NATIONAL WATER RESEARCH INSTITUTE

INSTITUT NATIONAL de RECHERCHE sur les EAUX

REPORT ON THE 1990 IDRC FUNDED STUDY TO DEVELOP A SELF-SUFFICIENT MICROBIOLOGICAL WATER QUALITY TESTING CAPABILITY WITHIN THE CREE NATION OF SPLIT LAKE

B.J. Dutka, P. Seidl and V. Spence

NWRI CONTRIBUTION 90-170

RRB 90-75

REPORT ON THE 1990 IDRC FUNDED STUDY TO DEVELOP A SELF-SUFFICIENT MICROBIOLOGICAL WATER QUALITY TESTING CAPABILITY WITHIN THE CREE NATION OF SPLIT LAKE

by

[1]B.J. Dutka, [2]P. Seidl and [3]V. Spence

[1]Rivers Research Branch
National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario, L7R 4A6
[2]IJC, Windsor, Ontario
[3]Split Lake Band of First Nations
Split Lake, Man.

DECEMBER 1990
NWRI CONTRIBUTION 90-170

MANAGEMENT PERSPECTIVE

A study was proposed (1987) by Environment Canada personnel to investigate the possibility of delegating the collection, analysis, reporting and responding to bacteriological contamination of drinking and recreational waters to the community health representatives of the Cree Nation of Split Lake. With the financial support of the IDRC (International Development Research Centre) Ottawa, a technology transfer project was initiated in June 1990 with the Split Lake Cree Band of the Assembly of First Nations in Manitoba. This project "Development of Microbiological Water Quality Testing Capability" had two major goals: a) adapt research and monitoring bacteriological laboratory procedures so that they could be applied by untrained personnel using minimal equipment and supplies; and (2) to assist the Cree Nation of Split Lake to become self-sufficient in monitoring and controlling the bacteriological quality of their drinking and recreational waters.

The project was initially started by visiting this isolated Northern Manitoba site and preparing a list of supplies and basic equipment as well as meeting with the Band council. Then after the supplies were in order an intensive hands-on training session took place for three days with video taping. The trainee was a young male Cree member with Grade 10. The training covered glassware cleaning and sterilization, media preparation, sample collection, sample testing, test result recording and bacterial isolate collection for confirmatory studies by the NWRI laboratory. Procedures were instituted to follow up on samples showing bacteriological contamination. These procedures involved (a) resampling the

contaminated source; (b) informing the householder to empty their water barrel and clean it (Javex); (c) monitoring delivery truck hygiene; (d) monitoring water barrel hygiene; (e) extra chlorination of the water treatment plant water; and (d) informing the community health officer (Cree Band member).

Follow-up on-site visits were made approximately every two months to ensure quality of technical work, rectify any technical errors and to provide back-up consultation and moral support.

The eventual goal of this study is to have a basic bacteriological laboratory operated by members of the Cree Nation of Split Lake which can monitor the local communities drinking and recreational water quality as well as providing by contract a service to other Indian Bands within boat or car access to Split Lake.

The impetus for this technology transfer was the concerns expressed by the local Cree community health representative, that when a water sample was sent out into the Provincial water quality testing system, results were received 4 - 6 weeks later. Of course these results would be useless by the time they arrived and the Band council members were given no guidance on what these out-dated results meant.

The success along with the problems encountered in this self-help experiment are described in detail.

PERSPECTIVE GESTION

En 1987, le personnel d'Environnement Canada proposait une étude en vue d'examiner la possibilité de déléguer aux représentants en santé communautaire des Cris du lac Split, le prélèvement d'échantillons d'eau, leur analyse, les rapports et les mesures à prendre pour lutter contre la contamination bactériologique de l'eau potable et de l'eau utilisée à des fins récréatives. Avec l'aide financière du CRDI (Centre de recherche pour le développement international) à Ottawa, un projet de transfert technologique a été entrepris, en juin 1990, avec la bande des Cris du lac Split de l'Assemblée des premières nations au Manitoba. Ce projet de développement d'une capacité de vérification de la qualité microbiologique de l'eau visait un double objectif : a) adapter des méthodes bactériologiques expérimentales de recherche et de surveillance de manière qu'elles puissent être utilisées par du personnel inexpérimenté avec un minimum d'appareils et de fournitures, b) aider les Cris du lac Split à devenir indépendant au niveau de la surveillance et du contrôle de la qualité bactériologique de leur eau potable et des eaux utilisées à des fins récréatives.

Le projet a débuté par une visite de ce site isolé situé dans le nord du Manitoba, l'établissement d'une liste de fournitures et d'équipement de base et une rencontre avec le conseil de bande. Après avoir commandé les fournitures, une séance de formation pratique intensive a été tenue pendant trois jours et enregistrée sur vidéocassette. Le responsable de la formation était un jeune homme de la tribu des Cris ayant terminé une dixième année. La formation portait sur le nettoyage et la stérilisation de la verrerie, la préparation des milieux, le prélèvement d'échantillons, l'analyse des échantillons, la consignation des résultats et le prélèvement d'isolat bactérien pour des études de confirmation par le laboratoire de l'INRE. Des protocoles ont été établis pour le suivi des échantillons contaminés par des bactéries, et comprenaient a) un nouvel échantillonnage de la source contaminée, b) un avis à l'occupant lui demandant de vider son baril d'eau et de le nettoyer (Javex), c) la surveillance sanitaire du camion-citerne, d) la surveillance sanitaire des barils d'eau, e) une nouvelle chloration de l'eau de l'usine d'épuration, et f) un avis à l'agent du service de la santé communautaire (membre de la bande des Cris).

Des visites de suivi sur place ont été effectuées à tous les deux mois environ pour assurer la qualité des travaux techniques, corriger toute erreur technique et assurer un service de consultation d'appui et un soutien moral.

L'objectif visé, en fin de compte, est l'installation d'un laboratoire de bactériologie de base géré par les membres de la nation Crie du lac Split qui permet de surveiller la qualité de l'eau potable et utilisée à des fins récréatives des communautés locales et de fournir à contrat un service à d'autres bandes indiennes qui ont accès au lac Split par bateau ou par voiture.

Les préoccupations exprimées par le représentant en santé communautaire du groupe Cri local étaient à l'origine de ce transfert technologique. En effet, lorsqu'un échantillon d'eau était envoyé au réseau provincial de vérification de la qualité de l'eau, les résultats parvenaient 4 à 6 semaines plus tard, et bien entendu, à leur arrivée, ils étaient inutiles, et le Conseil de bande n'avait reçu aucune directive quant à la signification de ces résultats périmés.

Les réussites ainsi que les difficultés rencontrées dans le cadre de cette expérience d'autonomie sont décrits en détail.

ABSTRACT

This report presents the results from a unique experiment in which scientifically untrained Cree Band members, after being given minimal on the spot training were responsible for the establishment of a self-administered water quality monitoring program. In this program raw drinking water source supplies, treated drinking water in distribution systems and in barrels as well as recreational waters were monitored over a six month period. The bacteriological procedures used in this project were qualitative and semi-quantitative P/A and H_2S paper strip tests and the A-1 broth MPN procedure for fecal coliforms. The results and problems of this self-help experiment are described in detail.

RÉSUMÉ

Le présent rapport contient les résultats d'une expérience spéciale dans le cadre de laquelle des membres inexpérimentés de la bande des Cris, après avoir reçu une formation ponctuelle minimale, ont été chargés de l'établissement d'un programme autogéré de surveillance de la qualité de l'eau. À cette fin, des approvisionnements en eau potable brute, de l'eau potable traitée dans des réseaux de distribution et en barils ainsi que des eaux utilisées à des fins récréatives ont été surveillés pendant une période de six mois. Les analyses bactériologiques effectuées dans ce projet étaient des essais qualitatifs et semi-quantitatifs de présence ou d'absence, des essais sur bandelettes pour le dosage de H_2S, et des épreuves de dépistage de coliformes fécaux par la technique du nombre le plus probable en bouillon A-1. Les résultats et les problèmes de cette expérience d'autonomie sont décrits en détail.

INTRODUCTION

Outside of the urban centres in Canada, there are many small pockets of habitation scattered throughout the northern and rural parts of Canada which do not have ready access to treated and routinely monitored drinking waters. This is especially true of the majority of the Inuit and Indian communities.

In 1987 a preliminary bacteriological study of the recreational and potable waters was undertaken in several isolated Northern Manitoba Indian communities. This lead in 1988 to a pilot study to examine the feasibility of setting up a self-administered bacteriological water quality monitoring program in a remote Indian community (Seidl et al. 1990). The Cree Nation in Split Lake Manitoba (Fig. 1), was selected as the site for this study (Seidl et al. 1990). There were two closely related objectives in this study: the first was to evaluate the suitability of four simple inexpensive bacteriological water quality tests (Dutka, 1991) which would be used by technologically untrained Band members to assess the bacteriological quality of their potable water supplies and their recreational waters; and the second objective was to determine the bacteriological quality of Split Lake recreational and potable waters.

Both, the data (Seidl et al. 1990) from these two preliminary studies and the positive attitude of this Cree community were strongly supportive of our concept that an isolated community with minimal support could be responsible for ascertaining the quality of their potable waters and source waters. To this end a proposal was developed by B.J. Dutka (NWRI) and P. Seidl (IJC) in conjunction with the Cree Nation Council of Split Lake and was submitted for

possible funding to the International Development Research Centre (IDRC), Ottawa, Canada.

This proposal lead to the awarding of a Grant in April 1990 to the Council of Split Lake by the IDRC to "Develope a self sufficient microbiological water quality testing capability within the Cree Nation of Split Lake of The Assembly of First Nations". The general objective of this proposal was "to evaluate the feasibility of using simple inexpensive bacteriological tests by Split Lake community members to screen drinking water supplies and raw drinking water sources in isolated northern communities".

Specific Proposal Objectives

The specific objectives of this IDRC supported proposal were:

1. to develop a prototype, basic bacteriology laboratory to be run by Cree community members of Split Lake, Split Lake, Manitoba;
2. to initially develop local expertise in the Presence/Absence (P/A), and A-1 fecal coliform MPN procedures;
3. to evaluate quantitative variations of the P/A test to establish the possibility of developing a numerical index; and
4. to identify the Enterobacteriaceae which are found in selected P/A, and A-1 broth positive samples.

General Proposal Objectives

1. To train community health representatives in the implementation of a self-sufficient bacteriological program, and

2. to improve community awareness and knowledge of drinking water and recreational water quality in Split Lake.

Study Area Background

The community of Split Lake, Manitoba, is located at latitude 50° 15' north, and longitude 90° 07' west, on a peninsula on the north shore of Split Lake on Indian Reserve No. 171 (Fig 1a).

Most of the shorelines of Split Lake are bedrock controlled with a narrow discontinuous zone of exposed bedrock at the water's edge. Sandy shorelines are generally found in coves protected by rock headlands. The area is in a zone of discontinuous permafrost within the Canadian Shield. The community is located in an area with relatively deep clay soil.

The community is accessible by an all weather gravel road, Provincial Road No. 280, approximately 120 kilometres northeast of Thompson and approximately 820 Kilometres north of Winnipeg, Manitoba (Figure 1). The Band's mother tongue is Cree and approximately 1,300 people live on the reserve, with 1600 Band members registered. Housing is in short supply and with an average family size of 5.3 persons, overcrowded conditions exist. These housing conditions are similar to those found on most reserves in Manitoba.

Water Supply and Treatment

The Cree Nation of Split Lake as one of the five Indian reserves affected by a hydroelectric project and also a signatory to the Northern Flood Agreement has recently (1987-1988) received upgraded

water supply and sewage treatment facilities. Prior to this initiative, treated water supply was limited to a distribution system that served the school and teacherages and, for a time, a series of standpipe taps of filtered and chlorinated water were distributed throughout the community. These systems experienced operational problems, especially due to freezing and vandalism.

The gathering of water by pail from either the standpipe or the lake has gradually ceased as 300 litre water containers (Fig. 2) were installed in houses and water is delivered by truck (Fig. 3). Although this method attempted to increase water quantity to the houses, water quality was still questionable and contamination problems were experienced both at the source and in the homes.

The problems experienced with the water tanks in the homes was mainly due to the resident's unawareness of what was good hygiene. Many of the residents circumvented the intent of using a closed water barrel with its bottom tap, by removing or modifying the lid and hand-dipping water for their use. This practice allowed for the easy contamination of the whole 300 litres of water.

The new drinking water treatment plant recently built is providing piped water to the west end of the community and for the water trucks which deliver the water to the rest of Split Lake. Eventually all homes will receive piped treated water.

Sewage Disposal and Treatment

The school and teacherages use an extended aeration package plant for sewage treatment with discharge to the north side of the peninsula into Split Lake (Figure 1). This plant now inoperative experienced

many operational problems and the treatment provided was very erratic and inadequate. Septic tanks with fields are used by the Nursing station, the Northern Store and the R.C.M.P. office. Most of the residents use a pit privy for sewage disposal. The west end of the community is now serviced by upland sewage lagoons built in 1989.

Eventually with the extension of the piped water system all houses will have in-house toilets with the sewage being collected in these lagoons for treatment.

BACTERIOLOGICAL PROGRAMME

A very basic laboratory was established in a small room in the basement of the Nursing station at Split Lake (Fig. 4, 5, 6). The laboratory consisted of, 1 folding table, 1 table, 2 small sets of shelves, a small canning autoclave, small incubator, later another small incubator was purchased, a pan balance, a rinsing pipette washer, a household common use refrigerator and the kitchen stove of the Nursing station which was used as the hot air oven and to heat the liquid media and sterilize some of the glassware. There was hot and cold contaminated water and a large double sink which was used to wash the glassware.

The laboratory was minimally supplied with pipettes, tubes, bottles, sample bottles, petri dishes and all the necessary media and chemicals for the tests.

Bacteriological Tests

Two very simple, relatively inexpensive bacteriological water quality tests were evaluated during this phase of the study; the P/A (Presence/Absence) test (Clark 1968) for drinking water assessment and the five tube, three series, Most Probable Number test (MPN) for fecal coliforms using A-1 Broth (APHA 1985) for assessing the recreational and raw potable water quality.

The P/A test can be performed using various amounts of media so that a rough quantitative measure can be made. In the routine test, 50 mL of media is placed into a screw capped bottle and autoclaved. Then 100 mL of potable water sample is added, the capped bottle is shaken, and then incubated at 35°C for up to 5 days. If the colour of the media changes from red to yellow, a positive result (contamination) is recorded indicating the potential presence of one or more indicator bacteria such as coliforms, E. coli, Pseudomonas aeruginosa, staphylococci or fecal streptococci. Isolation and identification procedures were carried out on positive samples for confirmation. To quantitate the results, P/A broth volumes were dispensed to accommodate the testing of 100, 50, 25, 10 and 5 mL volumes of suspect potable waters or recreational waters.

A preliminary feasibility study using the H_2S paper strip technique was also carried out. For this study, the H_2S paper strip was prepared in a non standard procedure (Manja et al. 1982). In bottles, into which 100 mL of water sample were to be collected, one half of a Whatman #3 filter paper was placed into each bottle and then 5 mL of the appropriate chemical solution (Manja et al. 1982) was added to each filter paper. For bottles which were going to be used

to test 20 mL water samples (the standard procedure), one quarter of a Wattman #3 filter paper was added to each bottle and then 1 mL of the chemical solution was added to the filter paper. The bottles were then capped and sterilized by dry heat for 75 min. at 150°C.

Isolate Study

Positive P/A broths and H_2S paper strip samples were sub-cultured to MacConkey agar plates which were then sent to B.J. Dutka at NWRI in Burlington, Ontario. Here the cultures were purified and submitted to the Bacteriology Department, Joseph Brant Hospital for identification.

Training

During the first phase of this study a young Cree Nation Community member Douglas Kitchekeesik who had a grade 10 education was selected by the Split Lake Community to be trained for this study.

Approximately 15 hours of training was provided in June of 1990 by B.J. Dutka. This training involved the preparation of media, sterilization of media, preparing sterile bottles for sample collection, processing the samples, reading the sample results, collecting isolates and disinfecting, washing and sterilizing the tubes, bottles and pipettes. On July 24-26 P. Seidl visited the reserve and provided a one-to-one review of the sample collection procedure, and laboratory tests. In September 18 - 20, B.J. Dutka again visited Split lake to review the testing procedures and make modifications to the sampling programme.

SAMPLE COLLECTION AND ANALYTICAL PROGRAMME

This is the first scientific project that we are aware of, that has taken a laboratory research project and let the individuals being impacted by the problem actually do the laboratory work and data collection.

The details of the initial and revised collection and analyses programs are provided in detail to show the expectations of this project. In the hands of qualified technical staff working in traditional laboratories these expectations could easily be accomplished. However, working in a remote part of the country where there is no laboratory, and working with untrained staff who have never participated in any scientific project or laboratory work, and with various local, social and supply problems, any accomplishment must be congratulated. The self help part of this project can not only help the community but will build confidence in the band members involved in the analytical processes.

The initial programme was a follows:

(a) "One hundred and twenty-five potable water samples, in duplicate, will be collected from the water treatment plant, points in the distribution line, water trucks and water barrels and the Northern store and the Nursing station and tested by P/A method procedure.

(b) Evaluation of a qualitative P/A test by using 5 mL broth for 10 mL water, 25 mL broth for 50 mL water will be carried out on 50 duplicate water samples being tested in (a);

(c) Isolates will be collected from a maximum 25 positive drinking water samples by transferring to MacConkey agar and submitting them to B.J. Dutka, Ecotoxicology Laboratory, Rivers Research Branch, National Water Research Institute.

(d) Fifty natural water samples will be collected from areas used as drinking water sources and recreation and tested by the A-1 broth MPN and P/A dilution procedure (5 mL sample, 10 mL sample, 25 mL sample and 50 mL sample)".

As the summer progressed, several problems developed which greatly impacted on the above programme. These were:

(a) the non availability of P/A broth and A-1 broth from all distributors due to manufacturer's problems, which caused a delay and affected the flow of the programme;

(b) the availability of only one incubator to process samples at 35°C (five day test P/A) and 44.5°C (one day test, A-1 broth). With approximately a one day turn-around between stabilized incubator temperatures, it could take up to 9 days to run one set of 35°C and 44.5°C samples; and

(c) the marriage of Douglas Kitchekeesik and subsequent honeymoon during the sampling season (August 17, 1990).

The above problems were slowly and partially resolved by the following activities:

(a) the NWRI laboratory loaned the Split Lake Community all of its A-1 broth and P/A media which provided temporary relief so that samples could be processed at a lower rate. Later in the year 500 grams of P/A broth was delivered from the dealer's outlet. However, there is still a media back order;

(b) the incubator problem was solved on September 18, with the arrival of an incubator with refrigerator capabilities which was purchased by the Cree Nation Split Lake from Crown Assets; and

(c) with the return of Douglas Kitchekeesik from his honeymoon, laboratory processing started to return to normal although the summer recreational water sampling programme was greatly reduced and this important data can not be replaced for 1990.

A further problem developed shortly after B.J. Dutka's visit to Split Lake on September 17 - 20, 1990, and this was Douglas Kitchekeesik's decision to go hunting and quit working in the laboratory. This decision impacted heavily on the programme and one month of sampling time was lost. With the able assistance of Victor Spence, (the local Cree Community health representative who had been trained during the 1987 and 1988 studies to perform the bacteriological tests), Leon Flett a Split Lake Cree with grade 12 education was recruited to fill the void left by Douglas Kitchekeesik.

Under the able guidance of Victor Spence a modified water quality testing programme was resumed in late October.

REVISED PROJECT

During B.J. Dutka's visit to Split Lake in September, it was realized that the previously mentioned problems had impacted the original programme goals and that changes were required so that maximum benefits would be achieved from this programme.

In reviewing the programme it was found that some parts of the project were greatly ahead of schedule and exceeded the original proposals e.g. the drinking water samples which were to be tested in

10 mL, 50 mL and 100 mL portions by the P/A test, while other parts of the project were greatly behind schedule e.g. recreational water samples and isolate collection from P/A and A-1 broths.

In setting up a revised work plan a semi-quantitative H_2S paper strip test (Manja et al. 1982) for testing drinking water was included in the revision to evaluate the feasibility of developing this test for drinking water evaluation during the proposed 1991 programme.

Revised Project Details

1. "Seven sets of recreational water samples from six sites to be tested by A-1 broth. Two of these sets of samples should also be tested by P/A test using 5 mL, 10, 25 and 50 mL water samples. Isolates will be collected from one set of A-1 broth positive samples and P/A broth positive samples. The isolates should be collected from the lowest set of dilutions of A-1 broth that are positive and similarly from the smallest sample tested by the P/A procedure which was positive.

   Example

   Set 1 A-1 broth - 6 samples - also P/A broth dilutions
   Set 2 A-1 broth - 6 samples
   Set 3 A-1 broth - 6 samples - also P/A broth dilutions
   Set 4 A-1 broth - 6 samples
   Set 5 A-1 broth - 6 samples
   Set 6 A-1 broth - 6 samples
   Set 7 A-1 broth - 6 samples

   Isolates to be collected from either set 1 or set 3 and maximum number of isolates = 12.

2. Collect 3 sets of drinking water samples with 10 sampling sites per set for total of 30 samples.

   Each of the above samples will be tested

   (a) 10 mL, 50 mL and 100 mL samples by P/A method

   (b) 20 mL, 50 mL and 100 mL sample by H_2S paper strip technique.

   From a maximum of 10 samples with both P/A and H_2S paper strip tests positive, isolates will be collected from each positive medium from the lowest sample volume tested. Maximum of 20 isolates will be collected.

   From a maximum of five samples which are P/A positive and H_2S paper strip negative, collect isolates from the lowest sample volume giving positive result. Maximum of five isolates will be collected.

   From a maximum of five samples which are H_2S paper strip positive and P/A test negative, collect isolates from lowest sample volume giving positive result. Maximum of five isolates will be collected.

3. Thirty drinking water samples to be tested by the following procedures and volumes:

   100 mL P/A in duplicate

   20 mL and 100 mL H_2S paper strip

   10 mL into five tubes double strength A-1 broth at 44.5°C

   Isolates from the above will be collected following the regime provided below.

   (a) isolates from both P/A and H_2S paper strip tests which are both positive in the sample. A maximum of five isolates from each for total of 10 isolates;

(b) isolates from a maximum of five H_2S paper strip positive samples where the P/A test is negative;

(c) isolates from positive A-1 broth tubes, preferably from samples which had a P/A positive response and from which isolates were also collected, maximum five isolates".

RESULTS & DISCUSSION

P/A Duplicate Samples

One of the unknowns in this study was the question whether non-technically trained personnel could produce reproducible results in a qualitative bacteriological test. Another concern was how reproducible were P/A results when used in a semi-quantitative fashion.

A total of 45 drinking water samples from July 9 to December 13 were tested in duplicate using appropriate volumes of Presence/Absence (P/A) broth into which were placed 10 mL, 50 mL and 100 mL samples of drinking water. Incubation was at 35°C for up to 5 days. All 45 duplicated samples produced the same results as found in its paired sample. Twenty-nine of the samples were completely negative and five of the samples were positive in all volumes tested after 1 days incubation. From these positives it can be deduced that there were at least 10 indicator organisms per 100 mL of sample.

There were two samples which produced positive results (growth) in the 50 mL and 100 mL samples after 1 days incubation while the 10 mL sample remained negative for the full five days. Five samples produced similar results except that the 50 mL and 100 mL samples were

positive after 2 days incubation while the 10 mL sample remained negative for the full five days of incubation. These results suggest that there were less than 10 indicator organism per 100 mL, possibly two or more different types or mixes of organisms.

Two samples produced positive 100 mL samples after 24 hours of incubation while the 10 mL and 50 mL aliquots remained negative for the five days of incubation, an indication that there was only one or two indicator organisms per 100 mL water sample.

One duplicated sample had positive 100 mL sample volumes after 2 days of incubation and positive 50 mL sample after 4 days incubation. These results suggest that there were more than two indicator organisms per 100 mL and less than 10. The remaining positive duplicated sample had a positive 50 mL aliquot after 2 days incubation with both the 100 mL and 10 mL samples remaining negative during the whole incubation course. This rare result suggests there was a very sporadic distribution of indicator bacteria and probably in the range of 1 or <1 per 100 mL. It would be by extreme chance that in duplicate sets one would find only the 50 mL aliquots being positive after two days incubation.

These results suggest that the technical skills to prepare and apply these tests were mastered. Also the P/A test in its semi-quantitative format is a sensitive reproducible testing procedure which provides a estimate of the bacterial contaminant indicator load in the drinking water.

During this study isolates were collected from some of the positive P/A bottles by subculturing to MacConkey agar. Different colony types were identified by the Microbiology Department of the Joseph Brant Memorial Hospital in Burlington using Microscan panels.

In several samples there were more than one organism found and in one sample three organisms were identified. The indicator organisms identified in order of prevalence were: Klebsiella pneumoniae, Enterobacter cloacae, Enterobacter aerogenes, Citrobacter freundii, Klebsiella oxytoca, Klebsiella species, Enterobacter amnigenus, Pseudomonas fluorescens, Pseudomonas aeruginosa and Serratia amnigenus No E. coli were isolated from these duplicated samples which suggests there was no direct fecal contamination of the drinking water supplies. The contamination of the drinking water was more than likely due to poor hygienic practices.

Treated Drinking Water Sources

In Split Lake there are four main sources of treated/purified drinking water, the water treatment plant (WTP), the water truck which distributes WTP water, the Nursing Station and the Northern store. The WTP takes it's water from Split Lake, filters and chlorinates the water and distributes it to some of the community homes, the school, teacherages and the Band office. The water truck collects the water from the WTP from an outside overhead tap and distributes the water through a hose into individual water barrels in the homes. Both the Nursing station and Northern store have their own pump and filtering units to process the water from Split Lake for drinking, washing and cooking.

These four purified water sources were tested for contamination by the P/A method during the May 14 - Dec. 13 period. A summary of the results of this testing is shown below in Table 1 and in Table A of the Appendix.

Table 1. P/A test results of treated drinking water sources, Split Lake, Manitoba

Sampling Site	No. of times tested	No. of times negative	No. of times positive	% of time positive
WTP	19	16	3	15.8
Water truck	13	10	3	18.7
Nursing Station	16	5	11	68.7
Northern Store	15	5	10	66.7

From the above Table 1 it can be seen that the WTP and water truck delivery system provide the community with a much better quality of water than the two private treatment units.

The data also indicates (Table A, Appendix) that on two occassions the WTP and water delivery truck samples were both positive suggesting that there was a breakdown within the WTP on July 9 and December 13. Furthermore on July 9, all four treated water sources were contaminated, and isolates collected from the positive P/A broths indicated that the water truck, Nursing Station and Northern store samples were each contaminated by two species of Enterobacter cloacae. The WTP sample was contaminated with Enterobacter cloacae and Klebsiella pneumoniae. These results suggest that Split Lake waters prior to the sampling period contained elevated populations of Enterobacter cloacae and possibly lower populations of Klebsiella pneumoniae. From Table A of the Appendix it can be seen that on one sampling date the water truck water was contaminated while the WTP Water was negative for bacterial contamination, suggesting either a very dilute contamination of the WTP water or the truck load of water become contaminated due to a break down in sanitary operating procedures. Also, from Table A of Appendix it can

be seen that the WTP sample was contaminated on August 24/90 however, no water truck sample was collected on August 24, and thus we were not able to ascertain whether or not homes supplied with barrels received this polluted water.

Water Treatment Plant and Piped Distribution System

A total of 73 drinking water samples (26 sites) were collected from the water treatment plant (WTP) and residences and buildings (Table 2) receiving WTP water through the piped distribution system. These water samples, as were all drinking water samples, were tested semi-quantitively by the P/A test using 10, 50 and 100 mL samples of sample water. Of the 73 samples tested in this study 59 (80.8%) produced negative responses in the 5 day P/A test.

There were 26 different sampling sites in this study and 16 of these (61.5%) were negative; the frequency of sampling at these 16 non-contaminated sites was, one site 13 times, one site 4 times, one site 3 times and thirteen sites one time. The repeated sampling with negative findings at three sites, Grade 9 classroom, D. Spence residence and residence #4, suggests that the WTP does deliver good quality water most of the time.

The WTP was tested 19 times during this study period, May 14 to Dec. 13/90, and contaminated samples were found on three occasions. On the days the WTP water was found to be contaminated, the contamination was also reflected in the communitie's water supply e.g. on July 9, both community samples were positive, on August 24, three out of four community samples were positive and on December 13, one out of three community samples were positive. These results do not take into consideration those homes supplied by the water truck.

On July 9th, we had our best documentation of the impact a contaminated WTP water has on the community (Table 2). All three of the samples had >10 indicator organisms/100 mL and the isolate data indicated a mixed bacterial contamination with Enterobacter cloacae being found in all three water samples and Klebsiella pneumoniae also being found in the WTP and in one of the home samples. The water truck sample also was found to contain two different varieties of Enterobacter cloacae on this date. Due to the >10 indicator count estimate (Table 3) in all these samples, and the realization that water produced by the WTP is not necessarily used by all residences within the same hour or day, it is strongly suspected that the water had been contaminated for several days prior to sample collection. All water samples on July 9 were collected within one hour.

On August 24th, the WTP water was again found to be contaminated with three of the four community samples tested also being contaminated. This contamination appeared to be lower in bacterial concentration than the July 9th event. Unfortunately only one of the positive samples was subcultured for organism isolation (Residence 6, Table 2). This sample had a indicator bacterial density of <10/100 mL and the organism cultured was Pseudomonas aeruginosa. Similar to comments made on the July 9th samples, it would appear that the contamination had been ongoing for at least one day and the contaminated water was impacting the residences at different rates or selectively. The one positive household found on August 27th, which was being sampled for the first time may have been contaminated by the August 24th contamination. It should be noted that no alarm was raised until 24 hours after the WTP water proved to be positive from the August 24 sampling.

The third and final WTP positive sample occurred on December 13th and only one out of three residences tested was found to be contaminated. However, as can be seen from Table A of the Appendix, the water truck's water was also contaminated on this date. The contamination level was very low, approximately two indicator organisms per 100 mL, and again no isolates were collected to establish the source of the contamination. Since the WTP was tested on December 10, 1990 and the P/A tests were negative it must be assumed that this contamination occurred between December 10 and December 12.

The semi-quantitative format used with the P/A test (Table 3), does appear to give investigators a good idea of the severity of the bacteriological contamination. Fifty percent of the contaminated samples had bacterial indicator populations of 10 or greater/100 mL. This semi-quantitative P/A format coupled with an isolate collection and identification programme would be very instructive on the degree and sources of the bacteriological contamination impacting the WTP and the Split lake Community.

Mini-Study using P/A and H_2S Paper Strip Procedures

On September 19th and 20th, a total of 19 water samples were collected from (a) WTP; (b) Water truck; (c) Grade 9 classroom; (d) Northern Store; (e) Nursing Station; (f) Senior Group Home and (g) six residences, for the comparison of the P/A and H_2S paper strip technique in screening for indicator bacteria in drinking water.

In Table 4 the results of this study are summarized. From Table 4 it can be seen that 61.1% of the samples tested showed similar

positive and negative responses in the two tests. Also, it can be observed that the H_2S paper strip procedure if used alone, 66.7% of the contaminated water samples would have been found, while 94.4% of the contaminated samples would have been found by the P/A test procedure.

Bacterial isolates were collected from all P/A and H_2S paper strip procedures which were positive within 24 hours from the September 19th samples. Six of the nine samples collected were positive, five by the P/A method and two by the H_2S paper strip procedure. One water sample from a residence had both the P/A and H_2S paper strip procedures positive within 24 hours. Isolates from this positive sample indicated that Enterobacter cloacae were present in the P/A bottle and Enterobacter cloacae and Kluyvera cryocrescens were both present in the H_2S paper strip bottle. In the other H_2S paper strip positive sample E. coli were found. This E. coli was only the second isolated in 1990 from a drinking water.

In the other four P/A positive samples Klebsiella pneumoniae were found. Thus from this preliminary mini study it would appear that a semi-quantitative H_2S paper strip procedure is feasible, and has potential as a water quality indicator in these waters. More research is required to evaluate this very simple inexpensive drinking water testing procedure.

In another major study undertaken to evaluate the P/A test's ability to screen for indicator bacteria belonging to the Enterobacteriaceae, water samples were collected from the water barrels (taps) found in many of the homes (Table 5, Table C Appendix). As noted earlier these barrels were filled by removing the lid and holding the hose nozzle over the barrel and pumping in the

water from the truck, a process very similar to filling a car's gas tank. After filling, the closed barrels were then supposed to be drawn down by use of a bottom tap. Unfortunately this was not the case. In many homes the water was hand dipped from the top using a variety of pots, glasses etc. after the lid was removed and in at least one home the lid was cut in half and hinged so that there was easy access to the barrel. These procedures by passed the intended use of the barrels, as containers of uncontaminated water.

From Table 5 it can be seen that 21 water treatment plant (WTP) samples were tested with only three of samples (14.3%) producing a positive P/A test. The water truck, after filling up at the WTP by means of an overhead outside hose, was tested 15 times and three of the samples (20%) were positive by the P/A test. On two sampling occassions July 9 and December 13 both the WTP and water truck were found to be bacteriologically contaminated. On another occassion when a positive WTP sample was found, the water truck was not tested, while on another occassion the water truck sample was found to be contaminated but the WTP sample was negative. In this last instance (Nov 19) it is suspected that the water truck tank or hose was the source of the contamination, as distribution line samples collected on the same day (Table 2) were also negative, this supporting the belief that the truck was the source of this contamination.

The July 9th samples, have proven to be an excellent example of how important a good water supply is to any community. During July 1990 the water levels in Split Lake were very low, due to Hydro demands, which resulted in the exposing or almost exposing of the water intakes in the lake for the WTP, Nursing station and Northern store. This lowered water level is believed to have resulted in a

more turbid water due to the extra suspended sediments/particulates being sucked up by the WTP and other pumps. For the WTP this excessive organic load probably depleted the normal chlorine loading, resulting in a bacteriological break through. This break through resulted in the water truck water being contaminated, the home barrels receiving this water being contaminated and the homes along the distribution line also receiving contaminated water (Table 2). Thus any momentary failure can very easily be the focal point for an outbreak of enteric and other infections.

Isolates collected from these positive P/A broths including the Northern Store and Nursing Station all contained Enterobacteriaceae species and or Klebsiella pneumoniae with one sample containing Serratia forticitia and Klebsiella pneumoniae. Since all isolates were collected from the smallest sample volume that produced a positive P/A test, it must be noted that other Enterobacteriaceae were very likely present but to a lesser degree and their colonies were not able to be differentiated and selected from the major background growth for identification.

From the pattern of identified organism in the various P/A broths we can establish that Klebsiella pneumoniae and Enterobacter spp were the predominating Enterobacteriaceae in the near-shore waters of Split Lake. Also it can be seen that the P/A test has proven to be a simple reliable method for quickly pin pointing treatment insufficiency and breakdowns in sanitary practices. These problems can then be addressed immediately rather than having to wait days or weeks to be informed by an outside agency that Split lake drinking water had been or still was contaminated.

Based on the P/A semi quantitative approach used in these samples it can safely be said that there were more than 10 Enterobacteriaceae per 100 mL of water. Since the majority of the P/A broths produced positive responses in less than 18 hours, it is suspected that contaminating bacteria were in the 50 - 100/100 mL range.

Immediately after it was realized that the WTP water was contaminated, chlorination was increased. Water samples collected later in the day (July 10) after the increased chlorination were all negative (Tables 2 and 5) with the exception of one home (residence #1 Table C Appendix) whose water barrel still contained Klebriella pneumoniae, probably due to inadequate disinfection of the barrel before receiving a new water supply.

The above scenerio provides an excellent example of how a simple, community used, bacteriological testing procedure can be used to monitor their own drinking water quality and ensure its safety and the communities health.

On December 13 (Table 5) there was another example of the impact a contaminated drinking water source can have on a community drinking water purity. In this Table it can be seen that the WTP, water truck and the three home barrels which were tested, were all positive with estimated indicator counts varying from <10 to 10 or greater. Unfortunately, no isolates were collected from these positive P/A broths.

November 19th, the water truck sample was positive with 10 or more indicator organisms/100 mL as well as one home barrel. The positive home barrel was the Senior Citizen's home barrel which during this 1990 study was positive 15 times (88.2%) out of the 17 times it

was tested. There may not be a relationship between this positive water truck sample (Nov. 19) and the positive Senior Citizen's home barrel (Nov. 19).

During this home barrel study using the P/A test, 51 samples were collected from home barrels and 42 (82.3%) were contaminated and nine produced negative P/A tests. Seven of the nine negative barrel samples occurred during the months of Nov. and Dec., which may reflect an awakening awareness of good hygiene and the practices that help contribute to contaminated barrels or the onset of colder winter weather which inhibits the rapid growth of Enterobacteriaceae in the water barrels which are mainly stored in unheated porches.

From the identified isolates collected from the positive P/A broths subcultured to MacConkey agar, it was establishedthat the predominate Enterobacteriaceae were (1) Klebsiella species, (2) Enterobacter species, (3) Citrobacter species, (4) E. coli and, (5) Serratia forticita.

From the results shown in Table 5 it can be seen that generally the WTP and water truck provide the Split Lake Community with good quality drinking water. However, when there is a WTP breakdown, no matter how minor, the whole community is quickly impacted and the P/A test applied by Band members can quickly discover the problem and its source and solve the problem. Thus the community now has proven tools to help maintain its own drinking water quality.

In general the home barrels are the main sources of contaminated drinking water in Split Lake. This is probably due to a lack of understanding, by the barrel users, of how bacteria spread and that a clear water is not necessarily a clean water.

The Guidelines for Canadian Drinking Water Quality 1978 states:

"since the presence of any type of coliform organism in treated water suggests either inadequate tratment or contamination, the objective level for total coliforms should be no organisms detectable per 100 mL; however, in practice this level is not always attainable. The following maximum acceptable level is therefore recommended:

1) no sample should contain more than 10 total coliform organisms per 100 mL; and
2) not more than 10 percent of the samples taken in a 30-day period should show the presence of coliform organisms; and
3) not more than 2 consecutive samples from the same site should show the presence of coliform organisms; and
4) none of the coliform organisms detected should be fecal coliforms.

From the data obtained by the application of the semi-quantitative P/A test in this study, it can be seen that the majority of the contaminated drinking water samples contained 10 or more total coliforms/100 mL and some of them contained fecal coliforms (E. coli and Klebsiella pneumoniae). Thus the P/A test does provide the Split Lake Community with a simple, effective procedure to ensure that their potable waters stay within Canadian Drinking Water Quality guidelines.

Recreational Waters

The A-1 broth fecal coliform test has been shown in many studies to be a very sensitive and efficient test for estimating fecal coliform populations in water. Using this procedure as the primary test, six

Split Lake beaches had their near-shore waters tested during the July-December 1990 period. To some of these beach water samples a semi-quantitative P/A test was applied. This test was set up by incubating at 35°C to estimate the presence or absence of Enterobacteriaceae (coliforms) in 5, 10, 25, 50 and 100 mL aliquots of beach water.

Examination of the P/A test results (Table 6) it can be seen that this procedure usually provided higher indicator count estimates than the fecal coliform test. This is not unexpected since the fecal coliform test is only recorded as positive if acid and gas are produced after incubation at 44.5°C. Ths P/A test responds to any of the Enterobacteriaceae which can produce acid and gas and 35°C e.g. total coliform group. As can be seen from the isolates collected, both procedures (A-1 broth or P/A) will estimate the densities of the same types of indicator species. However, the P/A test also measures enterobacteriaceae not usually considered to be fecal coliforms e.g. Citrobacter freundii, Proteus species and Serratia species.

These data suggest that the P/A test might be of use to estimate the contamination of a natural water that is used directly from drinking, however it is too non-specific to be used for recreational water quality and thus over estimates the potential hazard.

Examination of the fecal coliform data (A-1 broth) in Table 6, presents evidence that the inshore beaches of Split Lake are only minimally impacted by fecal pollution with the highest fecal coliform count being 33/100 mL. Examination of all the A-1 broth data indicates that 86.8% of the fecal coliform MPN counts were <10/100 mL. Notwithstanding these very low fecal coliform counts, the isolate data indicates that 13 of the 29 indicator organisms (45%) identified

were E. coli. The only known source of E. coli in temperature and northern climates is fecal material. Thus these MPN counts are suggestive of a low grade on going fecal pollution of these waters. It is not known whether the origin of these E. coli are animals or man.

From the pattern of positive and negative A-1 broths found in this study, it would appear that the two band members performing this test are completely competent to carry out these test.

Future Studies

Since the H_2S paper strip technique (Manja et al. 1982) is based on the testing of only 20 mL of water sample while the P/A and membrane filtration test for total coliforms are based on testing a 100 mL sample, there is a strong possibility, as shown in the mini study, that with research into media concentrations versus sample volume, the H_2S paper strip could be used to test 100 mL sample volumes, thus perhaps making it comparable to the P/A test in sensitivity.

Another candidate procedure that is easy to perform, inexpensive to run and may provide an added margin of safety in water quality testing, is the bacteriophage/coliphage indicator system. Bacteriophages are virus-like entities that invade bacterial cells. Guelin in 1948, was the first researcher to properly apprise the potential of bacteriophages as indicators of fecal pollution. Since Guelin's recognition of the potential of bacteriophage to act as indicator systems, there have been several research reports indicating the potential of bacteriophage/coliphage to act as indicators of microbiological water quality (Besco, 1963; Kenard and Valentine,

1974; Scarpino, 1975; Wentsel et al., 1982; Grabow et al., 1984; Kennedy et al., 1985; Petrovicova et al. 1988). The most detailed and intensive studies on growth and recovery of coliphage can be found in the Atlanta Research Report of 1979 by Scott et al.. In an earlier major review of coliphages by Scarpino (1975) he stated "correlations appear to exist in fresh and marine waters between fecal bacterial pathogens, such as Salmonella and Shigella species and fecal indicator such as Escherichia coli and their bacteriophage". Then in 1984, Grabow et al. reported "coliphage counts could give a useful estimate of numbers of other microorganisms in sewage polluted waters" and in their studies "evidence is presented, that though counts of coliphages may not always directly correlate with those of enteric viruses, coliphages meet the basic requirements of an indicator for the virological safety of water".

From the studies performed at the Atlanta Research Corporation (1979) and others reported in the recent literature, it would appear that in the various environmental and drinking waters tested that the coliphage procedure (APHA 1985) is a reliable indicator of E. coli and coliforms. There is also sufficient evidence to suggest that the coliphage test has many advantages over tradiational bacteriological and possible virological hazards, this procedure has great potential for universal application, especially as all countries are faced with increasing stresses on water supplies, rising analytical costs, and decreasing budgets.

Split Lake Community Response

The Cree Nation community and democratically elected Council of Split Lake have welcomed the opportunity to conduct and coordinate a self-governed health service for the benefit of their people. Since the inception of the pilot scale program in 1988, this community effort has continually matured. The community involvement has escalated to a three-man team of investigators, trained sufficiently to maintain and report on the bacterial assessment of the community's drinking and recreational waters. The laboratory facilities have been consolidated to a room solely used for the bacterial assessment of samples with the exception of the sterilization oven which is in the Nursing Station kitchen.

The sampling network has touched most of the community residents of which approximately 50% are still obtaining their drinking water from 300 L polyethylene barrels. There has been full cooperation from the households sampled. The residents have cleaned their water containment system, whether tap or barrel, when told that their supply was contaminated. In fact, the entire infrastructure of water distribution and residents of the community is directly linked to the drinking water assessment reported by the investigators. The remedial response strategy applied to the contamination of the water supply is felt throughout the water distribution system.

The trust and continuing confidence in the nature of the results has been growing from repeated experimentations by the trainees and this increased knowledge and awareness has been transferred into the people. This self sufficient bacterial assessment program has improved their understanding of the potential sources of

contamination, the frequency and types of contamination of both drinking and recreational water sources, and the selected available options for remediation and mitigation of the problem. The Council is proposing to create a fund for long term support of this water assessment effort and to consider the development of a separate laboratory facilities which could be used for a number of environmental assessment options.

In 1987, when the first contact was made with this community, there was no knowledge or awareness of the source of the continual contamination of the water supply. Now the community has the scientific tools to develop understanding and build upon their experience.

SUMMARY

1. The P/A test used in a semi-quantitative mode showed reproducible results and provided the Cree Nation of Split Lake with quick direct information on the quality of their drinking water.
2. The finding of positive P/A test results, triggered an immediate response by the Band members to clean up the problem area.
3. Isolate data collected from the positive P/A tests indicated that this procedure was responding to the Enterobacteriaceae in the drinking water.
4. The A-1 broth test from fecal coliforms worked well in this primitive laboratory and ensured the Reserve that their recreational waters and raw drinking water source waters were only minimally polluted by fecal pollution.

5. Isolates from positive A-1 broths indicated that the procedure was isolating and enumerating E. coli and other Enterobacteriaceae. No difficulties were encountered with the
6. performance of either the P/A or A-1 broth tests.
7. The results of H_2S paper strip water quality test procedure used in a semi-quantitative mode indicated that there was potential for this procedure in this Northern Canadian community.
8. The positive responses received from Band members who were informed of their contaminated water supply coupled with their immediate remedial activities, indicates that this project was well supported by the whole Split Lake community.

REFERENCES

American Public Health Association 1985. Standard Methods for the enumeration of water and waste water. 16th editor. APHA, AWWA Washington D.C.

Atlantic Research Corporation. 1979. Evaluation of coliform bacteria and bacteriophage relationships in assessment of water quality. Final Technical Report, NSF Grant No. PFR78-19196 December, 1979. Division of Problem Focused Research Applications, NSF, Washington, D.C. 20550.

Besco, G. 1963. Enterophages in coastal sea waters - considerations on the general epidemiological importance of their discovery in surface waters. Nuovi Ann. Iq. Microbiol. 14:8-20.

Clark, J.A. 1968. A presence-absence (P/A) test providing sensitive and inexpensive detection of coliforms, fecal coliforms and fecal streptococci in municipal drinking water supplies. Can. J. Microbiol. 14:13-18.

Grabow, W.O.K., P. Coubrough, E.M. Nupen, and B.W. Bateman. 1984. Evaluation of coliphages as indicators of the virological quality of sewage polluted water. Water SA 10, 7-14.

Guelin, A. 1948. Etude des bacteripohages Typhiques. Vi-dans les eaux. Ann. Inst. Pasteur, Paris 75, 485-489.

Kennedy, J.E., G. Bitton and J.L. Oblinger. 1985. Comparison of selective media for assay of coliphages in sewage effluent and lake water. App. and Environ. Microbiol. 49:33-36.

Manja, K.S., M.S. Maurya and K.M. Rao. 1982. A simple field test for the detection of feacal pollution in drinking water. Bull. W.H.O. 10:797-801.

Petrovicova, A., A. Simkova and J. Cervenka. 1988. Enteroviruses and coliphage in different water ecosystems. Z. gesamte Hyg. 34:522-523.

Scarpino, P.B. 1975. Human enteric viruses and bacteriophages as indicators of sewage pollution. In: Discharge of Sewage from Sea Outfalls. A.L.H. Gameson, Ed. Pergamon Press, Oxford, pp 49.

Seidl, P., B.J. Dutka, V. Spence and R. Webster 1990. Self-administered bacteriological assessment program and Split Lake Manitoba. Ecological Report Series, Northern Flood Agreement, Manitoba. Environment Canada, Fisheries and Oceans No. 90-2.

Simkova, A. and J. Cervenka. 1981. Coliphages as ecological indicators of enteroviruses in various water systems. Bul. WHO 59(4):611-618.

Wentsel, R.S., P.E. O'Neal and J.F. Kitchens. 1982. Evaluation of coliphage detection as a rapid indicator of water quality. Appl. and Environ. Microbiol. 43:430-434.

Table 2. Results of P/A test applied to water samples collected from the Water Treatment Plant, homes and buildings receiving water through distribution lines.

	Water Treatment Plant	Grade 9 Classroom	Band Office	Residence	Residence	Residence
DATE P/A	May 14/90 Negative			1(A) Negative		
DATE P/A	May 22/90 Negative	Negative		2 Negative		
DATE P/A	June 4/90 Negative	Negative	Negative	3 Negative		
DATE P/A	June 15/90 Negative		Negative	2 Negative		
DATE P/A Isolates	July 9/90 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae Enterobacter cloacae		10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae Enterobacter cloacae	3 10 + 1 day 50 + 1 day 100 + 1 day Enterobacter cloacae Pseudomonas fluorescence		
DATE P/A	July 10/90 Negative		Negative	3 Negative		
DATE P/A			Aug. 8/90 Negative	4 Negative		
DATE P/A Isolates	Aug. 24/90 10 + 2 days 50 neg. 100 + 1 day		10 neg. 50 + 5 days 100 neg.	1 Negative	5 10 + 1 day 50 + 1 day 100 + 1 day	6 10 neg 50 + 1 day 100 + 1 day Pseudomonas aeruginosa
DATE P/A	Aug. 27/90 Negative			1 7 6 Negative	5 9 Negative	8 10 + 1 day 50 + 1 day 100 + 1 day
DATE P/A	Sept. 11/90 Negative	Negative		10 10 neg 50 + 1 day 100 + 1 day		
DATE P/A	Oct. 16/90 Negative	Negative		1 Negative	11 Negative	
DATE P/A	Oct. 24/90 Negative	Negative		12 Negative		
DATE P/A	Oct. 30/90 Negative	Negative		14 Negative	13 10 neg 50 neg 100 + 1 day	

Table 2. Results of P/A test applied to water samples collected from the Water Treatment Plant, homes and buildings receiving water through distribution lines.

	Water Treatment Plant	Grade 9 Classroom	Band Office	Residence	Residence	Residence
DATE P/A	Nov. 11/90 Negative	Negative		11 10 neg 50 neg 100 + 1 day	15 Negative	
DATE P/A	Nov. 19/90 Negative	Negative		11 Negative	16 Negative	
DATE P/A	Nov. 21/90 Negative	Negative		17 10 + 1 day 50 + 1 day 100 + 1 day	18 Negative	
DATE P/A	Dec. 3/90 Negative	Negative		19 Negative	20 Negative	
DATE P/A	Dec. 6/90 Negative	Negative		21 Negative		
DATE P/A	Dec. 10/90 Negative	Negative		22 Negative	23 Negative	
DATE P/A	Dec. 13/90 10 neg 50 + 4 days 100 + 2 days	Negative		22 10 neg 50 neg 100 + 1 day	24 Negative	

1A - see residence list in Appendix Table B.

Table. 3. Pattern of P/A responses to contaminants in Water Treatment Plant and Distribution Lines.

	Pattern of P/A responses						
	10 neg 50 neg 100 neg	10 + 1 day 50 + 1 day 100 + 1 day	10 neg 50 + 1 day 100 + 1 day	10 neg 50 neg 100 + 1 day	10 + 2 days 50 neg 100 + 1 day	10 neg 50 + 4 days 100 + 2 days	10 neg 50+5 days 100 neg
# of Responses	59	6	2	3	1	1	1
Estimated Contaminating Bacteria/100 mL	<1	>10	<10	<2	≈10	≈2	1

Table 4. Summary of P/A and H_2S Test Results from September 19th and September 20th/90 Study

	H_2S results		P/A results			No. of Samples
Volume tested- mL	20	100	10	50	100	
Positive - days	-	-	-	-	-	6
Positive - days	-	3	-	-	-	1
Positive - days	-	-	1	1	1	3
Positive - days	3	1	-	-	3	1
Positive - days	3	3	1	1	1	1
Positive - days	-	1	1	1	1	1
Positive - days	-	3	1	2	1	1
Positive - days	-	3	-	1	1	1
Positive - days	-	-	-	-	2	1
Positive - days	-	-	2	1	1	1
Positive - days	-	-	-	-	3	1

6 samples H_2S neg P/A neg.
1 sample H_2S + P/A neg.
6 samples H_2S neg P/A +
5 samples H_2S + P/A +

Table 5. Results of P/A test applied to drinking water collected from water treatment plant and home barrels being serviced by the water truck.

	Water Treatment Plant	Water Truck	Senior Group Home	Residence	Residence	Residence
DATE P/A Isolate	May 14/90 Negative			1(A) 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella oxytoca Citrobacter freundii		
DATE P/A Isolate	May 22/90 Negative	Negative	10 + 4 days 50 + 4 days 100 + 4 days	2 10 + 1 day 50 + 1 day 100 + 1 day Citrobacter freundii	3 10 + 1 day 50 + 1 day 100 + 1 day	
DATE P/A Isolate	June 4/90 Negative			1 10 + 3 days 50 + 3 days 100 + 3 days	4 10 + 1 day 50 + 1 day 100 + 1 day	5 10 + 1 day 50 + 1 day 100 + 1 day Enterobacter cloacae
DATE P/A Isolate	June 15/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae		4 10 + 1 day 50 + 1 day 100 + 1 day Enterobacter amnigenus	5 10 + 1 day 50 + 1 day 100 + 1 day Enterobacter cloacae Klebsiella Species
DATE P/A Isolate	July 9/90 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae Enterobacter cloacae	10 neg 50 + 1 day 100 + 1 day Enterobacter cloacae	10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae	6 10 + 1 day 50 + 1 day 100 + 1 day Enterobacter cloacae Enterobacter aerogenes	7 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae Serratia forticita	
DATE P/A Isolate	July 10/90 Negative	Negative	Negative		7 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae	
DATE P/A Isolate			Aug. 8/90 10 + 1 day 50 + 1 day 100 + 1 day Enterobacter species	8 10 + 1 day 50 + 1 day 100 + 1 day Enterobacter species	9 10 + 1 day 50 + 1 day 100 + 1 day E. coli	
DATE P/A	Aug. 24/90 10 neg. 50 neg. 100 + 1 day					
DATE P/A	Aug. 27/90 Negative					

A - see list of residences in Table C Appendix.

Table 5. Results of P/A test applied to drinking water collected from water treatment plant and home barrels being serviced by the water truck.

	Water Treatment Plant	Water Truck	Senior Group Home	Residence	Residence	Residence
DATE P/A Isolate	Sept. 11/90 Negative		10 + 2 days 50 + 1 day 100 + 1 day Klebsiella pneumoniae	10 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae	4 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae Enterobacter cloacae	
DATE P/A Isolate	Sept. 19/90 Negative		10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae	5 10 + 1 day 50 + 1 day 100 + 1 day Enterobacter cloacae	11 10 + neg 50 + 1 day 100 + 1 day Klebsiella pneumoniae	
DATE P/A	Sept. 20/90 Negative	Negative		2 10 + 2 days 50 + 1 day 100 + 1 day	12 10 neg. 50 neg. 100 + 3 days	
DATE P/A Isolate	Oct. 16/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae	13 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae		
DATE P/A	Oct. 24/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	14 10 + 1 day 50 + 1 day 100 + 1 day	15 Negative	
DATE P/A	Oct. 30/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	16 10 + 1 day 50 + 1 day 100 + 1 day		
DATE P/A	Nov. 7/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	17 Negative		
DATE P/A	Nov. 19/90 Negative	10 + 2 days 50 + 2 days 100 + 2 days	10 neg. 50 + 1 day 100 + 1 day	27 Negative		
DATE P/A	Nov. 21/90 Negative	Negative	Negative	18 10 + 1 day 50 + 1 day 100 + 1 day		
DATE P/A	Dec. 3/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	19 10 + 1 day 50 + 1 day 100 + 1 day		

Table 5. Results of P/A test applied to drinking water collected from water treatment plant and home barrels being serviced by the water truck.

	Water Treatment Plant	Water Truck	Senior Group Home	Residence	Residence	Residence
DATE P/A	Dec. 6/90 Negative	Negative	10 neg. 50 + 1 day 100 + 1 day	20, 21, 22 Negative		
DATE P/A	Dec. 10/90 Negative	Negative	10 + 2 days 50 + 1 day 100 + 1 day	23 10 + 1 day 50 + 1 day 100 + 1 day	24 Negative	
DATE P/A	Dec. 13/90 10 neg. 50 + 4 days 100 + 2 days	10 neg. 50 + 2 days 100 + 2 days	10 + 1 day 50 + 2 days 100 + 2 days	25 10 + 1 day 50 + 2 days 100 + 2 days	26 10 + 1 day 50 + 2 days 100 + 2 days	

Table A. Appendix. Record of P/A test results of treated drinking water sources

	Water Treatment Plant	Water Truck	Nursing Station	Northern Store
DATE P/A	May 14/90 Negative		100 mL + 4 days	
DATE P/A	May 22/90 Negative	Negative	Negative	10 + 1 day 50 + 4 days 100 + 3 days
DATE P/A	June 4/90 Negative		Negative	Negative
DATE P/A	June 15/90 Negative	Negative	Negative	Negative
DATE P/A Isolates	July 9/90 10 + 1 day 50 + 1 day 100 + 1 day Klebsiella pneumoniae Enterobacter cloacae	10 + 1 day 50 + 1 day 100 + 1 day Enterobacter cloacae (2 types)	10 + 1 day 50 + 1 day 100 + 1 day Enterobacter cloacae (2 types)	10 + 1 day 50 + 1 day 100 + 1 day Enterobacter cloacae(2 types)
DATE P/A	July 10/90 Negative	Negative	Negative	Negative
DATE P/A				Aug. 8/90 Negative
DATE P/A	Aug. 24/90 10 + 2 days 50 neg. 100 + 1 day			
DATE P/A	Aug. 27/90 Negative			
DATE P/A	Sept. 1/90 Negative		10 + 3 days 50 + 3 days 100 + 1 day	10 + 1 day 50 + 1 day 100 + 1 day
DATE P/A				
DATE P/A	Oct 24/ 90 Negative	Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day
DATE P/A	Oct.30/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	10 + 1 day 50 + 1 day 100 + 1 day
DATE P/A	Nov. 7/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	Negative

Table 6. Split Lake 1990 Recreational Water Quality Study Using Two Bacteriological Procedures.

BEACH	DATE	MPN A-1 broth 10, 1 .1 mL	MPN /100 mL	P/A 100	50	25	10	5	Count Estimate	Enterobacteriaceae Identified
AIRSTRIP	15.06.90	1 - 0 - 0	2	+	+	+	+	-	>10	E. coli (A-1)
	24.07.90	1 - 2 - 1	8	+	+	+	ND	+	>20	Enterobacter cloacae, E. coli (P/A)
	27.07.90	1 - 0 - 0	2	+	+	+	ND	+	>20	Klebsiella pneumoniae (A-1)
	19.10.90	1 - 0 - 0	2	+	+	+	+	+	>20	Klebsiella pneumoniae, E. coli (P/A)
	20.10.90	1 - 0 - 0	2	+	+	+	+	+	>20	E. coli (P/A)
	23.10.90	1 - 0 - 0	2							
	25.10.90	0 - 0 - 0	<2							
	31.10.90	3 - 0 - 0	8							
	06.11.90	1 - 0 - 0	2							
	14.11.90	3 - 0 - 0	8							
NURSING STATION	19.10.90	1 - 0 - 0	2	+	+	+	+	+	>20	E. coli, (A-1) E. coli Klebsiella pneumoniae, Citrobacter freundii
	20.10.90	3 - 0 - 0	8							
	31.10.90	5 - 0 - 0	23							
	06.11.90	1 - 1 - 0	4							
	14.11.90	3 - 0 - 0	8							
	03.12.90	1 - 0 - 0	2							
	05.12.90	3 - 0 - 0	8							
	12.12.90	0 - 0 - 0	<2							
	17.12.90	1 - 1 - 0	4							

Table 6. Split Lake 1990 Recreational Water Quality Study Using Two Bacteriological Procedures.

BEACH	DATE	MPN A-1 broth 10, 1 .1 mL	MPN /100 mL	P/A 100	50	25	10	5	Count Estimate	Enterobacteriaceae Identified
ANDERSON	24.07.90	2 - 1 - 0	7	+	+	-[2]	ND	-	>2	E. coli (P/A)
	27.07.90	0 - 0 - 0	<2	+	+	+	ND	+	>20	
	19.10.90	0 - 0 - 0	<2	ND[1]	+	+	ND	ND	>4	Citrobacter freundii, Serratia species
	20.10.90	3 - 0 - 0	8	+	+	+	ND	+	>20	Klebsiella pneumoniae (P/A)
	23.10.90	2 - 0 - 0	5							
	25.10.90	0 - 0 - 0	<2							
	31.10.90	1 - 0 - 0	2							
	06.11.90	0 - 0 - 0	<2							
	14.11.90	3 - 1 - 0	11							
	03.12.90	4 - 1 - 0	17							
	05.12.90	2 - 1 - 0	7							
	12.12.90	0 - 0 - 0	<2							
	17.12.90	1 - 0 - 0	2							
PORTAGE	24.07.90	1 - 0 - 0	2	+	+	+	+	-	>10	Citrobacter freundii (P/A)
	27.07.90	0 - 0 - 0	<2	+	+	+	+	+	>20	
	19.10.90	5 - 1 - 0	33	+	+	+	+	+	>20	E. coli, (A-1), Klebsiella pneumoniae, Serratia species
	20.10.90	3 - 0 - 0	8							Klebsiella pneumoniae
	23.10.90	5 - 0 - 0	23							
	25.10.90	1 - 0 - 0	2							
	31.10.90	0 - 0 - 0	<2							
	06.11.90	0 - 0 - 0	<2							
	14.11.90	0 - 0 - 0	<2							
	03.12.90	0 - 0 - 0	<2							
	05.12.90	1 - 0 - 0	2							
	12.12.90	0 - 1 - 0	2							
	17.12.90	0 - 0 - 0	<2							

ND[1] = not done
-[2] = negative

Table 6. Split Lake 1990 Recreational Water Quality Study Using Two Bacteriological Procedures.

BEACH	DATE	MPN A-1 broth 10, 1 .1 mL	MPN /100 mL	P/A 100	50	25	10	5	Count Estimate	Enterobacteriaceae Identified
BAY	15.06.90			+	+	+	+	-	>10	E. coli (P/A)
	24.07.90	1 - 1 - 0	4	+	+	+	+	+	>20	Klebsiella pneumoniae, E. coli (P/A)
	27.07.90	5 - 1 - 0	33	+	+	-	+	-	>10	E. coli (A-1)
	19.10.90	0 - 0 - 0	<2	+	+	+	+	+	>20	Proteus species
	20.10.90	4 - 0 - 0	13	+	+	+	+	+	>20	Klebsiella pneumoniae, E. coli, (A-1), E. coli
	23.10.90	1 - 1 - 0	4							
	25.10.90	0 - 0 - 0	<2							
	31.10.90	2 - 0 - 0	5							
	06.11.90	4 - 0 - 0	13							
	14.11.90	2 - 0 - 0	5							
	03.12.90	3 - 0 - 0	8							
	01.12.90	0 - 0 - 0	<2							
	12.12.90	0 - 1 - 0	2							
	17.12.90	0 - 0 - 0	<2							
OPPOSITE SIDE OF BAY BEACH	24.07.90	1 - 0 - 0	2	+	+	+	+	+	>20	Enterobacter cloacae
	23.10.90	0 - 0 - 0	<2							
BAY BEACH	25.10.90	0 - 0 - 0	<2							

Table A. Appendix. Record of P/A test results of treated drinking water sources

	Water Treatment Plant	Water Truck	Nursing Station	Northern Store
DATE P/A	Nov 19/90 Negative	10 + 2 days 50 + 2 days 100 + 2 days	10 + 1 day 50 + 1 day 100 + 1 day	
DATE P/A	Nov. 21/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	10 + 1 day 50 + 1 day 100 + 1 day
DATE P/A	Dec. 3/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	10 + 1 day 50 + 1 day 100 + 1 day
DATE P/A	Dec. 6/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	10 + 1 day 50 + 1 day 100 + 1 day
DATE P/A	Dec. 10/90 Negative	Negative	10 + 1 day 50 + 1 day 100 + 1 day	10 + 1 day 50 + 1 day 100 + 1 day
DATE P/A	Dec. 13/90 10 neg. 50 + 4 days 100 + 2 days	10 neg. 50 + 2 days 100 neg.	10 + 1 day 50 + 2 days 100 + 2 days	10 + 1 day 50 + 2 days 100 + 2 days

Table B. Appendix. List of residences which receive water through Distribution Lines from Split Lake WTP

1. D. Spence
2. Residence #4
3. Allison Kitchekeesik
4. William Beardy
5. Mary Ann Flett
6. John George Saunders
7. Jim Wavey
8. Alfred Cook
9. Alex Garson
10. Freddy Beardy
11. Dan and Gloria Flett
12. Albert Keeper
13. Eli Kirkness
14. Alfred Beardy
15. Nicanor Spence
16. John Wavey
17. William Flett
18. Brian Beardy
19. Michael Keeper
20. Donald Flett
21. Michael Spence
22. Patrick Kirkness
23. John Kirkness
24. Harp Flett

Table C. Appendix. List of residences which received their water from the water truck.

1. Douglas Kitchekeesik
2. Residence #1
3. Residence #3
4. Victor Spence
5. Josiah Saunders
6. Annie Kitchekeesik
7. Mary Flett
8. Kelvin Kitchekeesik
9. Lazarus Kitchekeesik
10. David Beardy
11. Noah Garson
12. Residence #2
13. Josiah Harvey
14. Jessie Harvey
15. Connie Flett
16 Lawrence Napitabo
17. John Kitchekeesik
18. Thomas Saunders
19. Roderick Spence
20. Mike Garson
21. Mike J. Garson
22. Joseph Harvey
23. John G. Garson
24. Jude Flett
25. George Beardy
26. John Garson
27. Allison Kitchekeesik

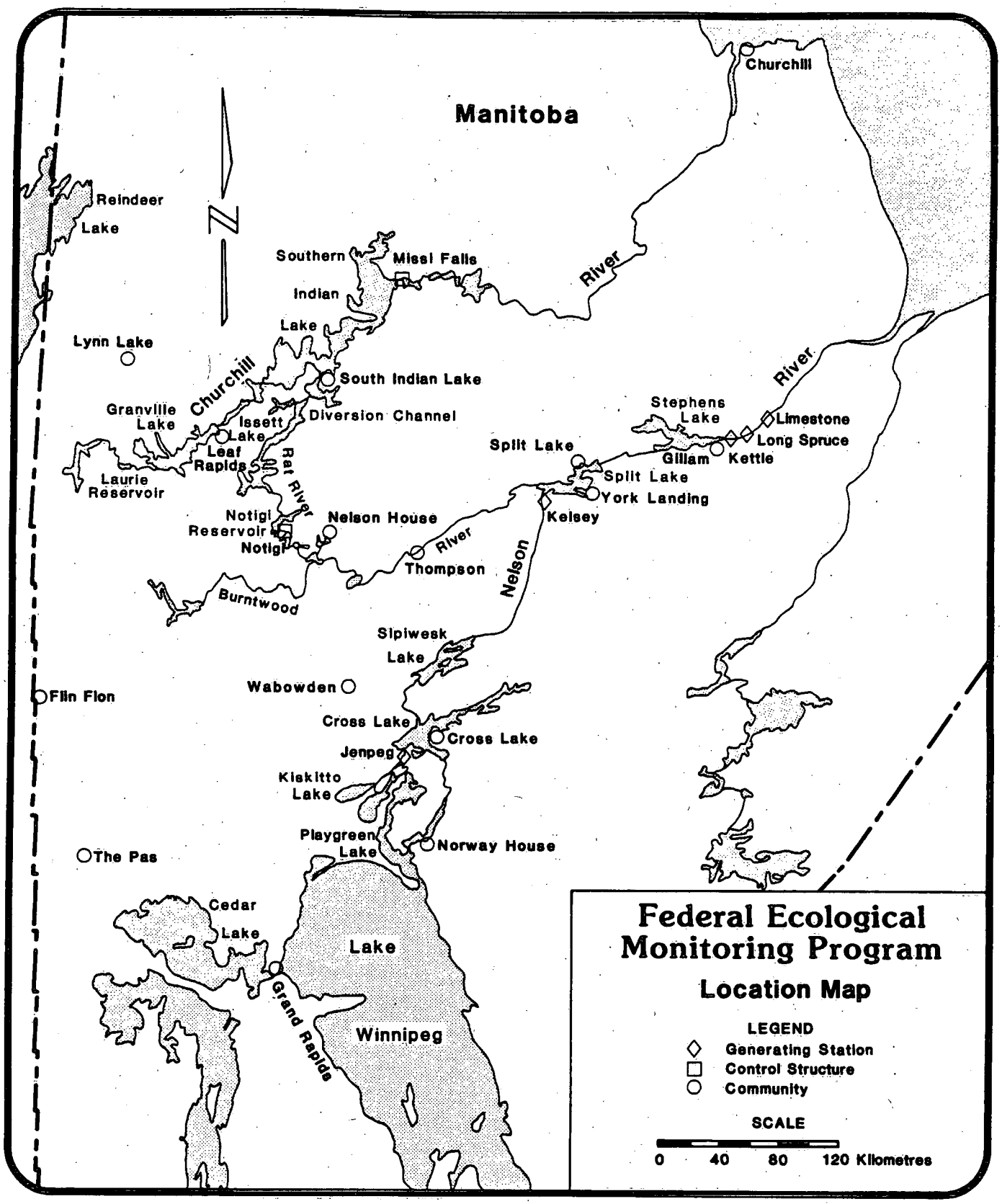


Figure 1. Northern Manitoba and Split Lake.

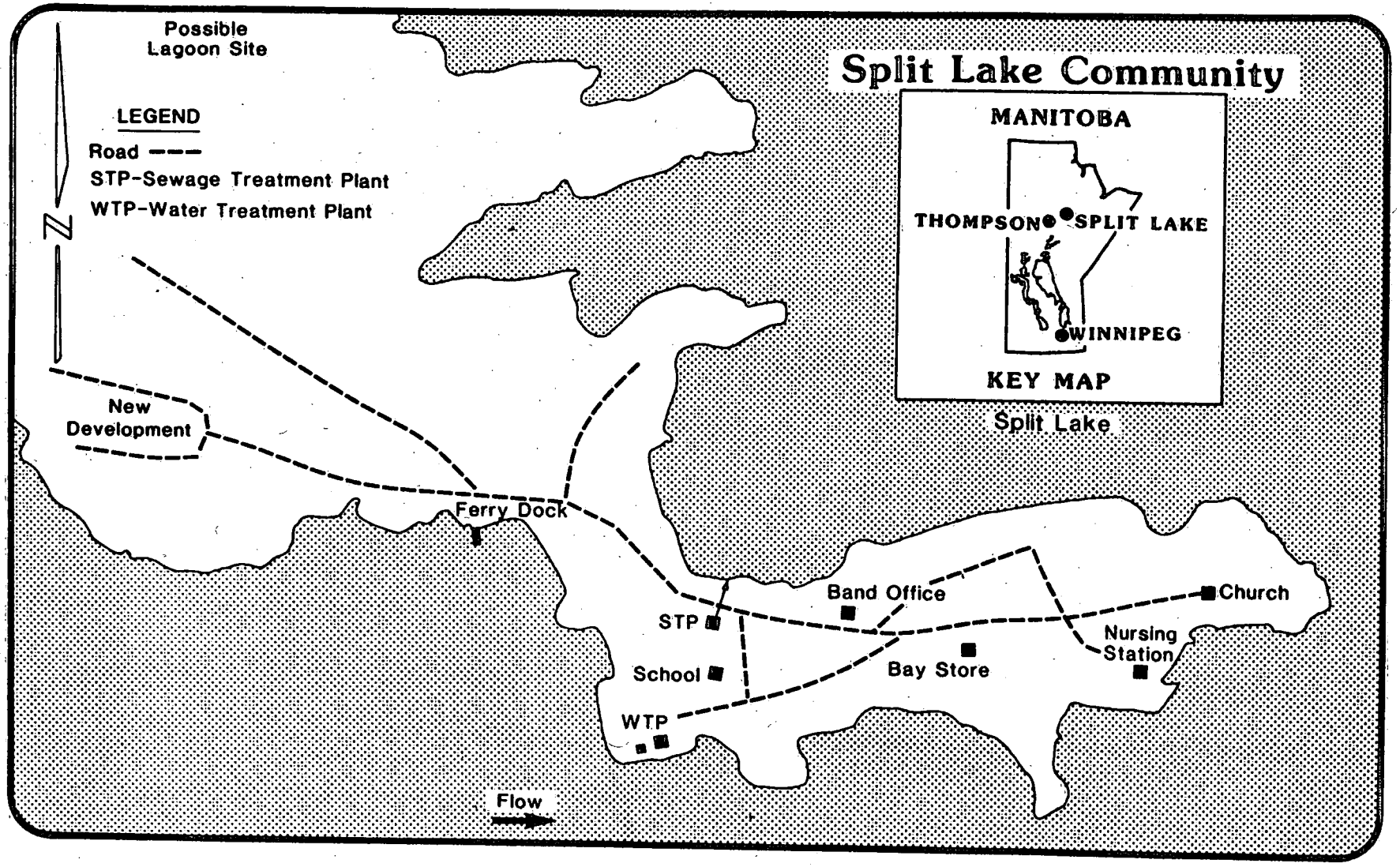


Figure 1a. Split Lake, Manitoba.

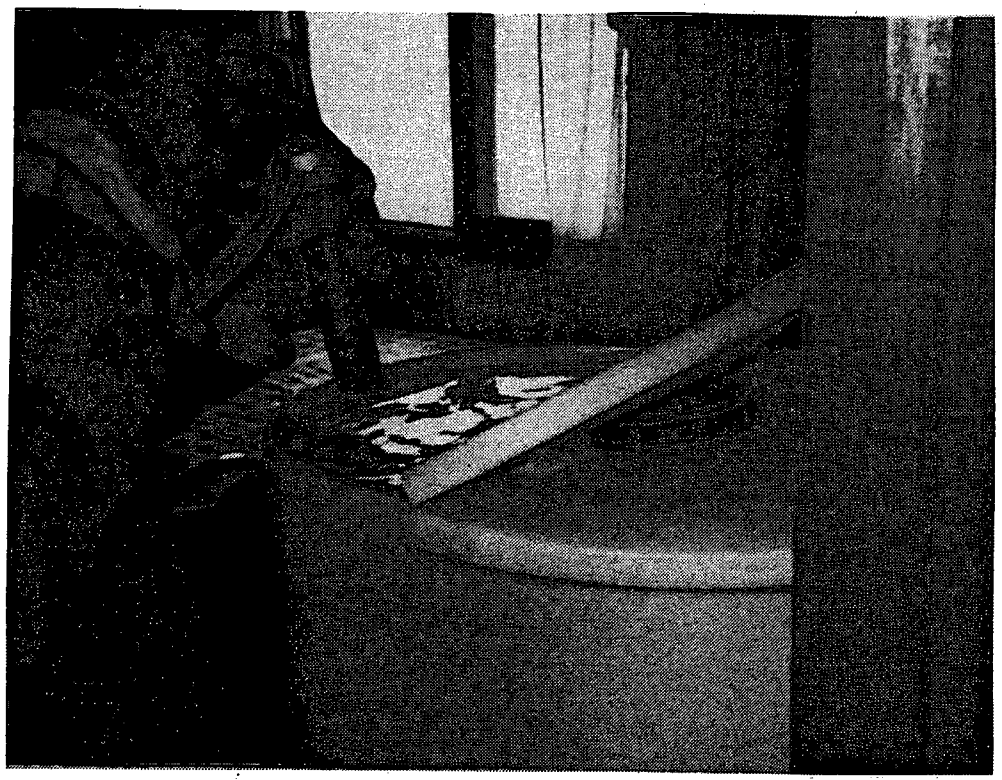


Figure 2. Filling of home barrels.

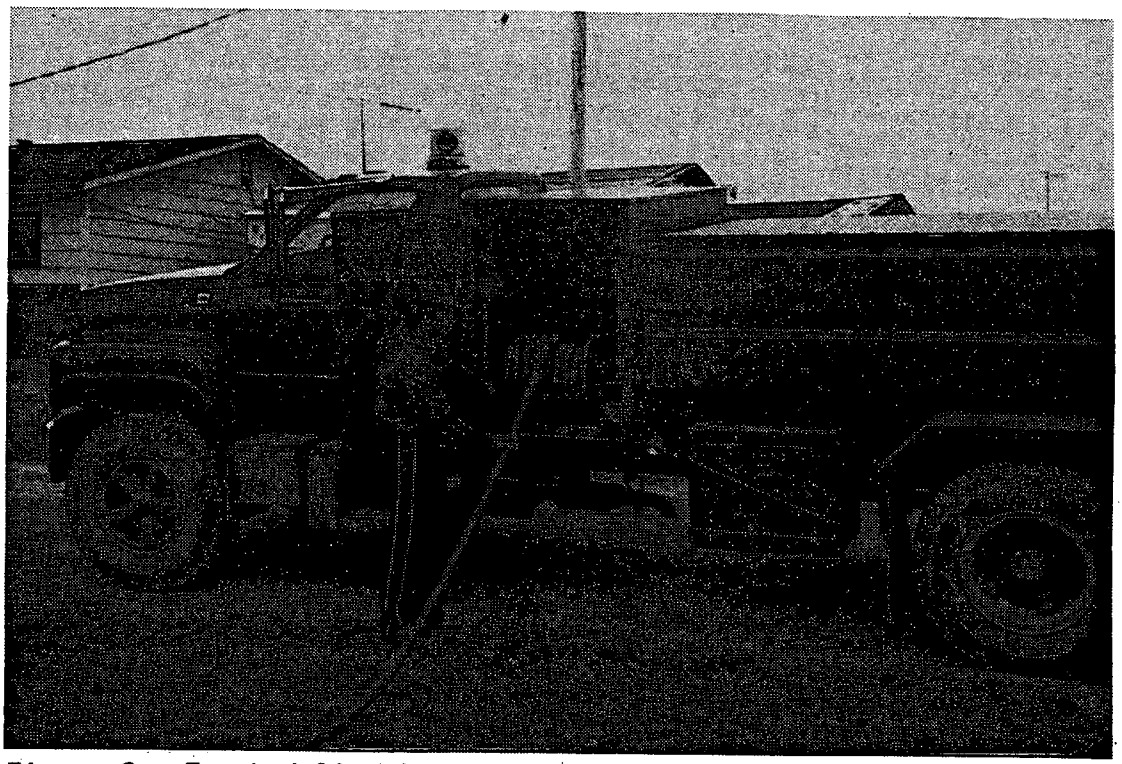


Figure 3. Truck delivering water.

Figure 4. Showing incubators and autoclave

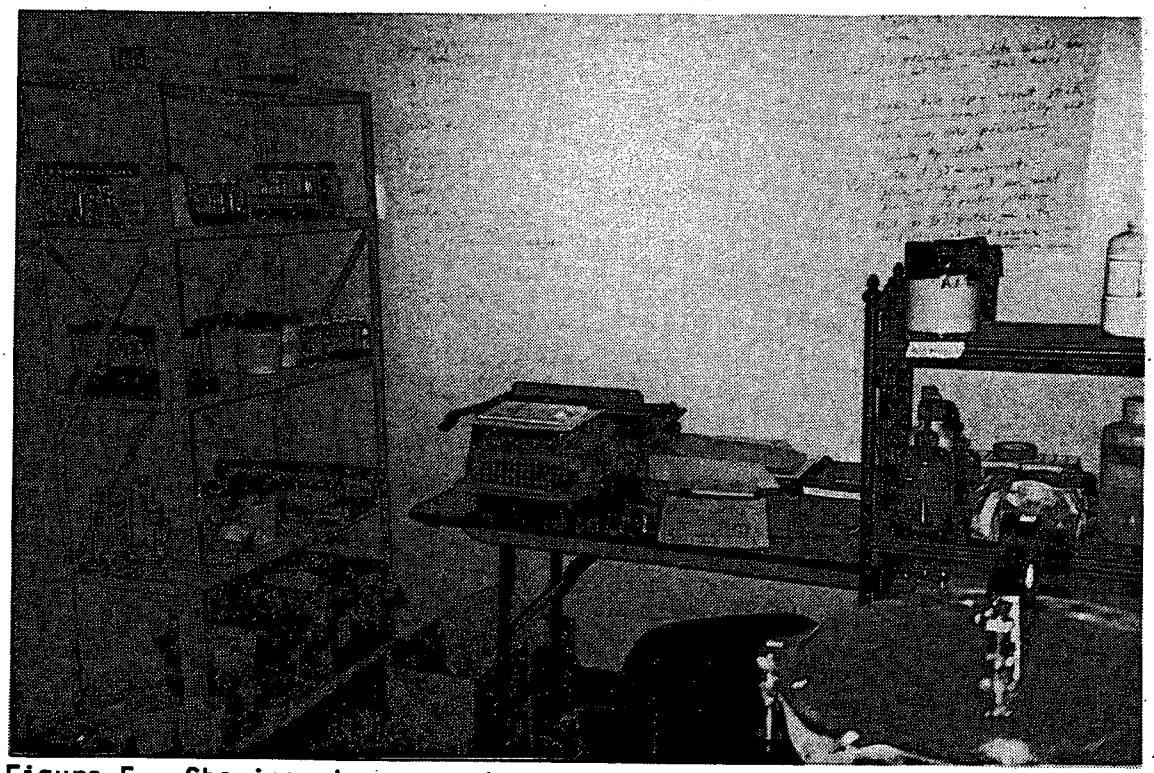


Figure 5. Showing storage and reporting area with instructions tacked to wall.

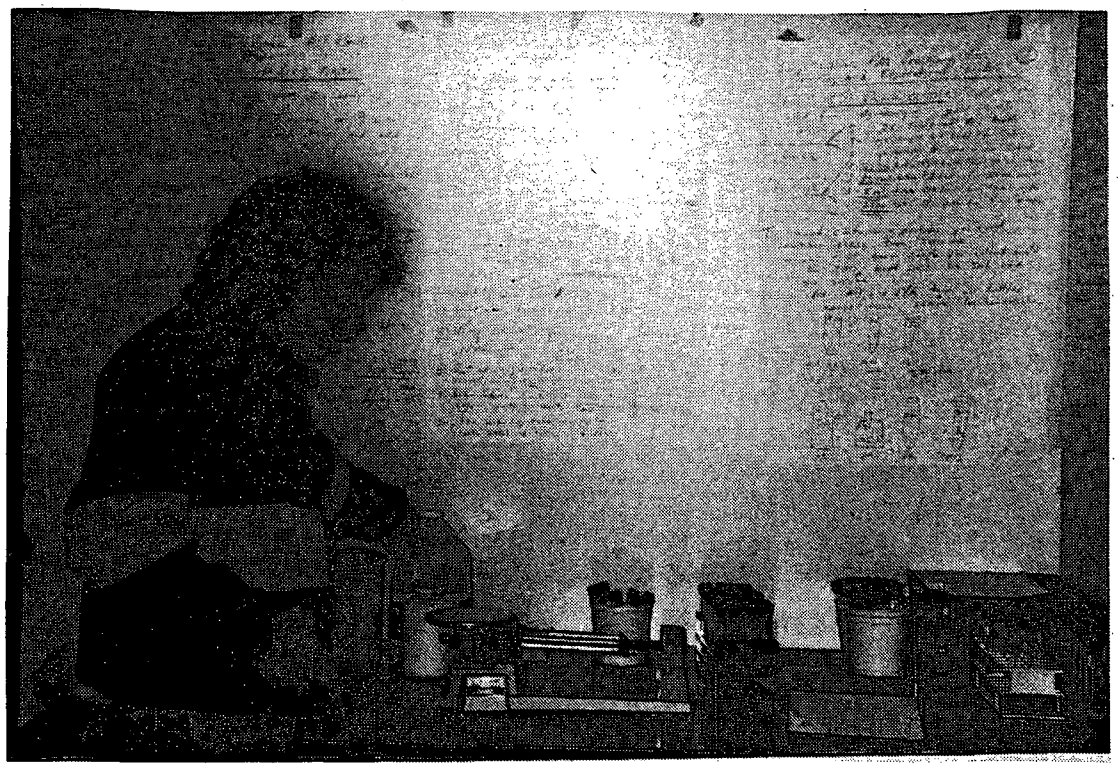
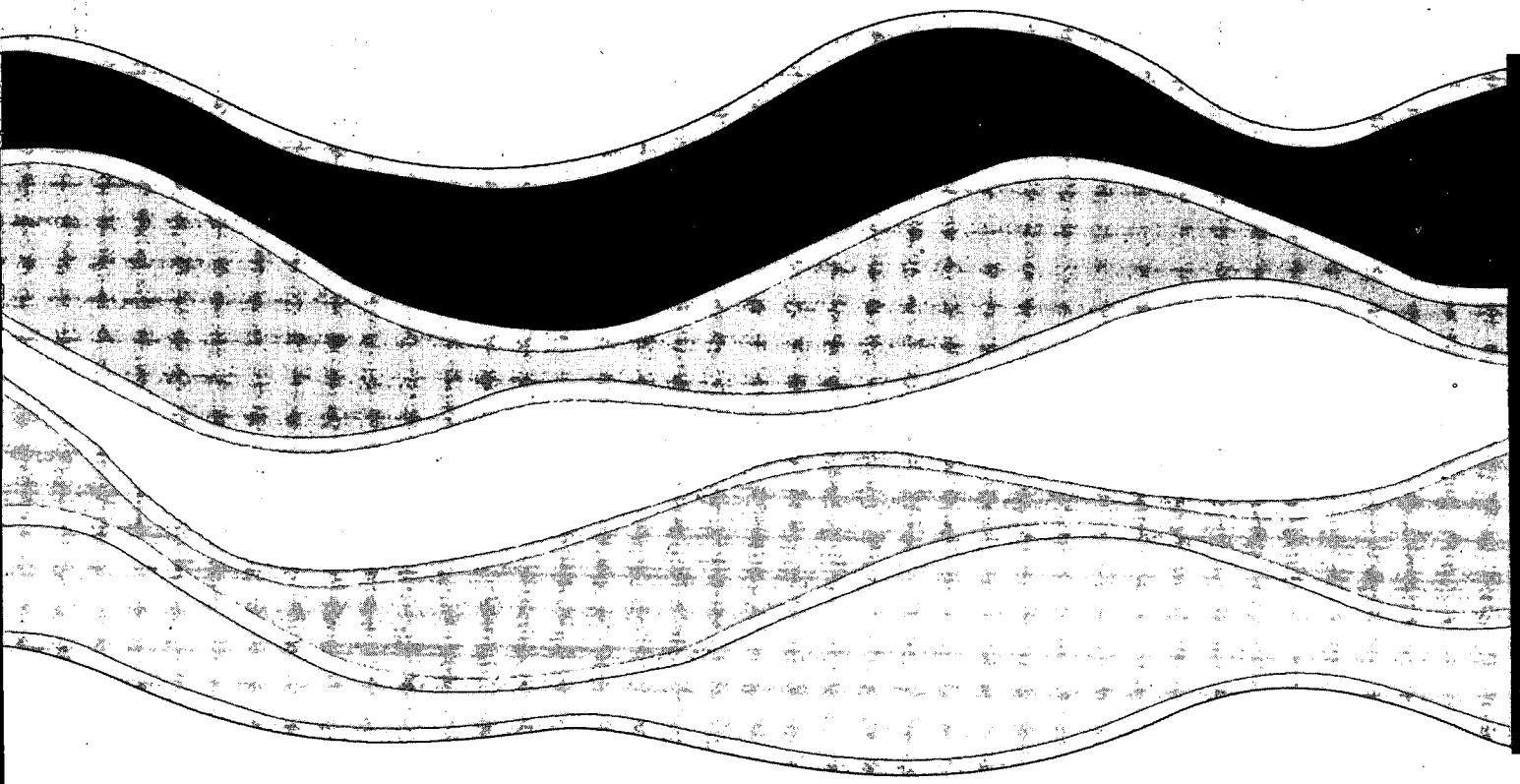


Figure 6. Media preparation and sample testing area with various procedures tacked to walls.



NATIONAL WATER RESEARCH INSTITUTE
P.O. BOX 5050, BURLINGTON, ONTARIO L7R 4A6

Environment Canada Environnement Canada

Canada

INSTITUT NATIONAL DE RECHERCHE SUR LES EAUX
C.P. 5050, BURLINGTON (ONTARIO) L7R 4A6