996). The effects of acid drainage may result in excessive levels of heavy metals in the wetland basins and arsenic in particular is accumulated by many plants. This may pose a threat to organisms at higher levels within the food chain that have eaten these plants. Also, it is second only to lead as the cause of metal toxicity of domestic animals (Ripley, 1996).

Acid mine drainage may also enter the groundwater table. A prediction of the mobility of metals within groundwater is that copper, nickel and cobalt move fairly rapidly, lead and silver move less rapidly and gold and tin move more slowly (Ripley, 1996). The mobility of these metals is also pH dependent and it is suspected that at the higher pH of the water in these shafts (6.5 to 7.0), many of the metals occur as precipitates on the bottom. Iron and aluminum are precipitated at a pH of 5.0 to 6.0. Surface waters receiving mine effluents may record an increased salinity as well as increased metals concentration.

The interactive effects between the various contaminants and groundwater recharge areas or overland flow were beyond the scope of this study. Other factors that can influence the chemical states of these contaminants are seasonal changes such as temperature, lake turnover and the altered water discharge and recharge patterns that result. The present movement of water through this system does not appear to threaten the water supply area but it is suspected that changes made to the system could. A good example is the dewatering of existing shafts which could resuspend or redissolve contaminants making them mobile within the system. It is therefore recommended that this type of activity is discouraged or a thorough water analysis is done, especially at depth, before this activity occurs.

Mineral Development

The Environmental Assessment Act was originally intended for public-sector projects but has been extended to include the private-sector. The process is required for undertakings such as mineral development. It evaluates from the environmental and economic point of view. If the board is not convinced the "public good" will be enhanced, approval for a project will not be recommended (Ripley, 1996). There are however ministerial powers to exempt projects and the Board's recommendation does not have to be accepted by the minister.

The possibility of mineral development within the watershed does exist and Table 1 illustrates some of the potential environmental impacts by example only. The Seabee

Mine is located in LaRonge, Saskatchewan, in a relatively flat area of bedrock covered with a thin layer of discontinuous glacial till and is located close to Laonil Lake. Gold occurs within quartz-vein material in association with pyrite, pyrrhotite and chalcopyrite. The mine has a projected life of five years (Ripley, 1996).

Potential Issue	Decree	Likelihood	Туре	Duration	Success
	Degree				
Treated effluent & mine water	Major	Possible	Direct	Long	High
Draining East Lake & using	Major	Possible	Direct	Long	High
East Pond for polishing					
Water diversion & dam	Minor	Certain	Direct	Medium	High
construction					
Sewage disposal	Minor	Possible	Direct	Medium	High
Withdrawal of water from	Minor	Unlikely	Direct	Medium	High
Laonil Lake					
Contaminant & spill control	Moderate	Possible	Direct	Medium	High
Vegetation clearance	Minor	Certain	Direct	Long	Moderate
Rare flora	Major	Unlikely	Direct	Long	Low
Wildlife disturbance	Minor	Certain	Direct	Long	Moderate
Winter access road	Minor	Unlikely	Indirect	Short	High
& wildlife					
Surface topography	Moderate	Possible	Direct	Medium	Moderate
Transport & storage of fuel	Major	Unlikely/Possible	Direct	Medium/Long	High
& chemicals	*				
Use of explosives	Moderate	Unlikely	Direct	Short	High
Atmospheric emissions	Major	Unlikely	Direct	Medium	High
Solid waste disposal	Minor	Possible	Direct	Medium	High
Traffic	Minor	Possible	Indirect	Medium	High

Source: Beak Associates Consulting Ltd. (1990).

Notes:

Degree

Minor: low significance, if small area or population affected or occurrence natural

Moderate: impact possible, but not irreparable

Major: significant, if a large area or population or endangered species is affected

Likelihood of Occurrence

Unlikely: may occur but highly unlikely on basis of current information

Possible: probability of occurrence not known and may depend on other factors

Certain: certain to occur as a result of mining or milling activities

Type

Direct: a result of the actual physical presence of the mine or mill

Indirect: secondary impact, related to increased traffic on access roads

Duration

Short: likely to last only until end of construction period or to occur infrequently

Medium: likely to last the life of the mine and mill

Long: likely to last even beyond the decommissioning stage

As seen from this example, one of the environmental impacts to a major degree is that of treated effluent and mine water. Cyanide is to be used for gold extraction and then naturally degraded in an impound area. It takes 9-10 months for this process and the rate is dramatically slowed with reduced temperature (Ripley, 1996).

Mercury is sometimes used as a supplement to cyanide leaching (although not in this example). Up to 10% of the mercury used in the amalgamation process is likely lost to the atmosphere and has local impacts (Ripley, 1996). Mines formerly using this process continue to be potential sources of toxicity. An area in Shubenacadie that was mined for gold between 1860-1930 is the origin for current deposition of arsenic, mercury, lead and zinc in downstream lakes (Mudroch, 1986). Although water concentrations are quite low, a large part of the Shubenacadie River System is gradually being contaminated.

Another mine developed near Bathurst, New Brunswick by Halifax based Nova Gold Resources Inc. operated from 1989 to 1992. Its experimental, indoor vat leaching process proved to be environmentally friendly due to less ground disturbance and a complete containment of effluent. It's success, however, proved to be much more costly than conventional methods (Ripley, 1996). Aside from new mines, new technologies may make the reworking of old waste rock and tailings piles profitable.

The future development of mineral extraction or the reworking of existing rock is not recommended in the watershed area as it would be hard, if not impossible, to cure the problem of contamination after the fact and wise to prevent the problem from occurring.

Clear-cutting

There has been clear cutting activity in the Minamkeak Lake designated area without the acquiring of proper permit applications or prior notification to the Department of Environment or the PSC of Bridgewater. A permit for land clearing or clear cutting is required, and is issued by Nova Scotia Department of Environment.

It is evident from the land use map that can be found at the town office, that a considerable portion of Minamkeak Lake Designated area has been cut. There is an area in excess of 1.5 km² of clear-cut land, mostly around Frederick's Brook.

An increase in the temperature of stream courses is caused by more sun exposure from the lack of tree canopy with clear cutting. When streams are exposed to direct sunlight more energy is absorbed from the sun than lost through evaporation.

Streams have more surface area per volume so more evaporation occurs. Under natural conditions, without human affects, a stream course cools the water temperature through evaporation. The tree canopy would still exist so the energy for the evaporation process would be drawn more from the water itself instead of the sun's energy. The shallower the water the faster the temperature will rise. With clear cutting there is going to be more surface runoff because the buffering zone has been eliminated. This causes an

increase in total suspended solids from siltation. The soils from the clear cut areas are not being held together by the roots of the vegetation, so erosion occurs. The settled sediments smother insect habitats and suffocation of juvenile fish and water insects occur. Also, the sedimentation alters otherwise ideal spawning grounds for fish.

Sedimentation and erosion also increases the nutrient loading of streams and lakes, which accelerates the rate of algal growth. (Hiltz, 2000)

Corrective action to prevent erosion from clear-cut areas should be taken to keep the streams and waterways clean and healthy. This keeps the water quality from deteriorating for present and future users. An incentive provided to harvesters for trees left standing in buffer zones would reduce the impacts of clear cutting, but is not presently an option.

Due to the detrimental effects of clear cutting in a watershed, more emphasis should be put on acquiring permits. The problem of permitting may be due to a lack of knowledge about the process. It is therefore recommended that a letter go out to all contractors and private wood lot owners that are within the protected watershed areas. The total affected area can be better determined through better monitoring.

Endangered Species

The Atlantic whitefish, also called Acadian whitefish, are a member of the Salmonidae family and are related to salmon and trout. They are an anadromous, or sea going species.

Atlantic whitefish populations occur in the Petite Riviere watershed. They are land locked in Hebb, Milipsigate, and Minamkeak lakes due to the construction in 1901 of the hydro-electric dam at the foot of Hebb lake blocking any upstream migration. It is not known whether these fish were anadromous at one time or not.

The Maritime Fishery Regulations, under the Fisheries Act on February 17, 1970, prohibited the taking of Atlantic whitefish from waters and/or the possession of the fish at any time of the year. Finally in 1984 the Atlantic whitefish was listed as an endangered species.

There is a lot that is not known about the Atlantic whitefish including the habitat requirements. Spawning is assumed to take place during the late winter months, but the exact spawning period and spawning locations are not known. There is virtually no information on the Atlantic whitefish spawning behavior or early life stages.

Atlantic whitefish have a wide variety of foods which was determined when they were captured in Hebb, Milipsigate, and Minamkeak lakes. Everything from flying ants (Hymenoptera) in Hebb lake and plankton (Cladocera) in Minamkeak lake to dragonfly nymphs (Odonata), adult Hemiptera and Coleoptera beetles, plankton (Cladocera), mayfly nymphs (Ephemeroptera), Truefly (Diptera pupae) and banded killifish. The wide variety may be due to the seasonal variation in available food at the time when the

Atlantic whitefish specimens had been caught.

Although the pH-tolerance of Atlantic whitefish is not known, acidification of southwestern Nova Scotia has impacted other native fish populations such as Atlantic salmon. (Nova Scotia Fish Series, Atlantic whitefish)

Unsuccessful attempts were made by the Department of Fisheries and Oceans to develop a hatchery program for this species.

This species of fish are sensitive to any changes in their habitat including pH, temperature, and oxygen levels. The designation of the watershed of Hebb, Milipsigate lakes and Minamkeak lake restricts the dumping of garbage and sewage into the lakes and anything otherwise detrimental in impairing the quality of the water.

The protection of the watershed that is now being enforced in and around the lakes by the town of Bridgewater may be vital in the protection from extinction of the Atlantic whitefish.

The Department of Fisheries and Oceans are doing a study on the Atlantic whitefish in Hebb, Milipsigate and Minamkeak lakes. It may be of interest to the Public Service Commission to follow this study. The findings of this study should reveal more information on the condition of the watershed system, including chemical parameters, and the biodiversity of the lakes. Also more research should be done on the option of declaring the three lakes of the watershed a wildlife protection area, in concern for the Atlantic whitefish and also to help in the protection of the water supply source.

Water Quality

A summary of the water quality of the samples taken appears in Table 2. The sampling program does not compare water quality over time but rather is a picture of the quality at one instant in time. The samples also provide a baseline for future study.

Samples were taken from five shafts and one abandoned quarry site (see Appendix). The results are compared here to the Pumphouse Dam site where water is drawn from Hebb Lake for the Town's supply. The Pinch Gut site is the location of the inlet to Hebb Lake from Wildcat Brook. It is compared here due to its particular water qualities to be further discussed. The Pumphouse Dam and Pinch Gut data was contributed by the Bridgewater PSC. Analysis for heavy metals contamination was done in areas where former cyanide and mercury use is suspected. Historical records indicate cyanide use at the Micmac mine (Micmac, early 1900's).

Table 2:

Water Chemical Quality Test Analysis

					~	I Cot / Imaily	0.0		
DESCRIPTION (mg/L)	Crank	lacknot	Oueon's	Aulenback	D1##		Dinet	Dumahawa	0
Location	Shaft	•				Old Wildcat		Pumphouse	Recommended
Location	Share	Shaft	Shaft	Shaft	Shaft	Bk. Quarry	Gut	Dam	Guidelines 1
Sodium	2.40	2.50	2.30	1.80	3.00		6.00	3.30	≤ 200
Potassium	0.70	0.60	0.50	0.50	0.30		0.40	0.20	2 200
Calcium	46.10	30.80	18.40	3.45	5.20		1.05	0.96	-
Magnesium	1.14	1.10	0.79	0.69	0.72		0.71	0.50	-
Hardness (CaCO ₃)	120.00	81.40	49.10	11.50	15.90		5.53	4.44	< 200
Alkalinity (CaCO ₃)	110.00	75.00	46.00	6.00	14.20		1.00	1.00	Not Provided (> 40) ³
Carbonate (CaCO ₃)	0.03	0.06	0.03	0.00	0.00		0.00	0.00	-
Bicarbonate (CaCO ₃)	110.00	74.90	46.00	6.00	14.20		1.00	1.00	-
Sulfate	2.30	3.10	3.60	3.00	< 2.00		3.60	2.40	≤ 500
Chloride	4.00	4.20	3.50	3.50	5.50		12.00	6.90	≤ 250
Silica	7.80	6.00	4.70	2.30	1.50		1.40	0.80	•
Ortho Phosphate (P)	0.05	< .01	< .01	< .01	0.01		< .01	< .01	< 0.20
Nitrate + Nitrite (N)	< .05	< .05	< .05	< .05	< .05		< .05	< .05	< 10.00
Ammonia (N)	0.20	.55	< .05	< .05	< .05		< .05	· .05	0.50
Iron	0.84	3.57	1.97	2.22	1.64		0.79	0.15	≤ 0.30
Manganese	0.42	0.63	0.09	0.27	0.11		0.06	0.06	≤ 0.05
Copper	< .01	< .01	< .01	0.01	< .01		< .01	< .01	≤ 1.00
Zinc	0.03	< .01	0.02	0.05	< .01		0.01	< .01	≤ 5.00
Arsenic	.002		.009	.008	.010	.002			.025
Cyanide	< .005		< .005	< .005					.200
Mercury	.00026		.00017						.001
Aluminum		•	< .10		< .10	0.29			< .20
Color (TCU)	17.50	100.00	60.00		87.50		125.00	30.00	< 15
Turbidity (NTU)	3.08	18.70	4.35	113.00	7.94		1.40	0.75	1.0 (0.1) ²
Conductivity	220.00	177.00	116.00	27.00	51.80		52.20	32.20	(0)
pH (no units)	6.40	7.00	6.90	5.40	6.50	3.78	5.70	6.10	6.5 - 8.5
Total Organic Carbon	2.80	2.40	2.10	5.60	4.20	0.7 0	10.00	3.60	Not Provided (<3) ⁴

- Guidelines for Canadian Drinking Water Quality recommended levels for each water quality parameter
- 2 AWWA (American Water Works Association) criteria for Giardia
- 3 AWWA criteria for control of corrosion protection
- 4 AWWA criteria for control of disinfection by-products

Water sampling and analysis at the shaft locations did not reveal elevated levels of any of the contaminants selected for testing.

Iron and manganese are elevated in all of the samples however are aesthetic qualities and pose no health concern. These are likely contributed to by the bedrock (or

disturbance of it) throughout the area. The elevated manganese and iron levels at the Pinch Gut site may contribute somewhat to the high color also recorded there. Most of the color, however, results from organic material from the swampy wetland in this area.

The low pH of the pit water at the Old Wildcat Brook Quarry is an indicator of the acidifying capability of the slate and shale contained in the Halifax formation bedrock. As previously mentioned, this is a concern during high runoff, flood conditions when the waters could drain to Wildcat Brook. A pH survey of this brook may help to determine the source of the low pH conditions that presently exist and subsequently drain to the Pinch Gut.

At the discharge of Hebb Lake (Pumphouse Dam) where water is drawn for the Town's supply, levels of most constituents are acceptable. Aside from the existing low pH of Wildcat Brook, no new problem was identified concerning contamination. This may indicate that:

- acid drainage from waste rock is being buffered and neutralized by carbonate contained within the bedrock above and/or below ground level
- acid drainage is being diluted in a large volume of lake water resulting in lowered levels at the outflow of Hebb Lake
- an equilibrium is presently maintained by the natural process of filtration of heavy metals through the wetland areas
- contaminants were flushed through the system since the mining activity ceased
- suspended and/or precipitated metals are settling to a lower level in the shafts or in lake bottom sediments and do not appear in the samples
- the recorded levels could be attributed to natural background levels due to the geology of the area
- the recorded levels could be attributed to the effects of acid precipitation (rain and snow)

An extensive sampling program is regularly conducted by the Bridgewater PSC at all major lake inlets (Wildcat, Birch and Frederick's Brooks) and at a number of outflow areas. The program accounts for seasonal changes such as water temperature and lake turnover and the resulting changes in various chemical constituents. Land use over the past 20 years has not changed much and this provides for fairly stable background levels and fairly predictable seasonal changes. Abnormal chemical changes can be recognized quickly.

The areas of concern for water quality within this system include:

- seasonally high levels of organics near the Wildcat Brook outflow to Hebb Lake
 and the northern shore of Hebb Lake due to some algal growth
- a low pH and high color in Wildcat Brook possibly due to bedrock disturbance

- and drainage from the shales and slates of the Halifax formation which reduce diversity of fish and insect species
- the undetermined potential of leached metals having been deposited in the lake and stream sediments of the water supply area
- the siltation effects of clear cutting which contribute to greater nutrient levels, algae growth and high organics and represents a potential problem on Frederick's Brook and the western end of Minamkeak Lake
- the effects of agricultural practices contributing pesticides, herbicides or bacterial contamination to receiving waters

The present treatment system uses chlorine to oxidize and reduce organics in the water supply. Chlorine also destroys pathogens (disease causing organisms) which are attached to the organic particles. This chlorine use leads to high levels of THM's, a byproduct of the combination of organics and chlorine. The new water treatment system presently under construction and to be completed in 2001 will help to eliminate this problem. A pH survey of the Wildcat Brook may help to determine the source of the low pH levels recorded and if acid mine drainage is a concern in this area. A review of extensive geochemical mapping by the Department of Natural Resources may alleviate concerns regarding heavy metal deposits in the lake and stream sediments.

Management of the watershed is presently recognized on a "landscape" scale with consideration of the interaction between the various stream and lake systems. On this scale, protection of the individual systems is highly important as a small-scale change in land use in one area can affect systems downstream also. The combined effects of several small changes could have significant effects overall. Land use regulations within the watershed are difficult to enforce, particularly as they relate to clear cutting and agriculture. Some of the present practices have been in use for many years and water quality concerns are sometimes not understood or not recognized.

MINE RECLAMATION

The Department of Natural Resources, Mining Engineering, has provided a handbook regarding information on the potential hazards and legal liabilities of abandoned mine openings located on private landowners property. The handbook describes remedial methods to reduce or eliminate the hazards that abandoned mine openings pose.

The Hazards and Remediation Handbook, Department of Natural Resources, states (from the Criminal Code of Canada):

Private landowners have the responsibility to ensure that individuals traveling on or using their land are made aware of potential dangers associated with abandoned mine

sites and ensure measures are taken to prevent personal injury. Private landowners should:

- Ensure that all individuals entering their property including trespassers, are made aware of the potential dangers of abandoned mine openings through proper signage or notices.
- Take reasonable measures to guard an open hole or related hazard to prevent individuals from personal injury.

Section 263 of the Canadian Criminal Code deals with offenses related to the <u>Duty to Safeguard Openings in Ice and Excavations on Land</u>. The section imposes legal duties in connection with openings in ice and excavations on land and describes the circumstances under which criminal liability may be attracted for failure to perform either duty.

Sub-section (2) of section 263, states that:

Everyone who leaves an excavation on land that he owns or of which he has charge or supervision is under a legal duty to guard it in a manner that is adequate to prevent persons from falling in by accident and is adequate to warn them that the excavation exists.

Sub-section (3), states that:

Everyone who fails to perform a duty imposed by sub-section (2) is guilty of:

- manslaughter, if the death of any person results therefrom;
- an offence under section 269, if bodily harm to any person results therefrom;
- an offence punishable on summary conviction

The procedures to remediate are outlined in Table 3 below:

Table 3: Remediation of Mineshaft Openings

Nature of Abandoned Mine	Closure Type	Method	Application	Effective Life
Opening		<u> </u>		LITE
Vertical or Near Vertical	Warning	Sign	Warn and Alert	Temporary
Openings	Barrier	Fence	Limit Access	Temporary
	Barricade	Steel Wire Screen	Restrict Access	Temporary
Vertical Shafts		Steel Grate	Restrict Access	Temporary
Inclined Shafts	Сар	Pre-Cast Concrete	Prevent Access	Long Term
Raises		Cast-In-Place Concrete	Prevent Access	Long Term
		Monolithic Concrete	Prevent Access	Long Term
		Сар		
	Seal	Backfilling	Prevent Access	Permanent
Horizontal or Near Horizontal	Warning	Sign	Warn and Alert	Temporary
Openings	Barrier	Fence	Limit Access	Temporary
	Barricade	Timber	Limit Access	Temporary
Adits		Steel Wire Screen	Restrict Access	Temporary
Declines	1	Steel Grate	Restrict Access	Temporary
Slopes		Rock or Concrete Wall	Prevent Access	Long Term

H	Seal	Blast Closure	Prevent Access	Permanent
_		Backfilling	Prevent Access	Permanent
Subsidence or Caving Feature	Warning	Sign	Wam and Alert	Temporary
_	Barrier	Fence	Limit Access	Temporary
	Seal	Backfilling	Prevent Access	Permanent

The Department of Natural Resources had suggested, with respect to the remediation of mine openings that steel grates because they cause the least amount of disturbance to the environment. (Henneck, 2000)

CLAIMS STAKING

Process

Under the Mineral Resources Act an individual, 19 years or older, or a company can conduct prospecting or regional exploration on lands that are available for staking upon the following conditions:

- that such persons register with the Department and receive a Prospectors Identification card.
- that only non-disturbance type work (e.g.: outcrop mapping, soil sampling, most geophysical surveys) is carried out, and
- that permission to enter upon lands be obtained from the relevant landowners before prospecting commences.(A guide to mineral exploration legislation in Nova Scotia, p. 3)

Prospecting may not be conducted upon lands designated National Parks, Candidate Protected Areas, and upon Provincial Parks and lands closed by the Department of Natural Resources.

The Department of Natural Resources. Minerals and Energy Branch, must be consulted regarding any proposed exploration activity in Municipal Water Supply Watershed areas. (A guide to mineral exploration legislation in Nova Scotia, p. 3)

Form No. 6- Application for Exploration License must be filled out in order to apply for single or multiple exploration licenses by identifying the coterminous claims and their relevant tract numbers and claim reference maps.

Every applicant for a mineral right who is submitting his or her first application, has 15 days to file Form No. 7 containing basic information, to the Registrar.

When an exploration license has been issued, the licensee has to obtain the permission of the landowner (the Minister of Natural Resources in the case of Crown lands) before doing the assessment work designed to prove the existence of a mineral deposit. Only non-disturbance type activities of geological, geochemical, and geophysical surveying may proceed without further authorization.

Claim Maintenance

An exploration license may be renewed indefinitely as long as certain annual conditions are met.

There is a minimum amount of assessment work that must be carried out in the evaluation of the mineral potential of a claim. During the first 10 years of the license the minimum cost is \$200. This requirement increases to \$400 per year for years 11 to 15 and to \$800 for all subsequent years.

In order for assessment work to be credited to a license it:

- must provide new or additional geotechnical data relating to the area
- must be reported in the prescribed manner,
- must substantiate costs that are acceptable to the Registrar, and
- must not have previously been accepted for credit.

A variety of activities qualify as "acceptable work" and their cost is credited at full and fair value. Such work includes prospecting, excavating, line cutting, surveying (geological, geochemical, geophysical, topographical), drilling, assaying and underground exploration work. With approval from the Registrar, reasonable expenses for accommodation, food, meals and transportation would be accepted. Expenses for airborne or preliminary ground surveys may be credited at up to 1.25 times their cost if acceptable data is submitted in a timely manner.

Capital costs of buildings, machinery, access roads, expense of reclamation, environmental studies, compensation to landowners, drafting and office maintenance, are also considered acceptable work to a maximum credit of ten- percent total.

Assessment work should be filed before the end of the license year, otherwise if submitted after that year it may only be credited for 50% of its documented value. Also any excess work accumulated may be accepted in subsequent renewals of the license.

Another option for the PSC of Bridgewater concerning the claim staking, in the Mineral Resources Act, Chapter 18 of the Acts of 1990, section 22, sub-section 1: Withdrawal of lands-

The Minister may withdraw any lands in the Province from being subject to application for an exploration license for all or certain minerals.

CONCLUSIONS

The Petite Riviere Watershed above Hebb Lake Dam provides a plentiful and quality water supply to the present users. Development within the watershed is minimal and has remained fairly constant for the past 20 years. This contributes to the stability of the water quality. The water sampling program that is presently employed is extensive. This historical and current land use study did identify a number of potential land use and water quality problems, most of which have been previously identified by the Bridgewater PSC. These problems include:

- the potential physical hazard of the abandoned mine shafts located in the vicinity of Milipsigate Lake
- the potential for future development of the mineral resource
- seasonally high organics in the northern shore area of Hebb Lake and high THM levels resulting from the necessary chlorine treatment process
- low pH waters entering the system from areas affected by disturbance of Halifax formation slates, such as Wildcat Brook
- potential siltation effects from clear cutting in the area of Frederick's Brook and the western end of Minamkeak Lake
- potential contamination effects from the agricultural use of pesticides, herbicides and fertilizers and bacterial contamination from liquid manure or drainage practices
- the undetermined possibility of metals contamination in the sediments of the streams and lakes of the water supply area
- the difficulty of enforcement of some of the Designated PWA regulations and a lack of notification to the Bridgewater PSC of development within the watershed

RECOMMENDATIONS

The following recommendations are made as a result of the Historical and Current Land Use Study of the Petite Riviere Watershed above Hebb Lake Dam. These recommendations are made in the interest of protecting the water supply for present and future users of the system and to reduce the risk of hazard liabilities regarding the abandoned mine shafts on PSC property:

- 1. Close monitoring should follow any activities suspected of causing ground disturbance or the discharge of any liquid effluents having the potential to contaminate the ground or surface water such as:
 - Christmas tree lots and herbicide use
 - Clear cutting, siltation and herbicide use
 - Agricultural contamination from herbicides, pesticides, and fertilizers (particularly bacteria from liquid manures and drainage practices)
 - Dewatering of existing mine shafts
- 2. Dangerous mineshafts on PSC property should be taped off and marked with hazard signs pending reclamation such as covering them with steel grate:
 - The Bluff Shaft is presently taped but requires further remediation
 - The Quigley Shaft and others close by require marking with tape and hazard signage pending further remediation
- 3. Mineral extraction should be very strongly discouraged in the watershed.
- 4. The option of Withdrawal of Lands from Exploration (Mineral Resources Act, 1990 Chapter 18, section 22, sub-section 1) should be investigated for the PWA areas.
- 5. The option of declaring the watershed a "Wildlife Protection Area" (due to the endangered Atlantic Whitefish) should be investigated through the Ecology Action Center
- 6. A pH survey of Wildcat Brook should be conducted to locate sources of acid mine drainage from previous open shale pits.
- 7. A review should be conducted of the extensive geochemical mapping done by the Department of Natural Resources. Minerals and Energy Branch to alleviate the possibility of heavy metals contamination of the watershed lakes and streams.
- 8. Land owners should be reminded of the prescribed regulations concerning the PWA's especially with regard to clear cutting and other forestry practices.

GLOSSARY

Anadromous: going up rivers from the sea to spawn. (ex: salmon)

Anaerobic: living, growing, or taking place, where there is no free oxygen.

Anticline: a fold of rock strata that bends downward on both sides from its center.

Aquifer: A stratum of earth or porous rock that contains water.

Argillite: a schist or slate derived from clay.

Arsenopyrite: A tin-white or steel gray orthorhombic mineral. It occurs in crystalline rocks and especially in lead and silver veins; it is the principal ore of arsenic.

Biodiversity: The number of species of organisms found in a biotic community.

Chalcopyrite: A bright brass-yellow tetragonal mineral. It is generally found massive and constitutes the most important ore of copper.

Coterminous: having a common boundary; bordering; meeting at their ends.

Deleterious: causing harm; injurious.

Drastic Aquifer Vulnerability Index: A map depicting areas of high and low potential for pollution of surface and groundwater. It is calculated by weighting the factors of: depth to water table; net recharge; aquifer media; soil media; topography; impact of the vadose zone; hydraulic conductivity of the aquifer.

Drumlins: a ridge or oval-shaped hill formed by glacial drift.

Littoral: Pertaining to the depth zone between high water and low water.

pH: a symbol used to indicate acidity or alkalinity. The pH scale, in common use, ranges from 0-14. 7 being neutral, 6-0 increasingly acidic and 8-14 increasingly alkaline.

Pyrite: a common yellow mineral with a metallic luster, a compound of iron and sulfur, which looks like and is often mistaken for gold. It is used in making sulfuric acid.

Pyrrohotite: A common red-brown to bronze pseudohexagonal mineral and is darker and softer than pyrite. Often contains as much as 5% nickel.

Quartzite: a granular rock consisting mostly of quartz and formed by the metamorphism of sandstone.

Schist: a kind of crystalline metamorphic rock that splits easily into layers. It is usually composed mainly of mica.

Strata: a bed or formation of sedimentary rock consisting throughout of approximately the same kind of material.

Till: glacial drift or deposit of stiff clay, gravel, sand, and boulders.

Turnover: Is the hydraulic mixing of water layers with in a lake that occurs in the spring and fall in temperate regions. Turnover is driven by water density changes caused by changes in temperature.

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Mr. Lloyd McCarthy, Age 80+ Conquerall Mills Lunenburg County Retired farmer and woodsman

Mr. Clarence Maughan, Age 70+ Waterloo, Lunenburg County Prospector and woodsman

Mr. Anzel Heim (deceased, Age 80) New Elm, Lunenburg County Lumberman and woodsman

Mr. Kenneth Zwicker, Age 75 Lapland & Wileville Lunenburg County Lumberman and woodsman Mr. Laurie Lacey, Age 65 Mines Road #2 Hebb's Cross, Lunenburg County Naturalist

Mr. W.D. Van Scoyk, Age 75+ Bedford, Halifax County Appraiser

Mr. Greg T. Horne. Age 50
Horne's Settlement
Hants County
(Son of the last full-time gold miner in
Nova Scotia. He related his knowledge
of his father's activities during the past
50 years).