

**Fraser River
Action Plan**



**Agricultural
Landuse
Survey in the
Matsqui
Slough
Watershed -
Summary
Report**

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**AGRICULTURAL LAND USE SURVEY IN
THE MATSQUI SLOUGH WATERSHED
SUMMARY REPORT**

July 1994

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EXECUTIVE SUMMARY

The North Matsqui region is an economically important agricultural area located within the Lower Mainland area of the Fraser River basin. In 1991, the gross farm revenues were greater than 47 million dollars with expenses greater than 27 million. The Matsqui Slough watershed which drains the eastern portion of the North Matsqui Agricultural region was selected as the study area. The goals of this study were to: (1) identify farms which followed the Code of Agricultural Practice for Waste Management and Agricultural Environmental Guidelines and (2) identify possible contaminant sources which could impact water quality. An inventory of the agrowaste facilities and management in the Matsqui Slough basin was carried out. This inventory included completing a telephone questionnaire followed by a site visit to each farm - a process that should be updated within 5 years to document changes. The quality of both the surface and subsurface waters in the basin were studied over a five month period and five fish species composition and relative abundance studies were carried out.

FARM SURVEYS

The livestock farms included in this study utilised a total of 1538 hectares of land in the Matsqui Slough watershed. Approximately 88% of the agricultural land was dairy farms, 8% hog farms, 6% poultry. One goat dairy farm (1.6 hectares) was identified in the watershed. The total amount of dairy/hog/poultry manure produced in the study area was 386,300 L/day using only the data from the farms studied, with an overall loading rate of 251 L/hectare/day (or 1.3 MCE/acre). Dairy operations generate 70% of the manure, hog producers 23% and poultry producers 7%.

Eighty-eight percent of the 42 dairy producers were interviewed. The average number of milking cow equivalents per farm was 95. Eighty-seven percent of the producers spread manure on their own property and have an average of 3.4 months storage. Forty-one percent of the storage facilities were concrete and 46% of these were covered. The mercator coordinates for the manure facilities were obtained using a Global Positioning System (GPS) and photographs were taken of all the facilities. An Environmental Sustainability Parameter (ESP) was developed which quantified the potential for contamination of the surface and subsurface waters from a farming operation based on the Code of Agricultural Practice for Waste Management and the Environmental Guidelines for the Dairy Producers. Farms with an ESP value greater than 80% were considered to have a low potential for degrading water quality. Eight percent of the dairy producers had an ESP value of greater than 80% and 78% were between 40 and 80%, while 13% had an ESP value less than 40%.

Four of the six hog producers were visited. The average number of sow equivalents per farm was 313. Half of the producers spread their own manure and have an

average of 4.6 months manure storage, with 25% of the manure storage being concrete and covered. All four producers have ESP values between 45% and 50%.

Ten of the 17 poultry producers identified from commodity listing were interviewed. The average number of broiler equivalents per farm was 26,311. Sixty percent of the producers have concrete manure storage, with 70% of the manure being exported off the farm. Sixty percent of the producers have ESP's greater than 80% and 30% less than 40%.

WATER QUALITY

Dissolved oxygen concentrations were below concentrations required for the protection of the identified fish species in the Matsqui Slough. The Canadian guidelines for the protection of freshwater aquatic life were exceeded at all sampling locations for total aluminum concentrations and at all sampling locations, except one, for total copper concentrations. Canadian and British Columbian water quality guidelines or criteria for the protection of freshwater aquatic life were exceeded at all sites for total iron concentrations. Nitrate concentrations in five of the ten wells sampled exceeded the 10 mg/L provincial and Canadian drinking water guidelines.

FISHERIES

Most of the salmonids were in the upper reaches of Clayburn Creek where all of the 47 fish captured were salmonids. Salmonids were also found in Willband and Page Creeks. The Matsqui Slough sites and Clayburn Creek at Harris Road had the smallest numbers of fish and species present.

RECOMMENDATIONS

An on-going water quality monitoring program should be developed and conducted. This program would have two objectives. The first objective is to collect sufficient data on the dissolved oxygen related parameters to apply conventional dissolved oxygen prediction models. The second objective is to monitor both the runoff and dry weather concentrations of aluminium, herbicides and pesticides, iron, copper and indicator bacterial densities particularly during the late summer and fall periods. The high concentrations of nitrates in some of the drinking water wells should be investigated further and the remedial measures required to reduce potable water nitrate concentrations to acceptable levels identified.

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1.0 INTRODUCTION

The Fraser River Action Plan (FRAP) was established to reduce the pollution inputs to the Fraser River and restore the natural productivity of the Fraser River basin. The primary goal of the agricultural component of FRAP is to implement a strategy to reduce the loading of nutrients, bacteria and agrochemicals from agricultural operations to ground and surface waters. Targets and strategies for the reduction are to be developed in consultation with stakeholders such as producer groups, the B.C. Ministry of Agricultural, Fisheries and Food, B.C. Ministry of the Environment, Parks and Lands, Agriculture Canada, Environment Canada, Department of Fisheries and Oceans and the B.C. Federation of Agriculture. The first step toward devising a strategy to achieve this goal is to identify the contaminant sources and to determine the loadings of specific contaminants. The major non point sources of potential contamination in rural areas are from agricultural operations.

The primary objective of this study was to develop an information base from which to assess whether the Code of Practice and the Guidelines are sufficient to sustain the surface and subsurface water quality in the lower Fraser River basin, which receives a greater amount of precipitation on an annual basis than other agricultural area in B.C. Unlike some agricultural studies which make extensive use of runoff estimates to estimate loadings, this project developed an initial detailed inventory of the manure handling and agrowaste practices on each individual farm. Nearly all (80%) of the individual farms were visited in the Matsqui Slough watershed with the only exceptions being individual farmers who chose not to participate or could not be contacted. In addition, this project documented in a limited way, the quality of the surface and subsurface waters and the fisheries resource in an extensively agricultural watershed. This document discusses the studies undertaken in the Matsqui Slough watershed which is intensively used by dairy, hog and poultry producers as well as commercial crop producers. Irrigation is extensively used throughout the watershed.

This document describes the methods used in the project and presents and discusses the data collected on agricultural operations in the Matsqui Slough watershed.

2.0 LEGISLATION

In B.C., legislative acts, regulations and guidelines that apply to agricultural operations include the federal Fisheries Act, the B.C. Waste Management Act, the Agricultural Waste Control Regulation and Code of Agriculture Practice for Waste Management, and the Environmental Guidelines for various producer groups developed by the B.C. Ministry of Agriculture, Fisheries and Foods and the producer groups.

The habitat section of the federal Fisheries Act prohibits the release of "deleterious substances" to waters frequented by fish. Deleterious substances are defined by this act as follows:

- ! any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or
- ! any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water.

In B.C., agricultural operations were recognized as a possible source of contamination to surface and subsurface waters; consequently, management guidelines were developed for agricultural producers. A Code of Agricultural Practice for Waste Management was developed by a committee including representatives from B.C. Ministry of Environment, Lands and Parks, B.C. Ministry of Agriculture, Fisheries and Foods, B.C. Federation of Agriculture, the Department of Fisheries and Oceans and the commodity group inspectors. All agricultural commodity groups had extensive input into the development of the Code. The B.C. Federation of Agriculture actively supported enactment of the Code which became part of the Agricultural Waste Control Regulation passed in 1992 under B.C.'s Waste Management Act.

The Code of Agricultural Practice for Waste Management was developed to reduce the export of substances from agricultural operations to the surface and subsurface waters by describing practices for using, storing, and managing agricultural wastes. The environmental sustainability of the farming operation is dependant on the proper construction and location of agrowaste facilities coupled with environmentally sensitive management of these wastes. These documents provide guidance to the producers so that the impacts of the individual farm operations on surface and subsurface water quality are minimized. The Agricultural Code defines pollution as "the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment". The Agricultural Waste Control Regulation exempts waste management aspects of agricultural operations from the permit process if these operations conform to the Code.

The B.C. Ministry of Agriculture, Fisheries and Food in consultation with the B.C. Federation of Agriculture and producer groups developed Environmental

Guidelines for the various Commodity Groups including dairy (MOAFF, 1993a), hog (MOAFF, 1993b) and poultry producers (MOAFF, 1993c). These guidelines further amplify the Code and provide practical details for the implementation of the Code.

3.0 STUDY AREA

The Matsqui Slough watershed has an area of about 4200 hectares (see Figures 1 and 2) and is a portion of the North Matsqui Agricultural region. The Slough discharges to the Fraser River just downstream of Mission. Most of the agricultural area in the basin is very flat with elevations between 5 and 8 metres above sea level. The drainage system for the Slough consists of over 28 kms of ditches, sloughs and creeks with one 5.6 kilowatt (7.5 HP), two 11.2 kilowatt (15 HP), one 18.7 kilowatt (25 HP), two 22.4 kilowatt (30 HP) and one 30 kilowatt (40 HP) pumps and 9 check gates. The pumping capacity for the system is 0.71 m³/s. Except for the drainage area on Sumas Mountain and near the base of the mountain, the drainage area has small gradients and the velocities in the creeks are small and largely controlled by pumps and check gates.

The Matsqui Slough watershed is intensively used for agricultural production and supports a wide variety of producers; more than 3,506 milking cow equivalents, 263,115 broiler equivalents, 1,250 sow equivalents, cole, blueberries and nurseries based on this inventory. Irrigation use is widespread. Studies by the Department of Fisheries (Schubert, 1982) in the Clayburn Creek system indicated maximum escapements of 600 to 800 coho in 1977 and 1978. The Clayburn Creek system is known to historically support salmonids.

4.0 METHODS

4.1 OVERVIEW

The methods for each of the project components are discussed in the following sections in the chronological order in which they were carried out. The questionnaire, which documented all the features of a particular farming operation, was developed in consultation with Environment Canada, Department of Fisheries and Oceans (DFO), B.C. Federation of Agriculture, B.C. Ministry of Agriculture, Fisheries and Food (MOAFF), and B.C. Ministry of Environment, Lands and Parks (MOELP). Once the questionnaire was developed, letters were sent to each individual producer to explain the purpose and objectives of the study. The letters were followed by a telephone interview to complete the questionnaire during which, permission was requested to visit the site. If a site visit was acceptable, the location of the agrowaste storage facilities were determined using a Global Positioning

System (GPS) and photographs of the farming operation related to the management of agrowastes were taken. The methods used at each step are discussed below.

Independent of the interviews and site visits, water samples were collected at six locations weekly for a three month period in the fall (October to December) and over a two month period in the winter (February and March). These samples were analyzed for chemical parameters. Well samples were also collected twice from 10 wells and analyzed for coliform, *Klebsiella*, *E. coli*. densities and nitrate concentrations.

Fish species composition and relative abundance was determined on five different days between October and March in the vicinity of the water quality sampling locations.

4.2 QUESTIONNAIRE

The main components in the telephone questionnaire were compiled by B.C. Ministry of Environment, Lands and Parks based on a previous agricultural survey in the Sumas watershed (Hutton, 1987) and a recent agricultural survey in the Abbotsford aquifer (Meier, 1993). A first draft of the questionnaire was circulated to a review committee consisting of B.C. Ministry of Environment, Lands and Parks, B.C. Ministry of Agriculture, Fisheries & Food, B.C. Federation of Agriculture, Environment Canada, and IRC for comments. After the first few interviews, it was apparent that a few minor changes to the telephone questionnaire would expedite the information gathering process. The site visit survey sheet that accompanies the telephone interview sheet was developed by IRC after the initial site visits to accommodate GPS information, observation and producer comments obtained on-site.

4.3 DEVELOPMENT OF CONTACT LISTS FOR LETTERS

The Ministry of Environment, Lands and Parks (Region 2) requested membership lists, including phone numbers and addresses, from the commodity groups listed in Table 1. From these lists, producers in the Matsqui Slough watershed were identified and notified of the Agricultural Land Use Survey through a letter from the Ministry of Environment, Lands and Parks providing information on the study (Appendix A). Not all producers in the Matsqui study area were identified by the commodity lists because either they were not listed or the farm address was not given or the mailing address was not in the study area. Most hobby farms were not identified in this study since they are not associated with a commodity group.

4.4 TELEPHONE INTERVIEWS

Approximately one week after the letters were sent, the producers were contacted by

telephone. During the telephone calls, the information for the questionnaire was obtained and an appointment to visit the farm was made. The interview questionnaire and site visit sheets used for this survey are presented in Appendix A.

To determine the most time efficient method for collecting the questionnaire information, six producers were contacted initially using two different approaches. For three of the producers, the interview was conducted over the telephone and a site visit was arranged at the end of the interview. The other three producers were contacted by telephone to arrange a site visit which included the interview. The approach of interviewing the producer on the telephone and then arranging for a site visit proved to be the most time efficient. Collecting general information about the farming operation prior to the site visit increased the effectiveness of the visit because more time could be spent by the interviewer touring the site, clarifying issues and points of concern identified during the telephone interview.

All remaining interviews were conducted by telephone with a site visit being requested at the end of the interview, unless the producer requested that the interview be done on site. The producer was at liberty to refuse to answer interview questions or to some or all components of the site visit. Interviewers exerted no pressure on those producers wishing not to participate in any part of the study.

The B.C. Chicken Marketing Board producers' list did not have contact telephone numbers; consequently, some producers could not be contacted. Difficulties were also experienced in contacting other commodity group producers, either because the telephone number provided by the commodity membership list was incorrect or the producer could not be reached after many attempts.

4.5 FARM VISITS

A time and date for the site visits was arranged during the telephone interview, if possible, as indicated in Section 4.4. The site visit consisted of a visual inspection of the outside agricultural waste handling practices relevant to a particular commodity; namely milk parlour waste, silage runoff, yard runoff, agricultural waste storage facilities, disposal practices, location of domestic wells and any other issues identified during the telephone interview. The producer was asked to identify the farm property boundaries on municipal maps. The location of any surface water was visually identified or was noted as being within the property boundaries as indicated by the municipal map. With the permission of the producer, photographs were taken of all agricultural waste storage facilities and any other features that the interviewer considered relevant.

After the general inspection was completed, the producer was asked if GPS equipment (Trimble Pathfinder Basic Plus) could be used to locate their manure storage facilities. For each manure storage facility, a data rover file was created

and the building/facility of interest circumnavigated. At many sites, it was not possible to circumnavigate the structure and only two or three sides, or a portion thereof, could be travelled. During the circumnavigation, data was continuously recorded electronically at a preset time interval. Additional positional data were collected at the corners of an agricultural storage facility by pausing on the perimeters. Obstacles which could not be avoided were included in the circumnavigation track. The locations of the manure storage facilities were determined within an accuracy of 2 to 5 meters on a North American Datum 1983 (NAD 83) Universal Transverse Mercator (UTM) Grid using a Trimble Global Positioning System (GPS) Pathfinder system with base station corrections.

All field staff were given instructions and hands-on experience in the use of GPS equipment and farm site visits over a course of a few days. Data sheets were developed for each individual farm. These sheets document the agrowaste operation and manure management on each farm. The manure storage capacities were determined by on site measurements wherever possible and a photographic library of the waste management operations on each farm was developed.

4.6 GPS/GIS MAPPING SYSTEM FOR MANURE STORAGE FACILITIES

Manure storage facilities coordinates were obtained with GPS to map their location using a Global Information System (GIS). The Agricultural Code of Practice states that the location of storage facilities "must be located at least 15 m from any watercourse and 30 m from any source of water for domestic purposes". However, these distances are too small to be differentiated on a Terrain Resource Information Management Map (1:20,00 scale) or an Energy Mines and Resources topographical map (1:50,000 scale). Thus only a general indication of a manure storage facilities distance from a watercourse can be obtained using either of these maps. The general procedure for mapping manure facilities is provided in the following list.

- ! Field (rover) files were collected as described in Section 4.5.
- ! The field (rover) GPS data was downloaded to a personal computer via the program "Pfinder" provided by Trimble.
- ! The acquisition time, according to the GPS receiver clock was retrieved from the data file via the "Pfinder" computer system. (Global positioning system time is Greenwich).
- ! Base station data from Terra Pro's White Rock location were downloaded for the files identified in step 2 above via a modem. The base station data

files were used to post-differentially correct field files. Without post-differential correction "GPS accuracy can range from 1 centimetre to 100 meters" (Trimble Navigation, 1992) depending on equipment, logging mode, clear view of the sky, if selective availability is activated, etc. With post-differential corrections, Trimble states that the Pathfinder GPS has an accuracy of two to five meters circular error probable (CEP). The CEP value is defined such that a circle of the radius will enclose exactly 50% of the data points. Thus, half the data point are within CEP radius circle and half are outside the circle (Trimble Navigation, 1992).

- ! Each rover file was differentially corrected with a corresponding base station file using the "Pfinder" program.
- ! Each differentially corrected rover file was averaged to produce a mean coordinate (northing, easting and altitude) for the location of the agricultural waste handling facility surveyed (centroid of the storage facility).
- ! A Geographic Information System (GIS) file was created for all the averaged GPS rover files. Identification numbers were added to the GIS ASCII file for the purpose of identifying corresponding survey information with the farms.

It was decided to provide the GIS data for each manure storage facility as an averaged point, instead of all differentially corrected positions collected for that facility in the field for three main reasons.

- ! The physical perimeter dimensions of an agricultural waste facility are not large enough to be differentiated on a 1:20,000 map or a 1:50,000 map. Thus, giving all differentially corrected positions in a GIS file would not provide additional information.
- ! As mentioned in Section 4.5, objects that were situated close to an agricultural waste storage facility were often include in the rover file positional data. By averaging all the differentially corrected rover positions the process of having to differentiate between the edge of the building/facility and the obstacle was avoided.
- ! In some cases, all GPS positions recorded in the field could not be differentially corrected by the base station data due to various differences in rover and base file parameter settings such as elevation mask heights, etc.. If the number of correctable positions was low, then an adequate representation of the path transversed in the field would not be produced by the differentially corrected positions. In some cases, the corners and/or the general perimeter of an agricultural storage facility could not

be determined. Averaging the differentially corrected positions eliminated the problem of providing partial paths for some storage facilities and complete circumnavigational paths for others. Consequently, each set of differentially corrected positional data was handled consistently from storage facility to storage facility.

4.7 SOIL MAP MOSAICS

The soil types are presented in Table 2 and Figure 3 and were compiled from the B.C. Ministry of Environment Assessment and Planning Division reports (Luttmerding, 1980 & 1981). The potential for drainage to surface waters and ground water can be inferred from the soil types and distribution.

4.8 SYNOPTIC SURFACE AND GROUND WATER QUALITY MONITORING

Six surface water quality sampling sites were originally selected to define the longitudinal water quality gradients from the headwaters to the outlets of the Matsqui Slough system, as depicted in Figure 2 and described in Table 3, with GPS coordinates. Two additional locations were added which were identified by a letter "B" preceding the sampling number in Figure 2 and Table 3.

The water quality gradients from the headwaters to the outlet of the Matsqui Slough were measured for dissolved oxygen and total ammonia-nitrogen from October to November weekly and once in December 1993. Additional parameters were measured from February to March. Table 4 summarizes the sampling dates, locations, and parameters for the fall sampling period (October to December) and the winter sampling period (February to March). Dissolved oxygen and temperature were measured in the field using a Yellow Springs Instrument Dissolved Oxygen meter (Model 57) during both the fall and winter sampling period. Field pH (Canlab Model 607) and conductivity (YSI Model 33) measurements were added to the winter survey. Water samples were not filtered or preserved in the field. The fall ammonia samples were delivered the same day to the Ministry of Environment, Region 2 office for transportation to the laboratory. The winter water samples were delivered directly to the laboratory the same day. The fall ammonia samples were analyzed by Zenon Laboratories, while winter samples were analyzed by Elemental Research Inc. Analytical detection limits and duplicate analyses of the winter water samples by Elemental Research Inc. are presented in Appendix B.

Ten private potable water supplies were sampled twice in March for nitrate and bacteriology (total coliforms, faecal coliforms, *E. Coli* and *Klebsiella*). Table 5 summarizes the sampling locations and reported well depths.

4.9 FISH SPECIES COMPOSITION AND RELATIVE ABUNDANCE

Fish were sampled on a presence/absence basis using a Smith Root backpack electroshocker at the six water quality sampling locations. The amount of shoreline area sampled at these stations ranged from about 20 to 60 m², depending on access at specific sites. Large differences in channel width between stations increased the variability in the efficiency of fish capture using this method. The best fish habitat available in the immediate area of each site was initially selected for sampling. The level of effort was standardized within locations in terms of shocking time and area covered, however flooding or freezing occasionally restricted access and reduced the fishable area at some sites.

Difficulties in recovering stunned fish in highly turbid conditions likely under-represented the overall presence of fish. During sampling, the capture of as many species as possible was emphasized over the tallying of more individuals of one species. In some cases, fish were observed only briefly before escaping the electric field; hence, the record of "trout" when species were not actually determined.

A description of physical habitat features was recorded at each station.

5.0 RESULTS AND DISCUSSION

5.1 INDIVIDUAL FARM DATA

The completed questionnaires and other information gathered during the site visits, including the photographs, were arranged in binders by commodity group for the watershed. Complete or partial information was obtained from 37 dairy, 4 hog, 10 poultry and 3 nurseries and 10 vegetable/berry farms. Coordinate data was collected and differentially corrected from 32 dairy farms with 49 manure storage facilities, from two hog farms with three manure storage facilities and from four poultry operations with seven storage facilities or barns. A summary of the GPS coordinate data is given in a separate appendix with the cross-reference index for the completed questionnaires.

5.2 DEVELOPMENT AND APPLICATION OF THE ENVIRONMENTAL SUSTAINABILITY PARAMETER (ESP)

In order to provide a method of comparing the potential for contamination of surface and ground water from agricultural operations in the Matsqui Slough watershed, a farm ranking system was developed using the information from the completed questionnaires. This ranking system produces a single number called an Environmental Sustainability Parameter (ESP). For the farm operations, the manure storage and disposal methods have the greatest potential for contaminating surface and ground waters; consequently, an evaluation of these manure management

methods is the largest component of the ESP value. The basis of the evaluation process are the methods recommended in the Code of Agricultural Practice and Environmental Guidelines. The ESP value was developed in consultation with the Ministry of Environment, Lands and Parks, Environment Canada, Ministry of Agriculture, Fisheries and Foods and Dairy Producers' Conservation Group.

Tables 6, 7 and 8 summarize the questionnaire information for dairy, hog and poultry groups respectively. The acreage (hectare=2.47 acres) identified per farm was the total of owned and rented land available to the producer for spreading manure. The components of these tables (6, 7 and 8) which were used in the ESP are in Tables 12, 13 and 14 which describe the various factors, rating systems and weightings used to develop the ESP value for the individual dairy, hog and poultry farms respectively. The factors considered in developing the ranking system are discussed in the Code of Agricultural Practice (1992) and the Environmental Guidelines for Dairy Producers in British Columbia (1993a), Poultry Producers in British Columbia (1993c) and Draft Environmental Guidelines for Hog Producers in British Columbia (1993b).

In Tables 6, 7 and 8, the ESP factors have been given numerical values from 0 to 5. Because not all of the factors have the same potential for the degradation of surface and ground waters, the factors were weighted. A farmer must have both good manure storage capacity and small numbers of animals per hectare to have a high ESP value. If the recommendations in the Code or Guidelines are practised or bettered on an individual farm, a value of zero is assigned to that factor. By using a zero rating for the best operating practice for each factor, this factor is then not affected by any weighting system. All the individual factor ratings are added to define the ESP for the farm. An ESP value of 100% indicates complete adherence to the Code and Guidelines. A high ESP value (90%) indicates that the potential for ground and surface waters is small. While a farm may have a fairly high level of compliance with the Code and Guidelines, the ESP system also considers poor yard drainage, silage drainage, storage drainage, septic tanks and woodwaste storage.

Tables 9, 10 and 11 show the development of ESP from the information given in the questionnaires summarized in Tables 6, 7 and 8 and the weighted factors in Tables 12, 13 and 14 for dairy, hog and poultry respectively. An example of the the computation of the ESP value for a poultry farm is presented below. The ESP value for hog and dairy were calculated in a similar manner. ESP values were computed in a computational spreadsheet.

EXAMPLE

Farm ID 1060, (Poultry - Broilers)
Summary Information

ESP Rank

Acres = 10, Animals = 20000	
Broiler Equivalents = 20000	
BE/Hectare = $20000/(10/2.47) = 4940 > 2280$	0
Manure Disposal = neighbour	0
Dry Manure Storage = concrete/covered	0
Woodwaste Storage = inside	0
Proximity of watercourse to storage facility = Not applicable	0
Tile field age for household domestic sewage = unknown	3
Ranking out of 119	3
ESP Percentage Ranking = $[(119-3)/119] \times 100 =$	97%

5.2.1 DAIRY ESP

Table 15 compares Ministry of Agriculture, Fisheries and Foods priority ratings of environmental concerns on dairy farms (Van Kleeck, 1994) with the priority rating used in the dairy ESP value for this study. The order of magnitude for the factors is similar, however the ESP weights the manure storage time and application rates higher.

For dairy operations, the revised median grass crop yield (12 tonnes/hectare) with a nitrogen application capacity of 360 kg/hectare was used to determine the allowable spreading rate of manure per hectare without supersaturating the soils with nitrogen (MOAFF, 1993a). This computation is based on an average manure production of 77 L per day per milking cow (MOAFF, 1993a). Milking cow equivalents (MCE) were determined as the total number of dairy animals divided by 1.52 to account for dry cows, young stock and heifers. A milking cow requires about three times as much feed as a dry cow. Manure storage capacity was determined using the storage facilities dimensions, a 77 L/d/MCE animal manure factor, a 27.3 L/d/MCE factor for milk parlour discharges to manure pits (Schmidt, personal communication) and rainfall input of 1091 mm/6 months when storage was uncovered. Storage facilities dimensions were taken from the questionnaire as reported by the producer, where available. Reported dimensions were not verified by measurements during the site visit. If the questionnaire data did not contain storage facility dimensions the size was determined from the corrected GPS files assuming a depth of 2.4 m (8 feet). If there were no data on storage capacity, an average ranking was used for this factor in the ESP value.

The contribution of yard and/or silage drainages to a pit were not quantified in this study and thus were not included in the pit storage time calculations which may result in somewhat longer storage times than actually exist. The yard drainage is related to rainfall events and silage drainage is seasonal. Consequently, these two factors do not have the same potential impact as number of milking cow equivalents (MCE) per hectare or the manure storage capacity.

For the dairy farms in the lower mainland, a storage time of six months is desirable. This allows the manure to be stored during periods when spreading is not desirable in the fall and winter rainy periods because soil is saturated or frozen (MOAFF, 1993a). A manure pit storage time of equal or greater than six months has been given a ranking of zero, with less than six months storage receiving higher rankings from 1 to 5 (see Table 12). Covered concrete facilities were given a ranking of zero while concrete uncovered and steel uncovered were considered equivalent in their potential to prevent agricultural waste pollution and both received the same relative ranking of 5. Earthen pits were considered to be more of a risk because of the possibility of exfiltration in sandy soils and were given a ranking of 15. For future studies an additional ranking of 25 have been added for an earthen pit where seepage had occurred. This survey did not identify whether seepage from an earthen pit was occurring. Seepage should be a component in future studies.

The Environmental Guidelines recommend that dry manure be stored in concrete covered facilities. Dairy farms which followed this recommendation or either had no dry manure to store, or disposed of the dry manure into the pit received a ranking of zero.

Milk parlour wastes, yard drainage and silage drainage should be discharged to the manure storage facility (MOAFF, 1993a). No runoff from any of these three factors was given a ranking of zero. Runoff from any of these three factors to a ditch is the least desirable since this provides for the greatest potential for water contamination. Obviously dairy farms without milking cows would have no milk parlour drainage. Yard drainage refers to any paved area to which the cows have access. Not all dairy farms have yard drainage. Some dairy operations do not use silage or they store their silage in water tight plastic casings from which there is no runoff. As mentioned earlier, silage drainage is seasonal, occurring after the silage is stored.

Figure 4 shows the distribution of the ESP values for the dairy producers. Four producers (11%) had ESP values greater than 80% and four producers (11%) were less than 40%. As agricultural practices changes with implementation of the Environmental Guidelines, a shift or skewness to the right should occur on the frequency distribution graph of the dairy ESP values. Thus, it is important to repeat a survey of this nature in the future to show what improvements have occurred.

5.2.2 HOG ESP

There are three types of hog operations: farrow to finish, farrow to wean and finishers. In farrow to finish operations, sows farrow piglets which are raised on the farm to maturity (5 to 6 months old). On farrow to wean farms, sows farrow the piglets which are raised on the farm until they are weaned (6 to 8 weeks old). They are then sold as weaner pigs to finisher operations or to market. The finisher

operations raise the weaner pigs to maturity for sale to market. For all three types of hog operations, the pigs are housed in barns for the duration of a cycle.

Similar to the dairy ESP, the median grass crop yield (12 tonnes/hectare) with a nitrogen removal capacity of 360 kg/hectare was used to determine the allowable spreading rate of manure per hectare without supersaturating the soils with nitrogen (MOAFF, 1993b). This computation is based on an average manure production of 72 L per day per sow called a sow equivalent (SE)(MOAFF, 1993b; Van Kleeck, personal communication). Manure storage capacity was determined using the storage facilities dimensions, a 72 L/d/SE animal manure factor and rainfall input of 1091 mm/6 months when storage was uncovered. For finishers, which represent 12% of a sow equivalent, a animal waste production factor of 8.9 L/d was used (Van Kleeck, personal communication). Storage facility dimensions were taken from the questionnaire sheet as reported by the producer, where available. Reported dimensions were not verified by measurements during a site visit. If the questionnaire data did not contain storage facility dimensions, the corrected GPS data were used to develop the perimeter and the depth was assumed to be 2.4 m (8 feet).

Unlike dairy farms, yard drainage, milk parlour discharge and silage runoff are not factors to be considered for a pig farm. The manure storage pit type for hog farms is ranked in a similar manner as the dairy farms.

The relative magnitude of each of the factors in the ESP is presented in Table 13 and the ESP values for the hog producers in Table 10 and Figure 5. All four producers interviewed had ESP values between 45% and 50%. As agricultural practices changes with implementation of the Environmental Guidelines a shift or skewness to the right should occur on the frequency distribution graphs of the hog ESP values.

5.2.3 POULTRY ESP

The manure production for poultry is based on the number of broiler equivalents (BE) per cycle. For other poultry units, it was assumed that a layer = 1.55 BE, pullet = 0.94 BE and turkey = 2.26 BE. The permissible manure loadings per hectare were based on a median grass crop yield (12 tonnes/hectare) with nitrogen removal capacity of 360 kg/hectare. The manure handling on poultry farms differs substantially from dairy farms due to the differences in the nature of the operations. Manure is normally removed from the barns at the end of a cycle (10 to 12 weeks for broilers/roasters and 10 months for breeders) then removed from temporary storage within a few days. Table 8 shows that all manure storage areas were greater than 15 m from any watercourse. The Agricultural Code of Practice recommends that manure storage be at least 15 m from any surface water not used as a potable drinking water supply.

Poultry spreading practices are also different. For example, dairy farms almost exclusively dispose of their manure on their own land. Eighty-seven percent of the poultry manure is removed from the farm. Therefore, manure disposal techniques were less of an environmental concern for the individual poultry farm. Since poultry manure storage was either piled on uncovered concrete slabs or in the field, the capacity of these two areas to store the manure was not limited by dimensions as is the case for the liquid dairy or hog manure. On poultry farms, yard drainage is not a factor since the birds are contained within the barns for the duration of a cycle for each type of poultry operation (i.e. layer, broiler, broiler hatching egg or turkey).

The relative magnitude of each of the factors in the ESP value are presented in Table 14. The ESP values for the poultry producers are presented in Table 11 and graphically in Figure 6. Six of the producers (60%) have ESP values greater than 80% and three producers (30%) have ESP values less than 40%. As agricultural practices change with implementation of the Environmental Guidelines, a shift or skewness to the right should occur on the frequency distribution graph of the poultry ESP values.

5.3 STATISTICAL SUMMARY OF FARM OPERATION BY COMMODITY GROUP

In 1991, 134 large farms in the North Matsqui Agricultural area (see Figure 1) had a total gross revenue of 47 million dollars with 36.6 million expenses. The Matsqui Slough watershed is part of the North Matsqui Agricultural region. A total of 79 producers identified in the commodity group's mailing lists were contacted (see Table 1). Eighty-one percent of the farms contacted participated in the study with varying degrees of enthusiasm. Of the remaining 19%, 5% chose not to participate in the study and 14% could not be contacted. Approximately 52% of the producers identified were dairy, 7% hog, 19% poultry, 4% nurseries and 18% vegetable/berry producers.

The livestock farms included in this study utilised a total of 1538 hectares of land in the Matsqui Slough watershed. Approximately 88% of the agricultural land was dairy farms, 8% hog farms and 6% poultry. One goat dairy farm (1.6 hectares) was identified in the watershed. The total amount of dairy/hog/poultry manure produced in the study area was 386,300 L/day using only the data from the farms studied, with an overall loading rate of 251 L/hectare/day (or 1.3 MCE/acre). Dairy operations generate 70% of the manure, hog producers 23% and poultry producers 7%.

Dairy

Of the 42 dairy farms identified in the Matsqui Slough watershed partial or complete data were collected from 37 farms, with three of the producers only

agreeing to the telephone interview portion of the study. Data from the 37 farms were used in the statistical summaries in Table 16. Two dairy producers refused to participate in the study and three producers could not be contacted.

The total land base utilized by dairy producers in the Matsqui Slough watershed was 1361 hectares, with 37 hectares available on average to a producer (includes owned and rented land). The total number of dairy animals (milk cows, dry cows, young stock and heifers) was 5108, with an average number of 138 per farm. The average dairy milking cow equivalent (MCE) was determined to be 95 (milking cow equivalents = total dairy animals/1.52) and the average MCE/hectare was calculated to be 3.4. The mean storage time for manure for the dairy producers was calculated to be 3.4 months, with a range from 0.51 months to 16.2 months. The desirable storage time is six months in order to eliminate the need for winter spreading from October to March. The most common storage facilities for the manure are uncovered concrete (41%) and earthen lagoons (41%). Half of the dairy producers have more than one storage facility. In the Matsqui Slough watershed, 16% of the dairy producers have a storage facility within 30 m of a watercourse.

Hog

A total of six hog producers were identified in the Matsqui Slough watershed. Two of the hog producers were not contacted. Questionnaire data for the four hog producers that did participate in the study was used for the statistical summary in Table 16.

The total land base used by hog producers in the Matsqui Slough watershed was 126 hectares, with an average of 32 hectares (includes owned and rented land). The average sow equivalents (SE) was 313. Farrow to finish operations usually reported the number of sows, while finishers would report the number of mature hogs (finishers = SE x 0.12). No farrow to wean operations were surveyed in this study. The average SE/hectare was determined to be 9.7. The mean storage time for the hog producers was 4.6 months. Half of the storage facilities are concrete uncovered (under barn) manure pits, and one quarter are concrete covered manure pits, and the remaining are earthen lagoons.

About 50% of the hog producers spread manure on their own farms. The remaining 50% spread manure on neighbouring properties as well as on their own land. In the Matsqui Slough watershed, 75% of the hog producers have a storage facility within 30 m of a watercourse.

Poultry

Ten of the 17 poultry operations identified in the Matsqui Slough watershed from

the commodity lists were surveyed. One poultry producer was also a dairy producer. Six of the poultry producers contacted were broiler chicken producers, one was an egg producer and the remaining three were broiler hatching egg producers. Two poultry producers chose not to participate in the study and five could not be contacted. Data from 10 poultry producers have been used in the statistical summary in Table 16.

The total and average land base utilized by poultry producers was determined to be 92 hectares and 9.2 hectares respectively (including owned and rented land). The average number of birds per operation was calculated to be 24205. The average broiler equivalents (BE) and BE/hectare was calculated to be 26311 and 6293. For the short period of time that poultry producers have manure on their property, 40% is kept uncovered on a field and 40% is removed from the property when the barns are cleaned. Approximately 30% of the poultry producers use only their land for manure spreading and 40% spread on neighbouring land. The remaining 30% spread manure both on their own land and neighbouring property. In the Matsqui Slough watershed, 10% of the poultry producers have a storage facility within 30 m of a watercourse.

Produce/Nurseries

Eighteen vegetable/berry/nursery producers were identified in the Matsqui Slough watershed. Questionnaire data was obtained from six berry producers, four vegetable producers and three nursery operations. The data from these 13 questionnaires have been summarized in Table 16. Five producers were not contacted. The total land base used by produce growers/nurseries was found to be 218 hectares, with an average of 17 hectares being used by these two commodity groups.

5.4 FERTILIZER, DOMESTIC SEWAGE, IRRIGATION AND PESTICIDE USE

Table 16 contains a summary of the chemical fertilizer, domestic sewage, irrigation and pesticide use for the four commodity groups: dairy, hog, poultry and vegetable/berry/nursery producers.

Fertilizer Use

The dairy producers occupy 76% of the land base of the Matsqui Slough watershed, and 78% of them use chemical fertilizers. The produce farms and nurseries occupy 12% of the study area and use chemical fertilizers on 85% this land. Twenty percent of the poultry producers use chemical fertilizers on their land, and 50% of the hog producers use chemical fertilizers.

Many of the producers base their chemical fertilization needs and application rates based on soil tests, the results of which vary from year to year and depend on soil chemistry. Chemical fertilizers that are commonly reported by dairy and hog producers include: a side dressing formulation for corn, additional phosphorus and special blends. Fertilizer application on hay or grass is usually in the spring and repeated after each cut. For corn, the fertilizer is applied at planting and as a side dressing which occurs six weeks after planting.

Domestic Sewage

Of the 64 producers participating in the Matsqui Slough watershed, three are on a municipal sewage system, the rest use septic tanks and tile fields. The producers on municipal sewage systems are located west of Riverside Road. The municipal sewage is treated at a secondary treatment plant (James Plant) discharging just downstream of Matsqui Slough outlet. Twenty producers did not know the age of their septic tanks and fields. The average age of the remaining 41 septic tank and fields was 27 years. Reported septic tank and tile field ages range from 1 to 100 years old, with six reported as greater than 100 years and 13 reported as less than 5 years old.

Irrigation Use

The main water supply source for the irrigation by the dairy producers in the Matsqui Slough watershed was well water. Other sources for irrigation include the Fraser River, Page Creek, Clayburn Creek and the irrigation ditches. Producers are currently using various irrigation systems such as reels and sprinklers. Eighty percent of the poultry producers and one half of the hog producers do not use irrigation. Seventy percent of the produce farms and nurseries use an irrigation system.

Pesticide Use

This survey only identified whether pesticides were used and the disposal methods used for pesticide containers. The largest user of pesticides in the Matsqui Slough watershed were the produce farms and nurseries. Ten percent of the poultry farms used pesticides and 43% of the dairy producers used pesticides. Container disposal was the responsibility of the companies applying the treatment for 63% of the dairy farms. The remaining dairy farmers rinsed, crushed and delivered their containers to a landfill or returned the containers to the supplier. All the poultry producers surveyed used contractors for their pesticide applications. Sixty-seven percent of the hog producers used contract applicators. The hog producers applying their own pesticides send their containers to landfills. Forty-two percent of the produce farms and nurseries used contract applicators. The remaining 58% sent their containers to a landfill or had them incinerated or recycle.

5.5 BASIN SURFACE AND GROUND WATER QUALITY

Surface Water Quality

Table 17 summarizes the field measurements (temperature and dissolved oxygen) and dissolved ammonia-nitrogen analyses for the fall sampling period from October to November. Figure 7 depicts the mean dissolved oxygen (mg/L and percent saturation) and total ammonia for the fall sampling period as a bar graph. The dissolved oxygen and ammonia concentration ranges are also indicated in Figure 7 by the vertical lines in the bar graph. Site 2 on Clayburn Creek had a high percentage saturation of dissolved oxygen (>90% in the fall and winter) because the upstream drainage area is undeveloped. Site 3 on Page Creek and Site 6 on Matsqui Slough were consistently low in dissolved oxygen.

Table 18 summarizes the field and chemical analyses (outlined earlier in Table 4) for the February and March sampling period. The dissolved oxygen concentrations in the winter sampling period were consistently greater (up to twice as high) than in the fall period. At Site 6 in the Matsqui Slough, the faecal coliform densities exceeded the recommended guidelines for produce which is eaten raw. The dissolved oxygen levels at Sites 1, 3B and 4 were consistently above 60% saturation in the fall, while the means at Sites 6 and 3 were less than 40%. These data indicated that there were diffuse sources of oxygen demand and/or sediment oxygen demand downstream of Site 2 with natural reaeration insufficient to satisfy these demands. The ammonia concentrations were progressively higher towards the outlet of Matsqui Slough. High ammonia concentrations can act as an oxygen demand and lower the concentrations of dissolved oxygen. This occurs when ammonia undergoes a nitrification reaction which requires two moles of oxygen for each mole of ammonium (Wetzel, 1983). Tables 19 and 20 present the Canadian water quality guidelines and the provincial water quality criteria.

In Section 5.6 the water sampling sites were classified as category I to IV fish habitat based on the site inventories and the professional judgement of an experienced fisheries biologist. According to water quality criteria of the Ministry of Environment, the range of dissolved oxygen concentrations required to support these categories is as follows:

- ! Category I: Spawning and rearing of salmonids - 6 to 11 mg/L
- ! Category II: Year round habitat for at least three non-salmonid species and occasional salmonids - 3 to 8 mg/L
- ! Category III: Marginal habitat for any fish species in the fall but improved winter habitat suitable for at least one salmonid species in

winter - 3 to 8 mg/L

! Category IV: Sparsely inhabited by only a few species in both seasons - 3 to 6 mg/L

The site classifications, dissolved oxygen concentrations and criteria have been summarized in Table 21 and in Figure 7. The sampling sites in Page Creek (Site 3) and in the Matsqui Slough (Site 6) were found to have dissolved oxygen concentrations not suitable for the fish habitat designation. In order for migratory fish to swim upstream to suitable spawning areas they must swim through the lower reaches of Matsqui Slough where dissolved oxygen concentrations may present an obstacle.

The metal analyses data are presented in Table 22 and the Canadian guidelines and provincial water quality criteria in Table 20. Total aluminum concentrations exceeded the Canadian guideline (100 µg/L at pH \geq 6.5 or 5 µg/L at pH<6.5) for the protection of aquatic life at all sites. Mean total chromium concentrations exceeded the Canadian (CCREM, 1987) and provincial criteria of 2 µg/L (MOELP, 1994) for phytoplankton and zooplankton protection at all sites, except Site 6. Canadian and provincial total chromium criteria (20 µg/L) for the protection of fish were not exceeded. Concentrations of total copper exceeded the maximum concentration for freshwater fish species (2 µg/L, 0 to 120 mg/L CaCO₃; CCREM, 1987) at all sampling locations, except Site 2 at the base of Sumas Mountain in February. Total iron concentrations exceeded both Canadian and provincial freshwater aquatic criteria (300 µg/L) at all sites. The zinc concentrations near the outlet of Matsqui Slough (Site 5) in February exceeded the criteria (30 µg/L) for freshwater aquatic life. The manganese concentrations in Willband Creek (Site 1) were within the provincial maximum concentration criteria range (100 to 1000 µg/L) for the protection of freshwater life. There are no provincial total phosphorus criteria for rivers. If it is assumed that portions of the Matsqui Slough are similar to small lakes which is reasonable considering the small velocities, the concentrations of total phosphorus at all locations exceed the recommended provincial guidelines (5 to 15 µg/L) for the protection of aquatic life and are indicative of a nutrient enriched body of water.

Surface Water Quality and Rainfall Events

One objective of the water quality sampling was to determine to what extent rainfall and the resulting runoff affect water quality in the Matsqui Slough watershed. Other numerous studies on rainfall runoff in both urban and agricultural areas have indicated that water quality can be degraded after a rainfall event (Table 23). The fall water quality consisted of collecting water samples at six sampling sites weekly for two months. This sampling program was not intentionally organized to collect samples after rainfall events. The winter sampling program in February and March

was planned so that some sampling days were after rainfall events and some during dry periods. Rainfall was considered to be indicative of runoff. There are no data available on the rainfall-intensity-duration and time response characteristics of the waterways in the Matsqui Slough watershed. This section discusses some different methods for determining which sampling surveys represented runoff events. These methods are required because no hydrograph data were available for the waterways during the sampling.

The distance from each sampling site to the outlet of Matsqui Slough is presented in Table 24 as measured from the topographic map (Mission, 92 G/I, 5th Edition, Energy, Mines and Resources Canada, NAD27). There are no data on the time-of-travel in the Matsqui Slough watershed. We have estimated the rainfall response times for a runoff and dry condition, based on the assumption that typical dry and wet weather waterway mean velocities for the Matsqui Slough watershed would be approximately 0.15 m/s and 0.3 m/s respectively (based on a visual inspection of the waterways). The travel time from the sampling sites to the outlet are also presented in Table 24. The travel time from Site 2 to the mouth of Matsqui Slough would be approximately eight hours in wet weather and sixteen hours in dry weather. This travel time is probably less than actual since the water level in the Matsqui Slough watercourses can be controlled by drainage ditches, weirs and pumps as outlined in the description of the study area in Section 3.0. A more conservative estimate of a typical travel time for this basin would be about 24 hours.

Daily rainfall data from Abbotsford Airport Station (Environment Canada, Atmospheric Environment Services) has been plotted in Figure 8 for the duration of water quality sampling period (October 1993 to March 1994). The rainfall data does not provide any information on the intensity/duration of the daily rainfall (i.e. 10 mm of rainfall in 3 hours or in 20 hours). Abbotsford Airport is located approximately 13 km south-west of the intersection of Bell Road and Page Road in Matsqui.

The water quality data were analyzed on a watershed basis for all sites and on a site basis for the three upstream sampling Sites 1, 2 and 3 based on differences between "wet" and "dry" sampling days. The difference between "wet" and "dry" concentrations was determined for ammonia, suspended solids and faecal coliforms. The watershed averages for the wet and dry periods are discussed first, followed by the site averages in the upper reaches of the basin.

In the following "wet" versus "dry" comparisons are based on crude time-of-travel estimates for the Matsqui Slough watercourses and synoptic water quality monitoring. Detailed time-of-travel studies and modelling of the Matsqui Slough basin are needed before the impact of rainfall events on water quality can accurately be assessed.

Watershed Averages for "Wet" and "Dry" Periods

The sampling days have been classified as "wet" and "dry" using a basin response time of 8 and 24 hours for the rainfall distribution plotted in Figure 8. This classification system shows that October 6, November 15, December 15, February 22, and March 3 were wet days for both the 8 and 24 hour response time. October 25, November 1, 8, 24, February 10, and March 24 were classified as "dry" sampling days.

8 hour Response Time		24 hour Response Time	
<u>"Wet" Days</u>	<u>"Dry" Days</u>	<u>"Wet" Days</u>	<u>"Dry" Days</u>
FALL			
Oct 6, 12, 18, 1993	Oct 25, 1993	Oct 6, 1993	Oct 12, 18, 25, 1993
Nov 15, 1993	Nov 1, 8, 24, 1993	Nov 15, 1993	Nov 1, 8, 24, 1993
Dec 15, 1993		Dec 15, 1993	
WINTER			
Feb 22, 1994	Feb 10, 1994	Feb 22, 1994	Feb 10, 1994
March 3, 10, 1994	March 24, 1994	March 3, 1994	March 10, 24, 1994

The differences in surface water quality concentrations during wet and dry sampling days were determined. The parameters were compared on a watershed basis by averaging the data from all sampling sites for the wet and dry sampling days and statistical testing for differences with a "t" test. Table 25 presents the basin averaged values for the parameters indicated earlier. There were no data on metals for the "dry" condition. Neither suspended solids nor coliforms were statistically significantly different.

For ammonia, the "dry" concentration was greater than the "wet" but the difference was not statistically significant. The suspended solids are greater during the "dry" condition. The "wet" basin averaged faecal coliform density is three times greater than the "dry" concentrations.

Metal concentrations were measured on February 22, and March 3, 1994 which were both classified as "wet" sampling days. During the week prior to March 3, 1994 approximately twice as much rain fell (122.7 mm) compared to the week prior to February 22, 1994 (62.9 mm). Total aluminum concentrations were a factor of two greater on a watershed basis on March 3 compared to February 22, 1994. Iron concentrations were approximately 1.8 times greater on March 3 than February 22, 1994. Selenium showed increased concentrations of a factor of 2.5 on a watershed basis. The metal concentrations for aluminum, iron and selenium appeared to be directly related to the amount of rainfall. For cadmium, lead, mercury and zinc, no difference was noted between February 22 and March 3, 1994.

Upper Reaches Averages for "Wet" and "Dry" Periods

The three upper-reach sites sampled in the Matsqui Slough watershed were; Site 1 - Willband Creek @ Valley Road, Site 2 - Clayburn Creek @ Clayburn Road and Site 3 - Page Creek @ Beharrell Road. To investigate local runoff impacts, the sampling days were classified as "wet" if it rained the day of sampling as indicated by the rainfall distribution plotted in Figure 8. Using this criterion, the "wet" and "dry" sampling days are:

<u>"Wet" Days</u>	<u>"Dry" Days</u>
FALL	
October 6, 12, 18, 1993	October 25, 1993
November 15, 1993	November 1, 8, 24, 1993
December 15, 1993	February 10, 1994
WINTER	
February 22, 1994	March 24, 1994
March 3, 10, 1994	

The "wet" and "dry" averaged water quality data for ammonia, suspended solids and faecal coliforms are presented in Table 26 for Sites 1, 2, and 3. Metal concentration data are only available for "wet" days. For Sites 1 and 2, the averaged ammonia concentrations for "wet" sampling days was 2.6 times greater than the averaged "dry" concentrations (Table 26) but was not statistically significant. For Site 3, the averaged "dry" sampling days ammonia concentration was greater than the averaged "wet" sampling days ammonia concentration by a factor of two (Table 26) which is statistically different at the 90% confidence level.

Table 26 indicates that no differences between "wet" and "dry" mean suspended solids concentrations were noted for Sites 1 and 3. However, the averaged "wet" days suspended solids concentration was 5.5 times higher than the averaged "dry" days suspended solids concentration for Site 2 but the difference was not statistically significant. For faecal coliforms, no differences were noted between the averaged "wet" and "dry" days densities at Sites 1 and 2. At Site 3, the averaged faecal coliform density on the "wet" days was 4.5 times greater than the averaged "dry" days density and was statistically different at the 90% confidence level.

As discussed previously, during the week prior to March 3, 1994 approximately twice as much rain fell (122.7 mm) compared to the week prior to February 22 (62.9 mm). From Table 22, aluminium concentrations were approximately seven times greater on March 3 at Site 2 than on February 22, 1994. Sites 1, 4 and 5 showed a two to three fold increase, with Sites 3 and 6 showing only marginal increases. Iron concentrations were six times greater at Site 2 and between 1.2 to three times greater at the other five sites. For selenium, Sites 3 to 6 showed an increase between a factor of two to four. Sites 1 and 2 showed no difference between the two sampling days for cadmium, lead, mercury and zinc.

Ground Water Quality

The well sample results are presented in Table 27. The bacterial densities in all well water samples were below detection limits. Canadian and provincial raw drinking water criteria are presented in Table 19 for nitrate, nitrite and faecal coliforms. There was one deep well (6.7 m). There was no difference in nitrate concentrations with depth for wells which were between 3.7 and 6.7 m deep. The nitrate concentrations in the well that was 18.3 m deep were below detection concentrations. Iso-concentration contours have been developed for nitrate and plotted in Figure 9. These contours were developed from nitrate concentrations in nine wells which were sampled on two different days. The concentration contours show the areas with nitrate concentrations greater than the domestic drinking water criteria of 10 mg/L. All concentrations were less than the livestock watering criteria of 100 mg/L. The shape of the iso-concentration lines in Figure 9 confirm the general ground water circulation direction of Gartner Lee (1993) and confirm the moderate vulnerability of the Matsqui aquifer documented by Kreye and Wei (1994) in Figure 10.

Figure 11 plots the seasonal variation of nitrate concentrations in drain tile effluent as reported by Schmidt (1993). If the mean measured seasonal variation of nitrate concentrations in tile field drains is used (Figure 11), the nitrate concentrations in March and April were between 40% and 70% of the annual maximum. Other well data from Halstead (1986) for a 5 m deep well in the western part of the Matsqui Slough watershed showed that the mean nitrate concentration from 1978 to 1981 was 5.7 mg/L (N=8) and the coefficient of variation was 0.22. For this 5 m deep well, the difference between the January-February nitrate concentration and the annual maximum in the fall was 40% increase.

If the same seasonal variation that was measured in the tile field drains (Schmidt, 1993) occurs in the ground water, the well nitrate concentrations can be 30 to 60% higher than those measured in this study. The tile field annual variation was probably greater than that would occur in the shallow wells, but at this time there is limited data on nitrate seasonal variation available. If the seasonal variation was greater than 40%, eight of the ten wells tested will have greater than 10 mg/L of nitrate.

5.6 FISH SPECIES COMPOSITION AND RELATIVE ABUNDANCE

Twelve species of fish were collected or observed during the study. Their distribution and relative numbers between locations, for all five field survey days combined, is shown in Table 28. Table 29 presents the field survey information for the five sampling days individually. Stickleback were by far the most ubiquitous species, representing approximately 46 % of the total catch and being captured at five of the six locations.

Salmonids were present at 50% of the locations on at least one occasion with rainbow/steelhead trout representing 24% of the total catch and 44% of the total salmonid catch. Only Site 2 on upper Clayburn Creek had salmonids present on all five visits and accounted for 85% of the total salmonid catch.

All of the sites supported fish life. Based on site inventories and professional judgement, the locations were classified into four categories (I, II, III, IV) according to the relative quality and permanency of fish habitats.

Category I sites likely contain consistently good water quality and year round habitat for spawning or rearing salmonid species in most runoff conditions. These sites were smaller headwater streams in the study area, and included Willband Creek (Site 1) and Clayburn Creek at Clayburn Road (Site 2). Of these, Site 1 had the lowest salmonid densities, yielding only two coho salmon and one rainbow/steelhead trout, while Site 2 yielded eight coho salmon, 23 rainbow/steelhead trout and 16 cutthroat trout in five visits.

Category II sites likely contain consistent year-round habitat for at least three non-salmonid species and occasional salmonids. There were no Category II sites identified in the Matsqui Slough watershed.

Category III sites contained marginal habitat for any fish species in the fall season, but provided improved habitat in the winter season for at least one salmonid, or at least three non-salmonid, species in winter. Page Creek (Site 3) is a Category III site.

Category IV sites were sparsely inhabited by only a few species in both seasons. These sites were Clayburn Creek at Harris Road (Site 4), Matsqui Slough (Site 5) and Matsqui Slough tributary (Site 6). These reaches do not provide spawning or rearing habitat for salmonid fish habitat due to low velocities and poor water quality conditions that likely persist year round. However, Matsqui Slough is important to local salmonid populations for brief periods each year as a migratory route. Anadromous stocks, although small in number, migrate through the Slough from the Fraser River and the headwater spawning areas each year. Gated dams at the mouths of both streams physically restrict fish access and worsen stagnant water conditions at certain seasons. During the summer-fall, low flow period when water quality conditions are poorest, fish movements between the Fraser and the headwaters may be restricted until significant runoff events in the late fall flush the stagnant water in the respective mainstems. Salmon are migrating upstream during the summer-fall, low flow period. Upgrading Category IV reaches to Category III will provide non salmonid habitat.

6.0 CONCLUSIONS

6.1 FARM INVENTORY

The process of sending an explanatory letter to each producer followed by a telephone interview and then a site visit was found to be a very effective method for obtaining information on the individual farm operations. The site visits were an important component of the study. These visits not only provided personal contact with the farmer but permitted the farmer to ask questions about the study and farm management.

A common questionnaire form was used for all the producers in this project. The agrowaste management practices of the dairy, hog and poultry producers were very different; consequently, a different questionnaire format for the different producer groups would expedite the information gathering process and make it more direct. Different questionnaires were required for the different producer groups. Unfortunately, most producers do not have quantitative information on their manure production, spreading rates and frequencies, chemical fertilizer spreading rates and frequencies, crop yield and protein levels and irrigation water usage.

All of the project cooperating farms in the Matsqui Slough watershed were visited and the agrowaste management practices and facilities were documented and photographed. Using this process, it was possible to determine the extent of application of the Code of Agricultural Practice and the Environmental Guidelines for the various producer groups. The average storage capacity of manure in the Matsqui Slough watershed was 3.4 months for the dairy producers and 4.6 months for hog producers. Eighty percent of the dairy producers had either concrete or earthen manure storage facilities. Nineteen percent of the concrete facilities were covered. For the hog producers, 50% of the manure storage was concrete and covered. Forty percent of the poultry producers had no manure storage and 40% use field uncovered storage for short periods. All dairy producers spread their manure on their own land, with 86% using splash plate spreading techniques; whereas, only 50% of the hog producers spread their manure on their own land and 30% of the poultry producers use their own land. This survey did not document the final destination of the manure once it was removed from a producer's property.

Forty-three percent of the dairy farmers used pesticides and 63% of the farmers had the pesticide containers removed by contractors. For the hog producers, 75% use pesticides and 67% of producers have contractors remove the containers. Only 10% of the poultry producers used pesticides. Approximately 83% of the produce and nursery producers used pesticides. Sixty percent of these producers used landfills to dispose of the pesticide containers.

Eighty-five percent of the produce and nursery producers used chemical fertilizers and 78% of the dairy producers used chemical fertilizers. About 50% of the hog and

30% of the poultry producers used chemical fertilizers. No information on the amount of chemical fertilizers used was available.

Nearly all of the producers had septic tile fields for the treatment of sanitary wastes. The biggest irrigators were the produce and nurseries at 69% followed by the dairy producers at 24%. Only about 20% of the poultry and 50% of the hog producers irrigate. There was no information on the amount of water used in irrigation although the source of the irrigation water was identified in the survey.

Environmental Sustainability Parameter (ESP)

The ESP values, which are a measure of the extent of the application of the Code of Agricultural Practice and Environmental Guidelines, were determined for each individual producer. Eight percent of the dairy producers had ESP value greater than 80% and 13% less than 40%. All four hog producers had ESP value between 45% and 50%. Sixty percent of the poultry producers had ESP values greater than 80% and 30% less than 40%.

6.2 WATER QUALITY

The dissolved oxygen concentrations were higher in the winter survey as expected. The dissolved oxygen concentrations in Matsqui Slough (Site 6) were degraded below the concentrations required to support the identified fish habitat. Total phosphorus at all sites exceeded the provincial criteria of 5 to 15 µg/L for lakes indicating nutrient enrichment in the drainage waterways. The faecal coliform densities in the Matsqui Slough (Site 6) exceeded the provincial criteria for irrigation water for produce that is eaten raw (200 FC/100 mL).

The concentrations of total aluminum exceeded the Canadian guideline for freshwater fish species at all sampling locations. The source appears to be Sumas Mountain because the concentrations were highest in the upper reaches of Clayburn Creek. The total copper concentrations exceeded the Canadian guidelines for freshwater fish species at all sampling locations except in Clayburn Creek (Site 2) in February. This site had the greatest density and diversity of salmonids. Total iron concentrations exceeded both Canadian and provincial freshwater aquatic criteria (300 µg/L) at all sites. Total zinc concentrations at the Matsqui Slough outlet (Site 5) exceeded water quality criteria for the protection of freshwater aquatic life. Possible sources of copper and zinc could be present in herbicides and crop seed pesticides formulations. Iron was ubiquitous in developed watersheds.

The nitrate concentrations in at least five of the ten wells sampled exceeded the 10 mg/L domestic drinking water criteria. Faecal coliform contamination of the wells did not exist.

6.3 FISHERIES

Salmonids were present at three of the six water sampling sites. All sites had fish but at two sites the fish species present was restricted to stickleback.

7.0 RECOMMENDATIONS

7.1 FARM INVENTORY

The inventory should be updated in 3 or 5 years time to document improvements in the farm environmental sustainability factors. Different questionnaires should be developed for the different producer groups because the agrowaste management practices vary. The questionnaire should be designed to be compatible with data base systems.

Some documentation is required on manure that is exported from the farm. This documentation should include the name of the remover, quantity, date of removal and the destination of the manure. Records of the spreading rates, volume spread and spreading dates would be useful.

More detailed information should be made available to the farmer on the best days for spreading manure and the allowable rate. This information should be accessible by telephone and be readily available locally as well as being locally specific. Information such as soil moisture, rainfall, frozen ground index, seasonal soil nitrate index, weather predictions, fisheries timing, flows in the Matsqui Slough watershed could be used in developing the spreading index. If possible, the spreading index would be modified locally by the individual farmer for the farm soil type and the nitrate levels determined by some method like a nitrometer.

There is no explicit information available on the export of material from the different farming operations with the exception of the report on nitrate (Schmidt, 1993). Consequently, there is a need for quantitative studies on milk parlour wastes, yard drainage, silage drainage and manure pit leachate on surface and subsurface water quality.

7.2 WATER QUALITY

Indicators of surface water quality degradations included dissolved oxygen, total phosphorus, total aluminum, total iron, total copper, total zinc, faecal coliforms and ammonia concentrations. The concentrations of metals and bacterial densities should be monitored during dry periods and periods after rainfall events. The kinetics determining the dissolved oxygen concentrations in the waterways is complicated by the small and variable velocities in the watercourses which to a large extent are controlled by pumps and check gates. If the sources of oxygen demand are to be identified and the most cost effective remedial measures determined, it will be necessary to gather the data and apply a conventional dissolved oxygen model such as QUAL2. Because most of the processes determining the dissolved oxygen concentration in the waterways are biological, a model is really the only way to understand and predict the dissolved oxygen regime in the waterways. The model must include ground water flow, stagnation conditions, variable flows

and sediment oxygen demand. An extensive data base will be required to apply the model with any degree of confidence. While there are data on flows in the waterways, there are no data on time of travel. It is recommended that the model be developed and applied to a sub-catchment like Matsqui Slough or Page Creek so that the model can be modified to suit the Matsqui Slough watershed.

7.3 WATERSHED PLANNING

As watershed and land use planning become accepted practices (MEE, 1993 (a), (b), (c)), studies of this nature will be required to adequately demonstrate changes in land use practices that can be used to demonstrate causes of receiving water quality degradation.

8.0 ACKNOWLEDGMENTS

We would like to acknowledge the assistance of the following personnel in this project without whose assistance this project could not have been successfully completed. Brent Moore and Elizabeth Freyman of the Ministry of Environment, Lands and Parks provided administrative and technical support throughout the project. Environment Canada provided the majority of the funding for this project and George Derksen of Environment Canada provided technical guidance and assistance throughout the project. Rick Van Kleeck of the Ministry of Agriculture, Fisheries and Food provided detailed technical assistance on all aspects of the farm operations and Orlando Schmidt of the Dairy Producers' Conservation Group also provided technical assistance on dairy producer operations and nitrate kinetics. Lastly, Jennifer Nener of the Department of Fisheries and Oceans contributed additional financial support to carry out fish and water quality surveys in the winter period. Merv Palmer managed the project and was supported by Neville Rising, Karen Moore, Marlene Fuhrmann and Ron Tschirhart who are all IRC employees. The fisheries work was carried out by Bill Bengeyfield and Ron Fink of Global Fisheries Consultants. The cooperation of the various producers within the Matsqui Slough watershed is gratefully acknowledged.

9.0 GLOSSARY

ASCII	American Standard Code for Information Interchange
BE	Broiler Equivalents
CEP	Circular Error Probable
CCREM	Canadian Council of Resource and Environment Ministers
DFO	Department of Fisheries and Oceans
DO	Dissolved Oxygen
ESP	Environmental Sustainability Parameter
FRAP	Fraser River Action Plan
GIS	Global Information System
GPS	Global Positioning System
HP	Horse Power
MCE	Milking Cow Equivalents
MOAFF	Ministry of Agriculture, Fisheries and Foods
MOELP	Ministry of Environment, Lands and Parks
NAD27	North American Datum, 1927
NAD83	North American Datum, 1983
QUAL2	Stream Water Quality Model
SE	Sow Equivalents
UTM	Universal Transverse Mercator

10.0 REFERENCES

Alberta Environment, 1987. *Stormwater Management Guidelines*.

CCREM, 1987. *Canadian Water Quality Guidelines*. Canadian Council of Resource and Environment Ministers.

Cole, R.H., R.E. Frederick, R.P. Healy and R.G. Rolan, 1984. *Preliminary Findings of the Priority Pollutant Monitoring Program*. Journal Water Pollution Control Federation, Volume 103.

Energy, Mines and Resources Canada, 1992. Mission Topographic Map, 92 G/1, 5th Edition, NAD27

Environment Canada Atmospheric Environment Service National Identification 1100030. Rainfall data for Abbotsford Airport for October 1993 to March 1994. Note: February and March rainfall data was unverified.

Gartner Lee, 1993. *Evaluation of Potential Drinking Water Contaminants - Fraser Valley*. Project 91-744. Gartner Lee Consulting Sperling Plaza 6400 Roberts Street, Suite 490. Burnaby B.C. V5G 4C9.

Halstead, E. C., 1986. *Ground Water Supply - Fraser Lowland, British Columbia*. Environment Canada, National Hydrology Research Institute, Saskatoon, Saskatchewan.

Hey, D.L. and G.C. Schueler, 1984. *An Evaluation of the Water Quality Effects of Detention Storage and Source Control*. Conference Proceedings: Urban Effects on water Quality and Quantity. Illinois Department of Natural Resources.

Hutton, K., 1987. *Lower Fraser Valley Agricultural Waste Management Survey*. Prepared for B.C. Ministry of Environment and Parks, Region 2.

Kibler, D.F., Editor, 1982. *Urban Stormwater Hydrology*. Water Resources Monogram #7 American Geophysical Union.

Kreye, R. and M. Wei, 1994. *A Proposed Aquifer Classification System for Groundwater Management in British Columbia*. British Columbia Ministry of Environment, Lands and Parks, Water Management Division.

Luttmerding, H.A., 1980. *Soils of the Langley-Vancouver Map Area, Volume 1: Soil Map Mosaics and Legend, Lower Fraser Valley (Scale 1:25,000)*, RAB Bulletin 18. Report No.15 British Columbia Soil Survey, Ministry of Environment Assessment and Planning Division, Kelowna, British Columbia.

Luttmerding, H.A., 1981. *Soils of the Langley-Vancouver Map Area, Volume 3: Description of the Soils*. RAB Bulletin 18. Report No.15 British Columbia Soil Survey, Ministry of Environment Assessment and Planning Division, Kelowna, British Columbia.

MEE, 1993. *Subwatershed Planning*. Ontario Ministry of Environment and Energy. Ontario Ministry of Natural Resources.

Meier, J., 1993. *Abbotsford Aquifer Agricultural Waste Management Survey*. Prepared for the B.C. Federation of Agriculture and B.C. Ministry of Environment, Lands and Parks, Lower Mainland Region.

MOAFF, 1994. *Study Zones of the Agricultural Inventory Project for the Lower Fraser Valley*. British Columbia Ministry of Agriculture, Fisheries and Food, 101-33832 South Fraser Way, Abbotsford, British Columbia. V2S 2C5.

MOAFF, 1993a. *Environmental Guidelines for Dairy Producers in British Columbia*. British Columbia Ministry of Agriculture, Fisheries and Food, 101-33832 South Fraser Way, Abbotsford, British Columbia. V2S 2C5.

MOAFF, 1993b. *Environmental Guidelines for Hog Producers in British Columbia, Draft Report*. British Columbia Ministry of Agriculture, Fisheries and Food, 101-33832 South Fraser Way, Abbotsford, British Columbia. V2S 2C5.

MOAFF, 1993c. *Environmental Guidelines for Poultry Producers in British Columbia*. British Columbia Ministry of Agriculture, Fisheries and Food, 101-33832 South Fraser Way, Abbotsford, British Columbia. V2S 2C5.

MOELP. 1994. *Approved and Working Criteria for Water Quality - 1994*. B.C. Ministry of Environment, Lands and Parks, Water Quality Branch, Victoria.

Schmidt, O., personal communication. British Columbia Dairy Producers' Conservation Group. 205-33780 Laurel St., Abbotsford, British Columbia. V2S 1X4.

Schmidt, O., 1993. *Effects of Field Management Practices on Nitrate Transfers to Tile Drains*. British Columbia Dairy Producers' Conservation Group Annual Report. 205-33780 Laurel St., Abbotsford, British Columbia. V2S 1X4.

Schubert, N. D., 1982. *A Bio-Physical Survey of Thirty Lower Fraser Valley Streams*. Canadian Manuscript Report of Fisheries and Aquatic Sciences 1644, Department of Fisheries and Oceans, New Westminster, British Columbia.

Trimble Navigation, 1992. *GPS Pathfinder Basic Manual*. PFBasic Release 2.00. Trimble Navigation Limited, Sunnyvale, California, U.S.A.

Waste Management Act: Code of Agricultural Practice for Waste Management, 1992. Province of British Columbia

Wetzel, R.G., 1983 *Limnology* Second Edition. Saunders College Publishing

Van Kleeck, R., personal communication. Waste Management Engineer. British Columbia Ministry of Agriculture, Fisheries and Food. #101 - 33832 South Fraser Way Abbotsford, British Columbia, V2S 2C5

Van Kleeck, R., 1994. *Dairy Environmental Assessment: Doing Your Own Evaluation*. British Columbia Ministry of Agriculture, Fisheries and Food Dairy Producers' Short Course. Clearbrook, British Columbia.

Figure 1
Matsqui Slough Watershed Study Area
within North Matsqui Zone

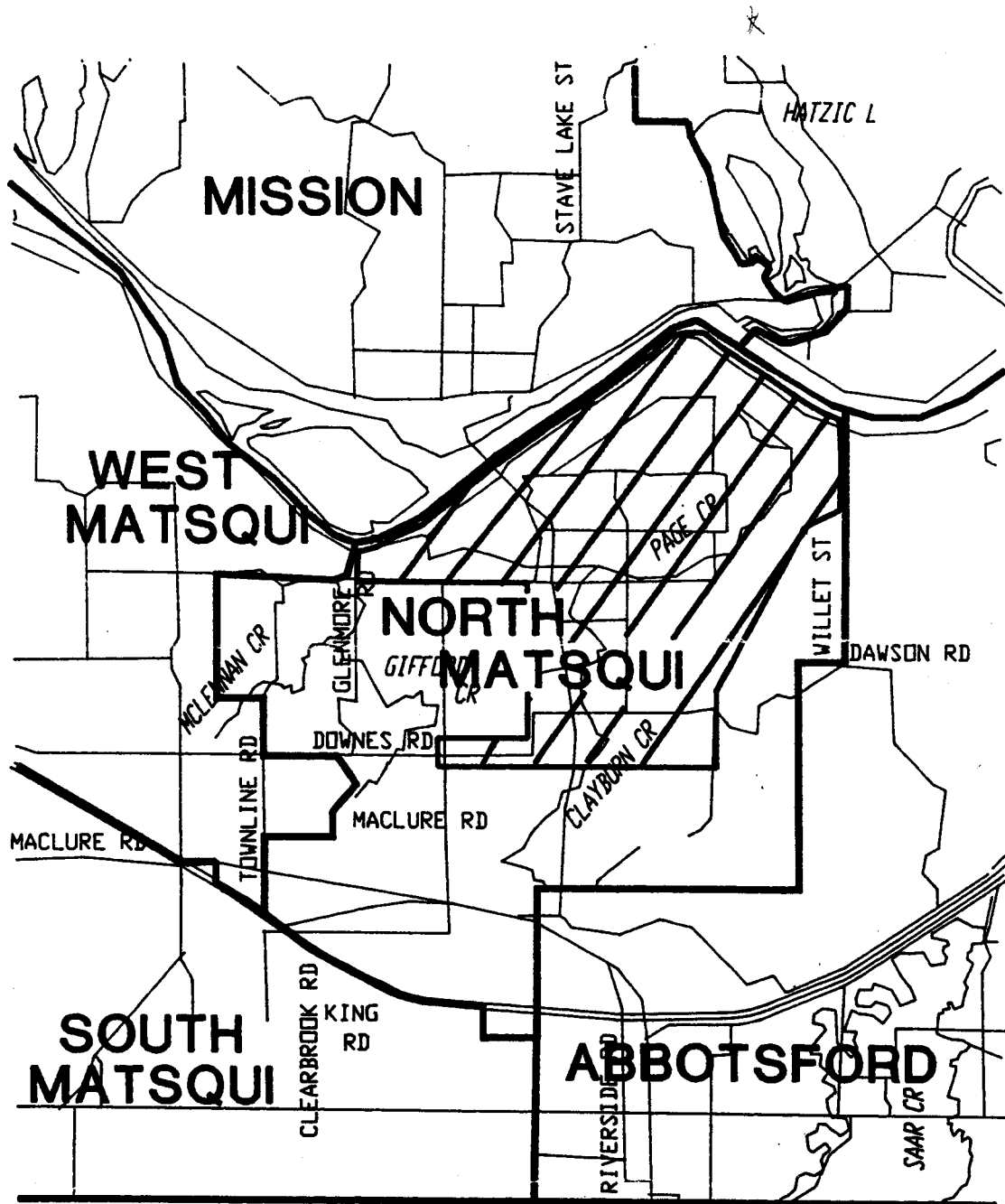


Figure 2
Matsqui Slough Watershed Study Area and Sampling Locations

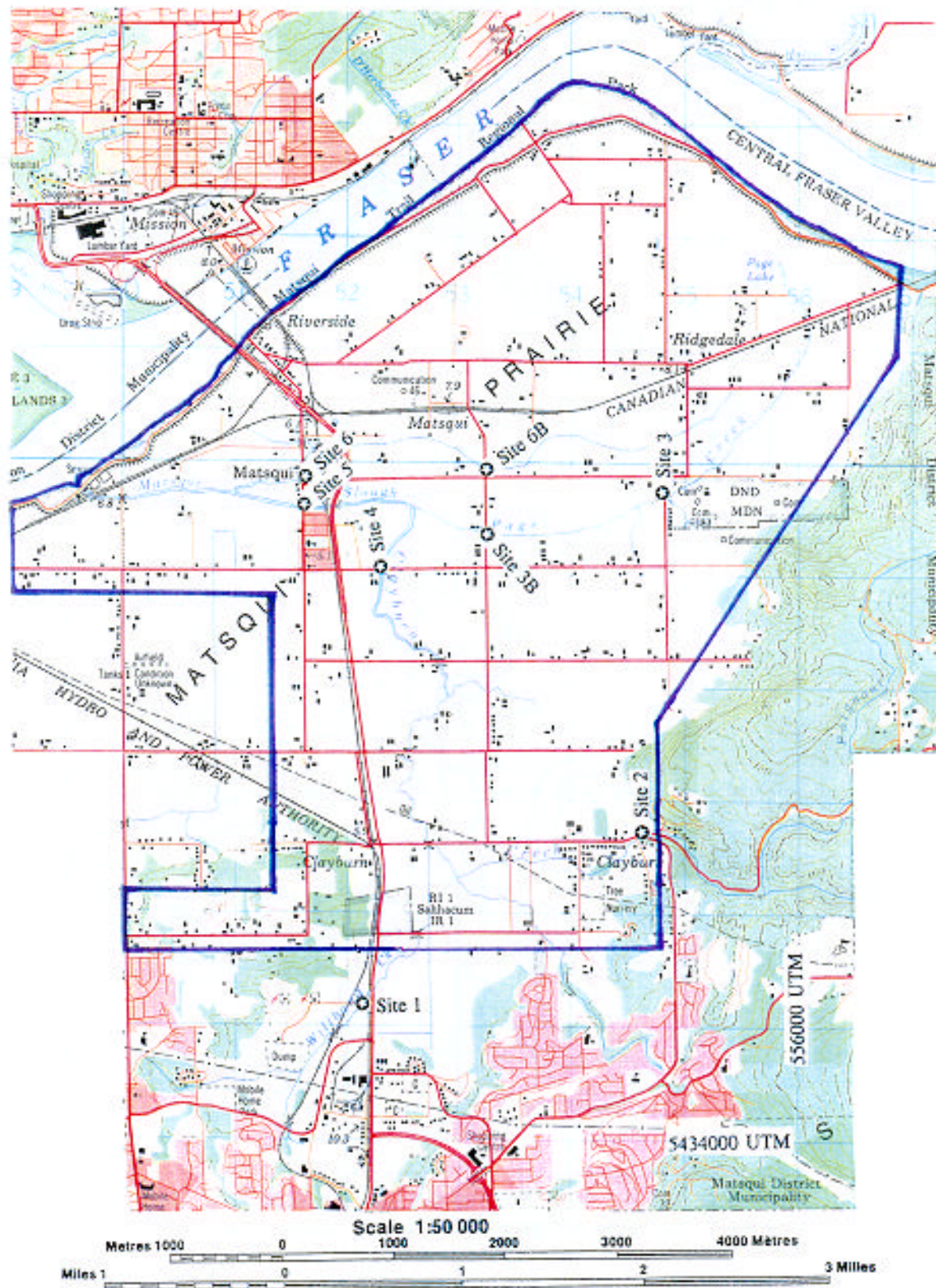
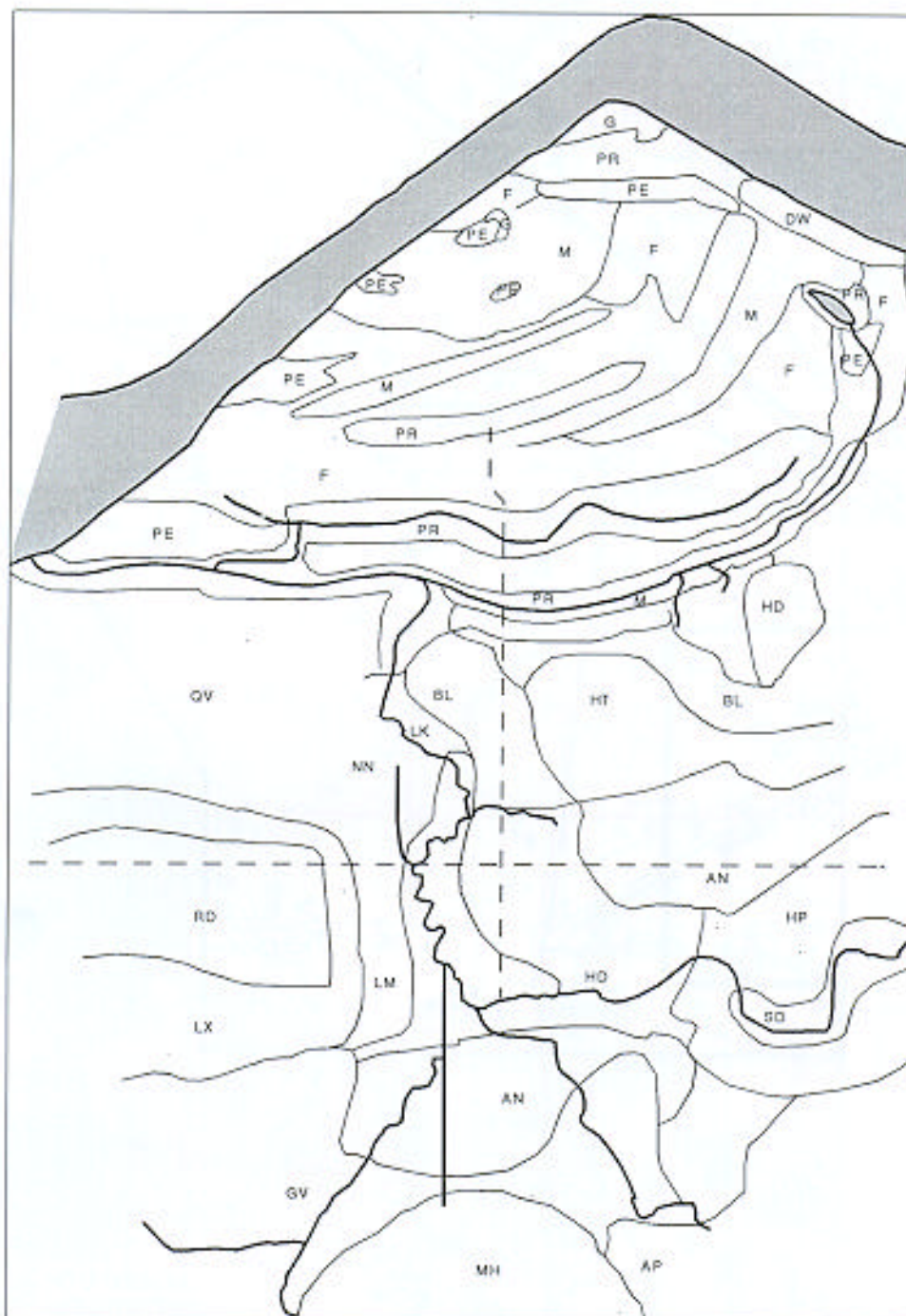
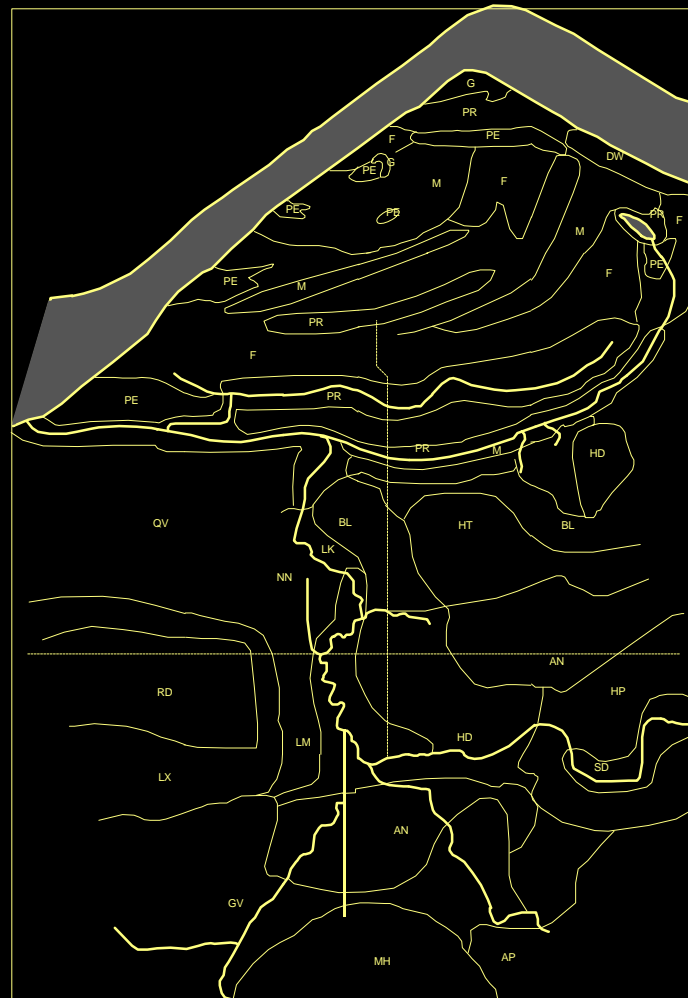


Figure 3
Matsqui Slough Watershed and Soil Map



Luttmerding, H.A., 1980. Soils of the Langley-Vancouver Map Area, Volume 1: Soil Map Mosaics and Legend, Lower Fraser Valley.

Figure 3
Matsqui Slough Watershed and Soil Map



Luttrell, H. S. 1980. Soils of the Legley-Vancouver Map Area, Valley.

Figure 4
Matsqui Slough Watershed Dairy ESP Frequency Distribution

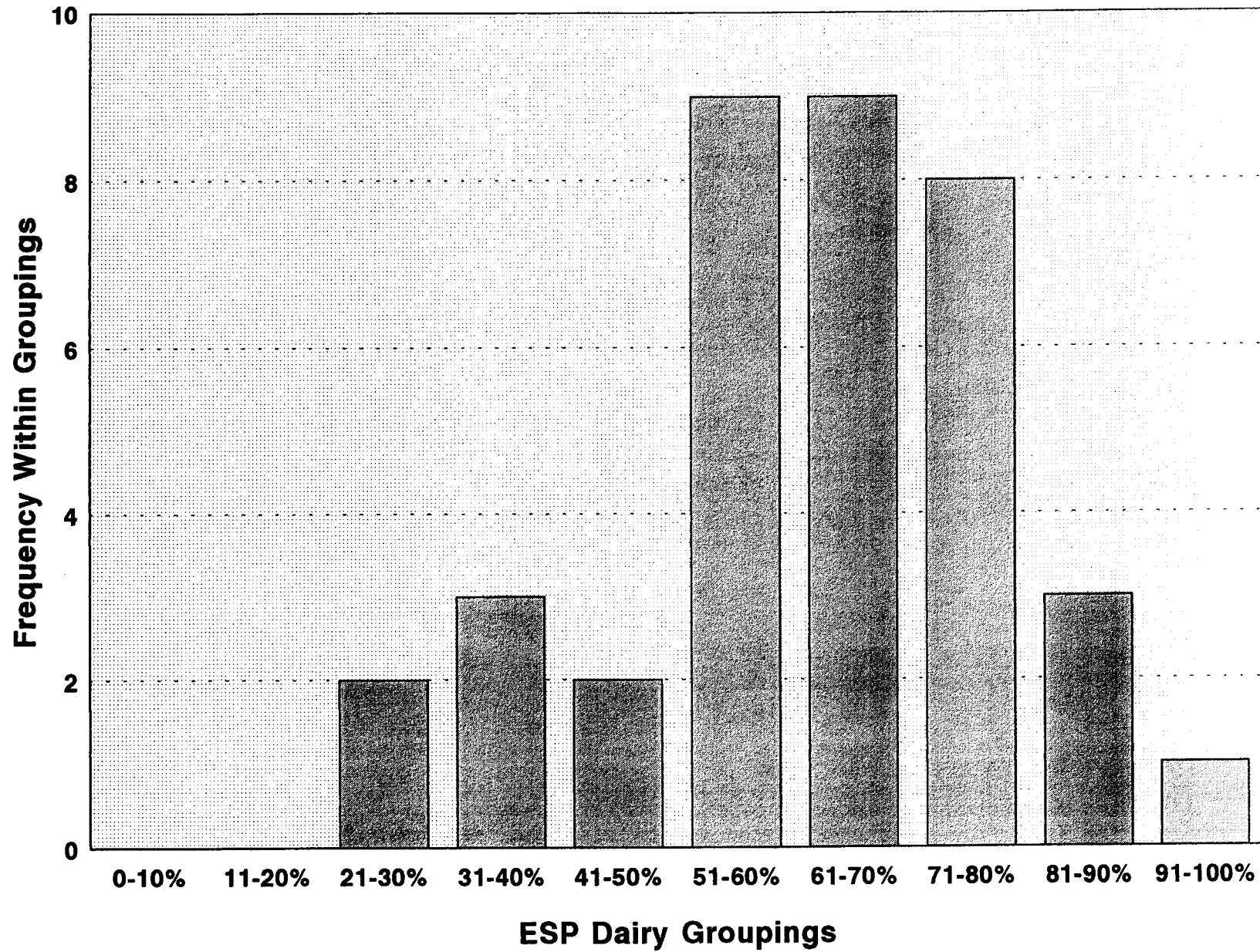


Figure 4
Matsqui Slough Watershed Dairy ESP Frequency Distribution

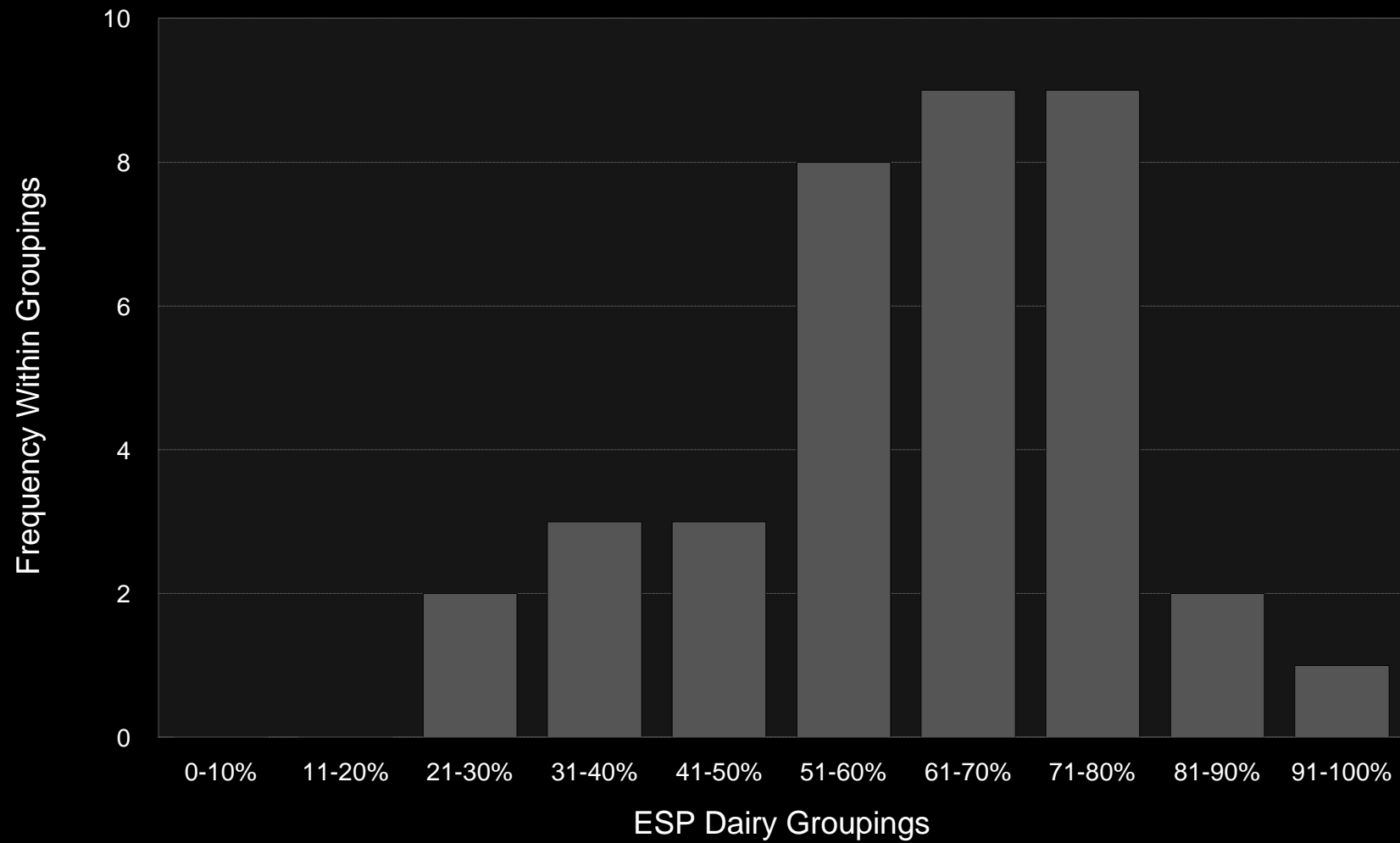


Figure 5
Matsqui Slough Watershed Hog ESP Frequency Distribution

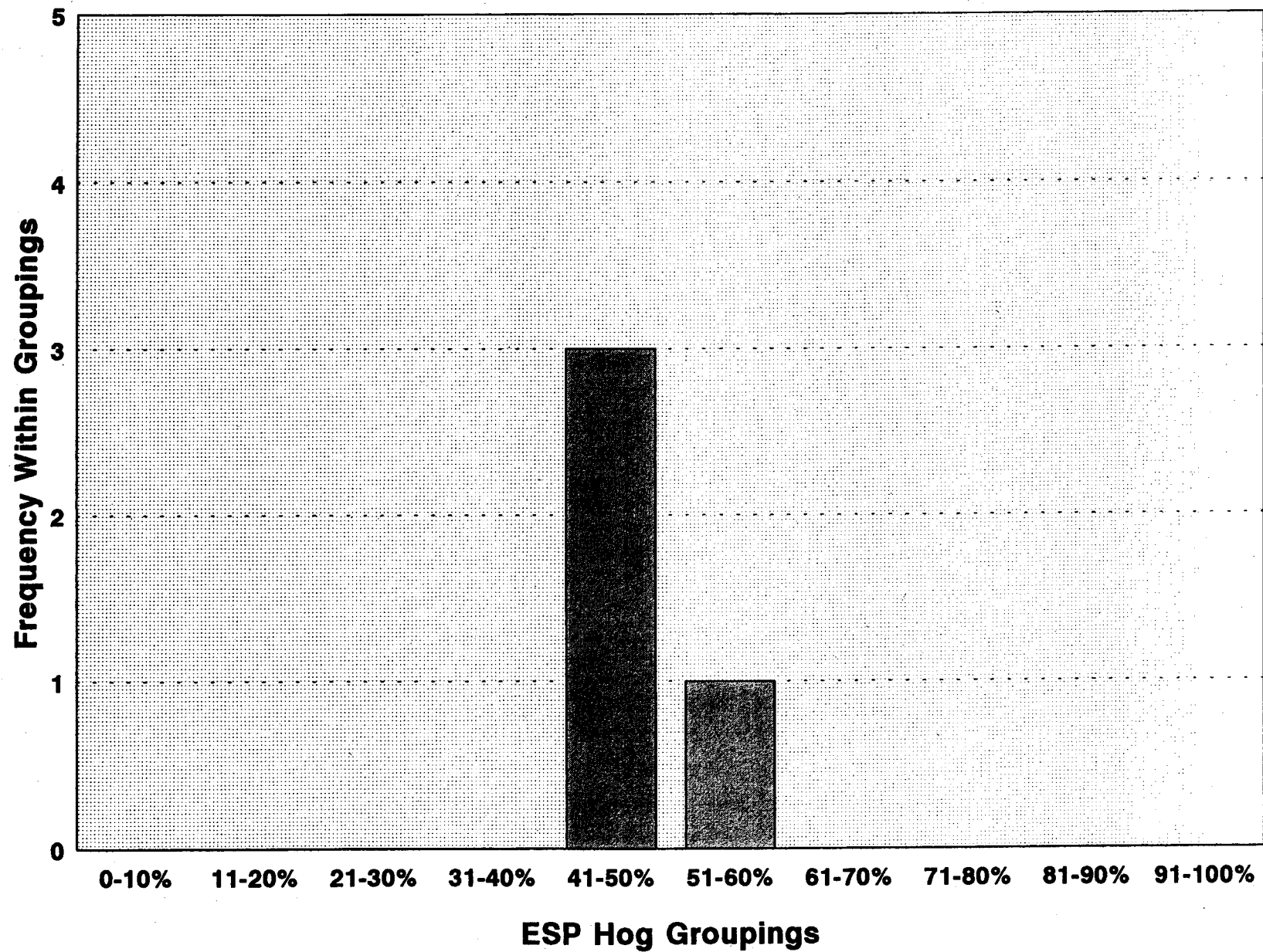
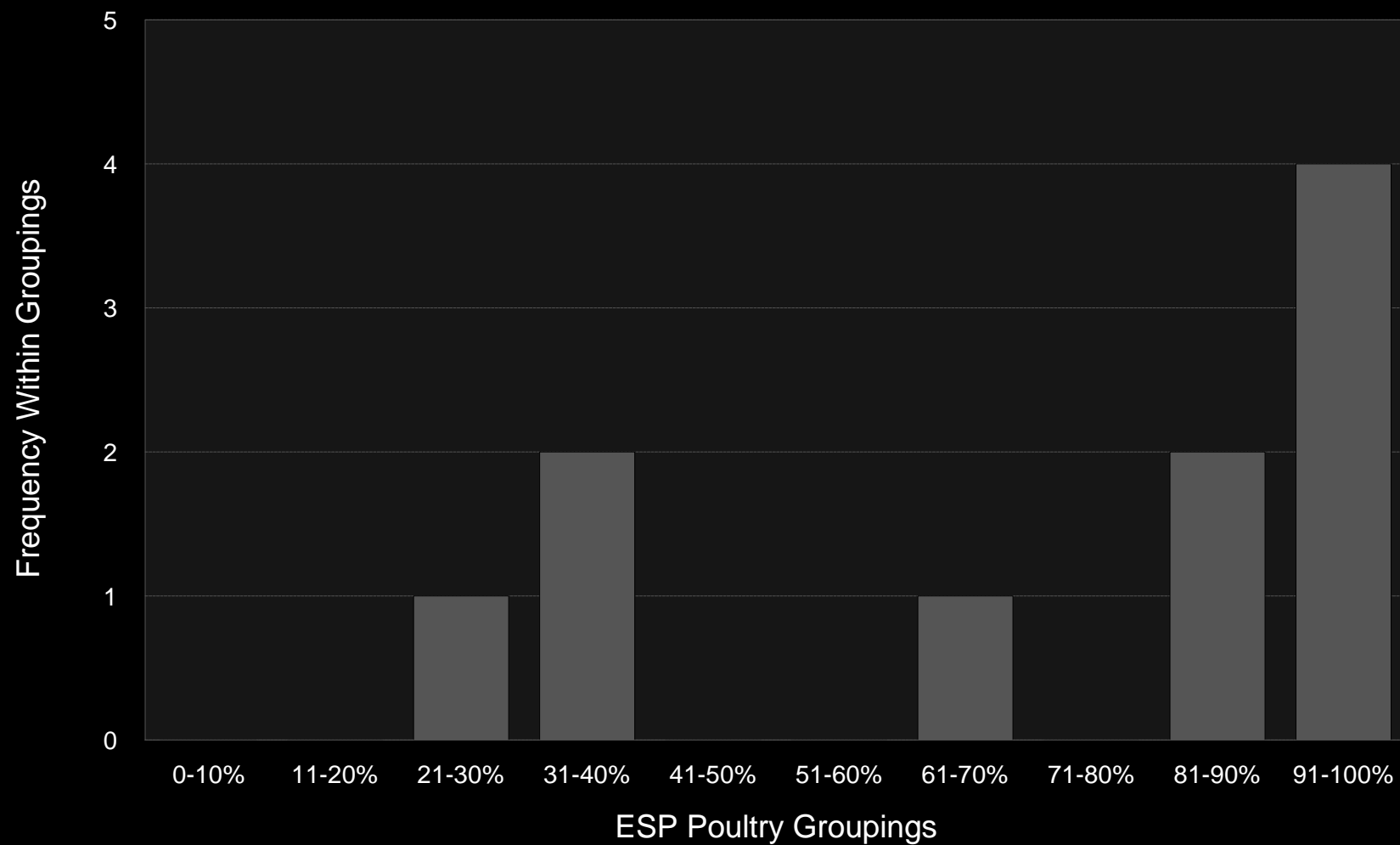


Figure 6
Matsqui Slough Watershed Poultry ESP Frequency Distribution



Fish Habitat Categories

Category I: Spawning and rearing of salmonids.

Category III: Marginal fish habitat in the fall; suitable habitat for at least 1 salmonid species in winter.

Category IV: Sparsely inhabited by only a few species in both seasons.

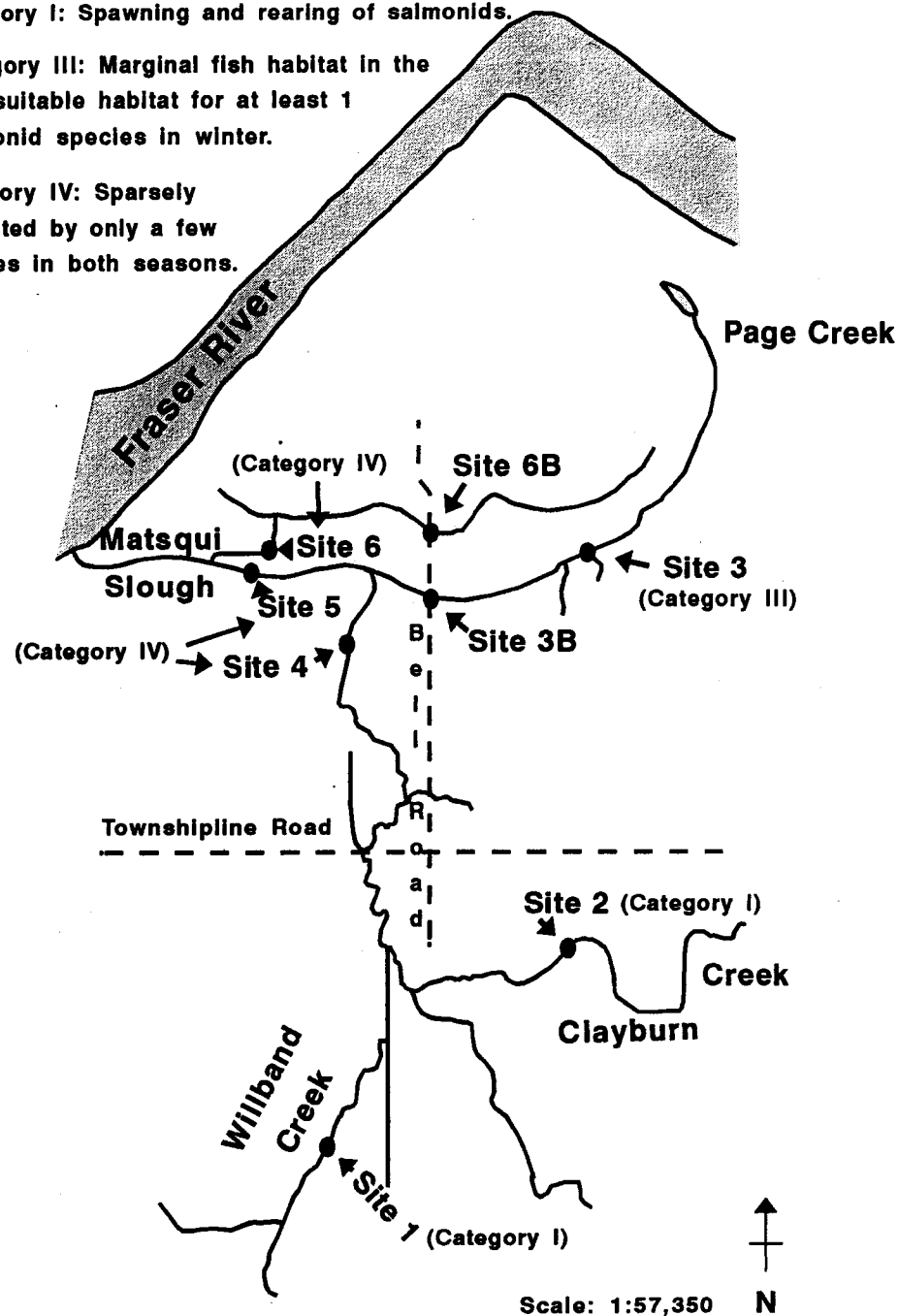


Figure 7

Matsqui Slough Watershed Surface Water Quality Data: Ranges and Means for Fall 1993

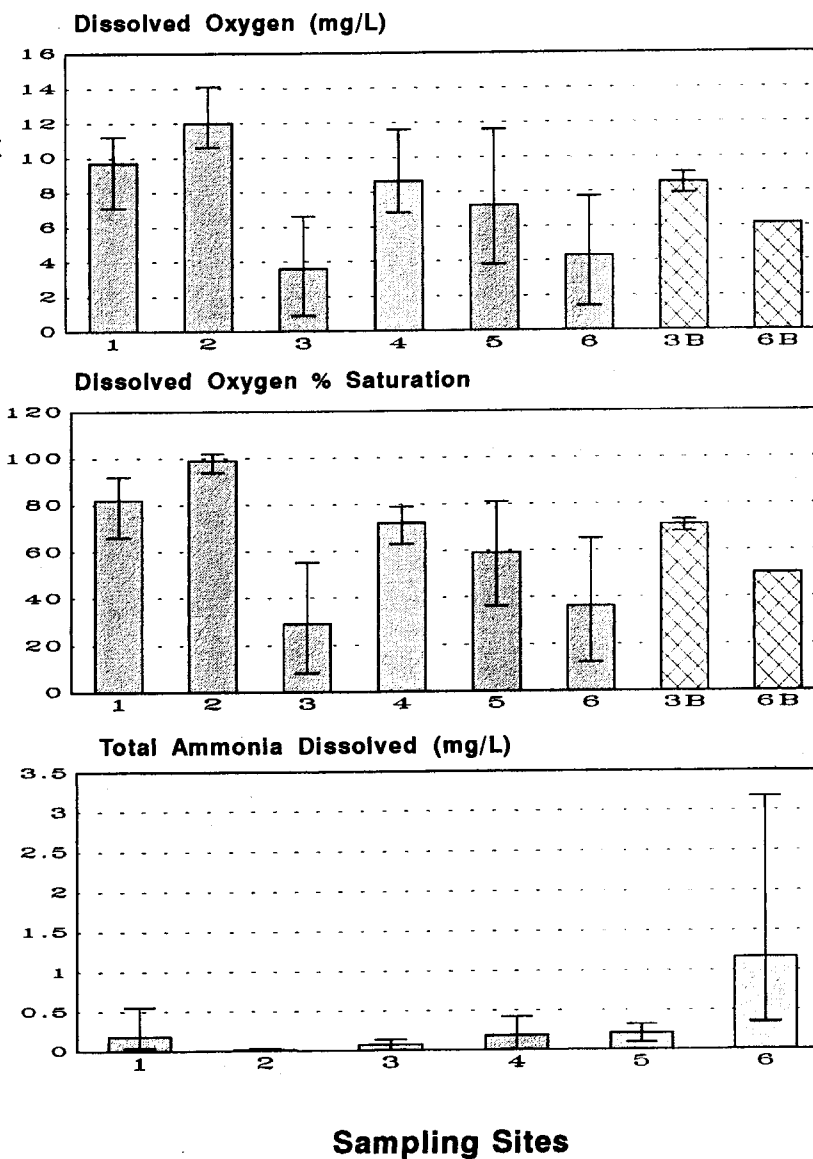
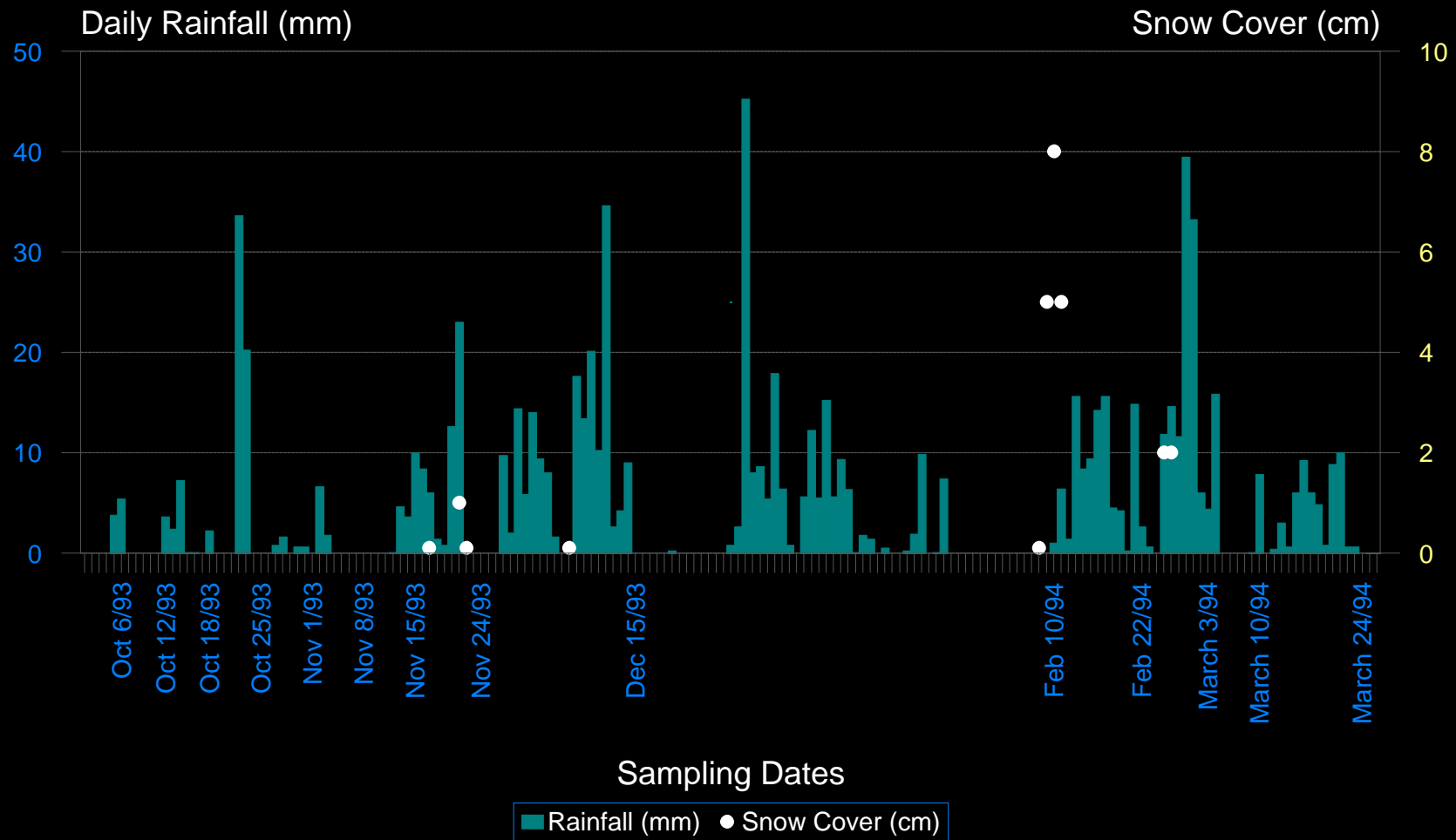
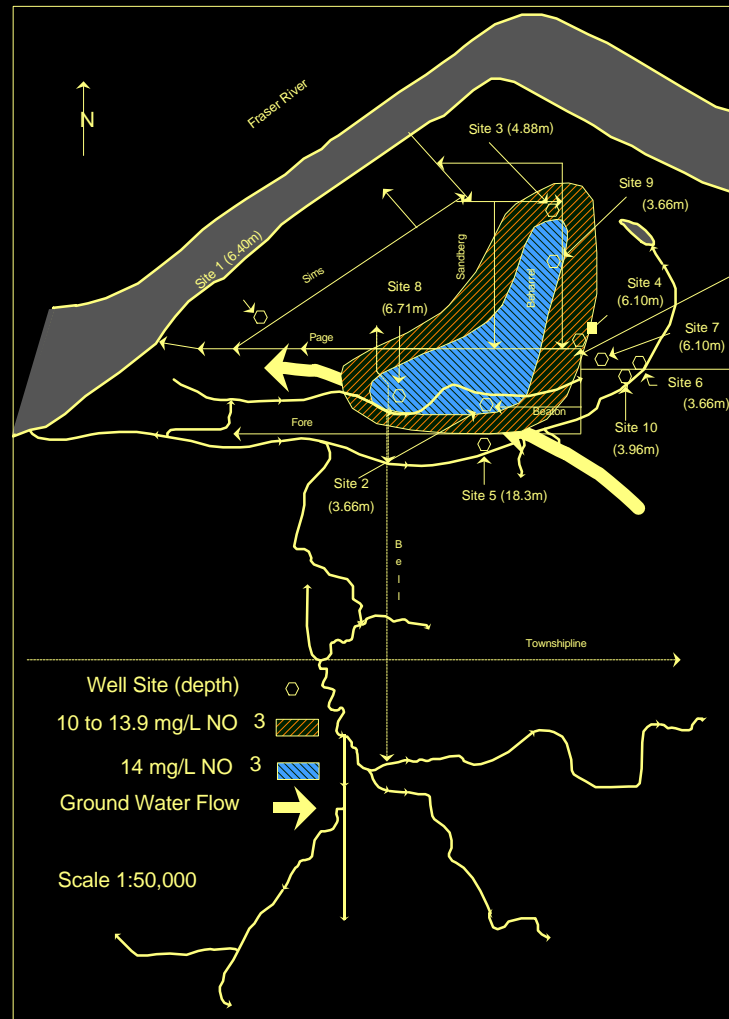


Figure 8
Daily Rainfall (mm) from October 1993 to March 1994
Abbotsford Airport Station *



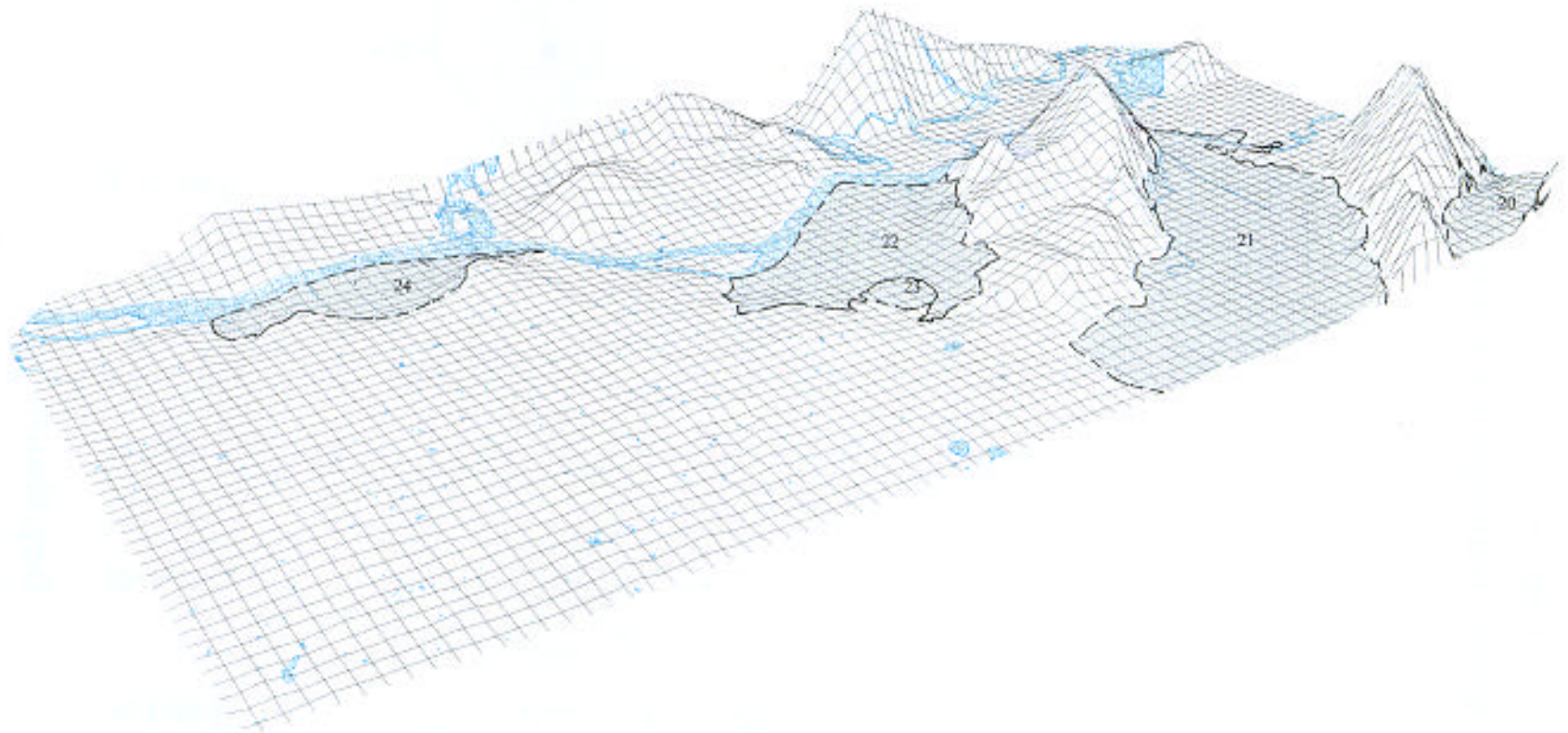
* Environment Canada Atmospheric Environment Service

Figure 9
Well Water Nitrate Concentrations and
Ground Water Flow Direction
for
the Matsqui Slough Watershed



Ground water flow directions taken from Gartner Lee, 1993

Figure 10
Matsqui - Abbotsford Vulnerability Class D Aquifers



-- -- Aquifer Boundary
 [] Aquifer

LEGEND

SIP LOCATION

- 21 JENAS PLAGE
- 22 MATSQUI PLAGE
- 23 FORD OF ABBOTSFORD
- 24 DEAN VALLEY

CLASS	LAND	PRODUCT	VOLUME	DEMAND	STATUS	FORMATION
21	10	MODERATE	MODERATE	LOW	UNDEVELOPED/CONERVED	FRANK RIVER SEDIMENT
22	10	MODERATE	MODERATE	LOW	UNDEVELOPED/CONERVED	FRANK RIVER SEDIMENT
23	8	MODERATE	MODERATE	LOW	UNDEVELOPED	FRANK RIVER SEDIMENT
24	10	MODERATE	MODERATE	LOW	UNDEVELOPED/CONERVED	FRANK RIVER SEDIMENT

 Environment Canada
 Environnement Canada

G.I.S. Services

Matsqui - Abbotsford Area

Vulnerability Class D Aquifers

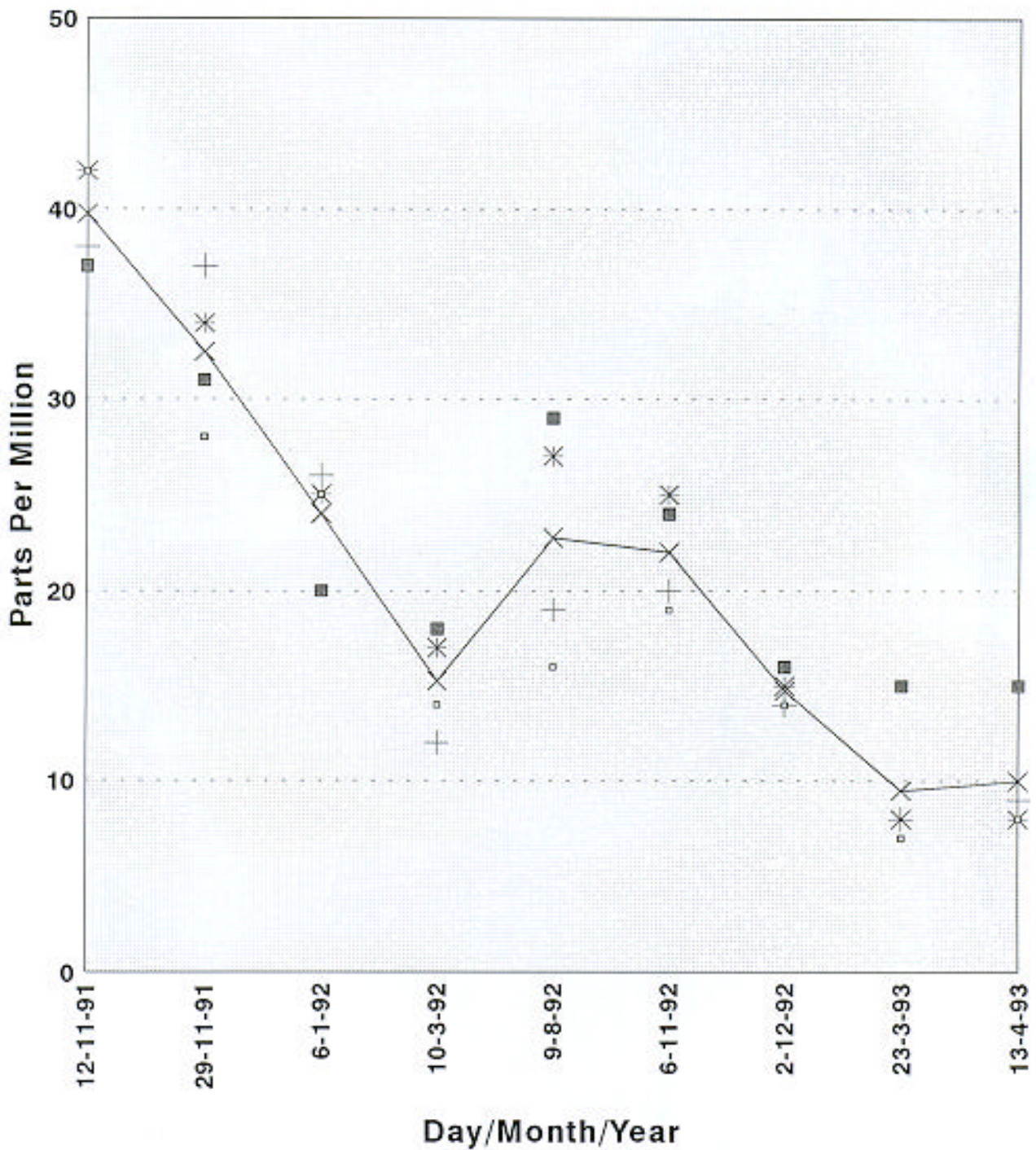
By: Guy MacLean

Date: March 1994

Scale: 1:50,000

Sheet: 1 of 1

Figure 11
Nitrate Concentrations in Drain Tile Effluent
in the Chilliwack Watershed from 1991-1993



° T1 (Cover Crop) + T2 (No Cover) * T3 (No Cover) ■ T4 (No Cover) x Average of All

APPENDIX A
SAMPLE NOTIFICATION LETTER, TELEPHONE INTERVIEW AND SITE VISIT SHEETS



Province of
British Columbia

MINISTRY OF ENVIRONMENT, LANDS AND PARKS
and MINISTRY RESPONSIBLE FOR
MULTICULTURALISM AND HUMAN RIGHTS

BC
Environment

Environmental Protection
15326 - 103A Avenue
Surrey, British Columbia
V3R 7A2
Telephone: (604) 582-5200
Fax: (604) 584-9751

File No. 43050-01

Attention:

On behalf of the Ministry of Environment, Lands and Parks, Integrated Resource Consultants (IRC) are conducting an Agricultural Land Use Inventory in the Matsqui Slough and Sumas River watersheds. This work is part of the Fraser River Action Plan (Green Plan) initiative in which industrial and other potential pollutant sources to the Fraser River system are catalogued.

The objective of this inventory is to identify farm management practices which could reduce the discharge of agricultural waste runoff to groundwater and surface waters. During the survey groundwater and surface water samples will be collected at a limited number of stations in both watersheds. The study will hopefully show that compliance with the existing Agricultural Waste Control Regulation and associated Code of Agricultural Practice will adequately protect the quality of the receiving environment.

It is our intention to work with the B.C. Federation of Agriculture in resolving concerns that are identified by the survey. Stakeholder groups could be formed in each watershed to discuss issues involving agricultural waste management and receiving environment impacts. The information collected during the survey could be presented in meetings with the local producers.

As part of this project, details on farm operations will be collected by telephone interviews with individual producers and site visits. Your co-operation in providing this information would be appreciated. If you have any questions please contact IRC (Karen Moore or Merv Palmer at 278-7714) or the Ministry of Environment, Land and Parks (Brent Moore at 582-5246 or Liz Freyman at 582-5318).

Sincerely,

M.C. Gow,
Head, Environmental Impacts Section

FRASER VALLEY WATER QUALITY SURVEY

AGRICULTURAL INVENTORY - TELEPHONE INTERVIEW

WATERSHED: MATSQUI _____ SUMAS _____ DATE: _____

GENERAL DATA:

FARM NAME: _____

ADDRESS: _____

TELEPHONE NO.: _____

OWNER: _____

OPERATOR: _____

TYPE OF OPERATION: _____

TOTAL SIZE: _____ ACRES

LEASES _____ ACRES TO _____

RENTS _____ ACRES FROM _____

AREA USED FOR -CROP PRODUCTION (SPECIFY CROPS):
YIELD AND PROTEIN LEVELS

_____ ACRES _____

_____ ACRES _____

_____ ACRES _____

-GRAZING: _____ ACRES - FEEDLOTS: _____ ACRES - BUILDINGS _____ ACRES

NO. OF ANIMALS: (BY TYPE -ANNUAL RANGE OR AVERAGE)

COMMENTS: _____

MANURE DATA:

MANURE PRODUCTION PER YEAR: _____

IMPORT OF MANURE PER YEAR: _____

EXPORT OF MANURE PER YEAR: _____

MANURE STORAGE: _____ PERMANENT

_____ COVERED _____ UNCOVERED

_____ CONCRETE _____ EARTHEN

_____ UNDER-CAGE STORAGE _____ UNDER-PEN STORAGE

CAPACITY OF FACILITY (TONS OR MONTHS): _____

PHYSICAL DIMENSIONS _____

_____ FIELD STORAGE _____ COVERED _____ UNCOVERED

APPLICATION: (SPECIFY AMOUNT, AREA, METHOD AND CROP)

DISPOSAL SEASON: _____

_____ ON-FARM _____

_____ OFF-FARM (SPECIFY LOCATION): _____

_____ CONTINGENCY SITE: (SPECIFY LOCATION): _____

WOODWASTE DATA:

TYPE: _____ SAWDUST _____ HOG FUEL _____ CHIPS _____ OTHER

USES: _____

STORAGE AND DISPOSAL PRACTICES: _____

MISCELLANEOUS:

HANDLING OF MORTALITIES: ☐ ON-FARM ☐ OFF-FARM (SPECIFY LOCATION)

LOCATION _____

METHOD _____

COMPOSTING FACILITY: ☐ COVERED ☐ UNCOVERED

MATERIALS COMPOSTED (LIST THEM) _____

SILAGE, MILK PARLOUR AND YARD RUNOFF:

TO TILE FIELD
TO MANURE PIT
TO SURFACE (NO COLLECTION)
TO DRAINAGE DITCH

CHEMICAL FERTILIZER APPLICATION -TYPE _____

-FREQUENCY _____ -AMOUNT _____

-CROPS _____

PESTICIDE APPLICATION ☐ YES ☐ NO

DISPOSAL OF CONTAINERS _____

IRRIGATION SYSTEM: TYPE: _____

WATER SOURCE: _____

NO. OF ACRES IRRIGATED: _____ FREQUENCY: _____

SEWAGE DISPOSAL: ☐ SEWER CONNECTION ☐ TILE FIELD - DATE INSTALLED: _____

DRINKING WATER: ☐ MUNICIPAL ☐ WELL

- DEPTH AND LOCATION _____

FUEL TANKS: ☐ ABOVE GROUND ☐ UNDERGROUND

YEAR OF INSTALLATION _____ REGISTERED WITH FIRE DEPARTMENT? _____

IF UNDERGROUND, IS IT >250 L VOLUME? _____

1000

DATE: _____

MUNICIPAL MAP: _____

PLAN NUMBER: _____

FILE NAME	DESCRIPTION

PROXIMITY OF MANURE FACILITY TO WATER COURSE: _____

COMMENTS:

APPENDIX B
ELEMENTAL RESEARCH INC. ANALYTICAL DETECTION LIMITS AND DUPLICATE ANALYSES
FOR WINTER WATER QUALITY SAMPLES

ERI Ref: C0-001

Summary of Results of Duplicate Analysis - February 10, 1994 Sampling

Sample		dup Stn. 6 Stn. 6		dup Stn. 7 Stn. 7		dup Stn. 9 Stn. 9		dup Stn. 10 Stn. 10		dup Stn. 15 Stn. 15		dup Stn. 13 Stn. 13		dup Stn. 1 Stn. 1	
Parameter	Units														
Alkalinity	mg CaCO3/L	130	130									60	58		
Hardness	mg/L			110	120										
pH	units			7.5	7.6										
Specific conductance	umhos/cm			320	320										
Total Organic Carbon	mg/L									2.3	2.3				
Turbidity	NTU			13	13										
Total Sus. Solids	mg/L			18	20										
Total Diss. Solids	mg/L			200	200										
Total Kjeldahl Nitrogen	mg/L					1.15	1.20								
Ortho Phosphate	mg P/L													0.007	0.007
Total Diss. Phosphate	mg P/L							0.058	0.063						
Total Phosphorous	mg P/L					0.285	0.228								

dup : duplicate sample

Summary of Results of Duplicate Analysis - February 22, 1994 Sampling

Sample		Stn. 1	dup Stn. 1	Stn. 2	dup Stn. 2	Stn. 6	dup Stn. 6	Stn. 10	dup Stn. 10	Stn. 11	dup Stn. 11
Parameter	Units										
Alkalinity	mg CaCO3/L					77	72				
Hardness	mg/L					58	63				
pH	units							6.7	6.9		
Specific conductance	umhos/cm							240	240		
Total Organic Carbon	mg/L			1.9	1.8			6.7	7.0		
Turbidity	NTU							26	26		
Total Sus. Solids	mg/L									72	74
Total Diss. Solids	mg/L									190	180
Free Ammonia	mg NH3-N/L			<0.005	<0.005			0.220	0.203		
Nitrate + Nitrite	(NO3+NO2)mg/L			1.84	1.75			6.29	5.58		
Total Kjeldahl Nitrogen	mg/L			0.36	0.33			1.20	1.20		
Total Nitrogen	mg/L			2.20	2.08			7.49	6.78		
Total Organic Nitrogen	mg/L			0.36	0.33			0.98	1.00		
Ortho Phosphate	mg P/L			0.005	0.002			0.042	0.041		
Total Diss. Phosphate	mg P/L			0.007	0.003			0.050	0.042		
Total Phosphorous	mg P/L			0.023	0.021			0.175	0.165		
Total Aluminum	ug/L	180	150								
Total Arsenic	ug/L	4.0	3.6								
Total Calcium	ug/L	13000	14000								
Total Cadmium	ug/L	0.11	0.09								
Chloride	mg/L							21	24		
Total Chromium	ug/L	7.1	6.2								
Total Cobalt	ug/L	0.24	0.20								
Total Copper	ug/L	2.3	1.9								
Total Iron	ug/L	720	640								
Total Potassium	ug/L	1200	1200								
Total Magnesium	ug/L	3400	3100								
Total Manganese	ug/L	100	87								
Total Mercury	ug/L	<0.05	<0.05								
Total Molybdenum	ug/L	0.73	0.70								
Total Nickel	ug/L	2.0	1.8								
Total Lead	ug/L	1.0	1.4								
Total Phosphorous	ug/L	<20	<20								
Total Sodium	ug/L	9000	8700								
Total Selenium	ug/L	<0.05	0.05								
Total Strontium	ug/L	84	76								
Total Tin	ug/L	0.04	0.04								
Total Zinc	ug/L	19	15								

dup : duplicate sample

Summary of Results of Duplicate Analysis - March 3, 1994 Sampling

Sample		dup Stn. 1 Stn. 1		dup Stn. 2 Stn. 2		dup Stn. 4 Stn. 4		dup Stn. 5 Stn. 5		dup Stn. 10 Stn. 10		dup Stn. 13 Stn. 13		dup Stn. 9 Stn. 9		dup Stn. 7 Stn. 7	
Parameter	Units																
Alkalinity	mg CaCO ₃ /L	34	38									46	42				
Hardness	mg/L	39	37													96	89
pH	units			6.3	6.5							6.9	6.9				
Specific conductance	umhos/cm			49	51							120	120				
Total Organic Carbon	mg/L							5.7	5.5	8.9	7.7						
Turbidity	NTU			15	18							4.2	4.8				
Total Sus. Solids	mg/L					35	31							54	57		
Total Diss. Solids	mg/L					70	71							160	160		
Free Ammonia	mg NH ₃ -N/L							0.260	0.260	0.300	0.240						
Nitrate + Nitrite	(NO ₃ +NO ₂)mg/L							1.95	2.00	5.21	5.33						
Total Kjeldahl Nitrogen	mg/L							1.00	1.16	1.82	1.69						
Total Nitrogen	mg/L							2.95	3.16	7.03	7.02						
Total Organic Nitrogen	mg/L							0.74	0.90	1.52	1.45						
Ortho Phosphate	mg P/L							0.078	0.078	0.107	0.108						
Total Diss. Phosphate	mg P/L							0.082	0.081	0.112	0.109						
Total Phosphorous	mg P/L							0.148	0.120	0.282	0.273						
Total Aluminum	ug/L	330	320													2700	2900
Total Arsenic	ug/L	2.6	2.6														
Total Calcium	ug/L	15000	14000													20000	20000
Total Cadmium	ug/L	0.05	<0.03													0.050	0.050
Chloride	mg/L			3.0	3.5							4.5	5.0				
Total Chromium	ug/L	4.1	4.1													41	43
Total Cobalt	ug/L	0.41	0.39													13	12
Total Copper	ug/L	3.8	3.0													11	10
Total Iron	ug/L	890	850													6100	6600
Total Potassium	ug/L	2200	2100													9700	10000
Total Magnesium	ug/L	4600	4300													46000	47000
Total Manganese	ug/L	160	150													220	220
Total Mercury	ug/L	<0.05	<0.05													<0.05	<0.05
Total Molybdenum	ug/L	0.70	0.87													0.71	0.76
Total Nickel	ug/L	1.8	1.7													250	240
Total Lead	ug/L	0.96	0.93													0.88	0.91
Total Phosphorous	ug/L	80	60													400	350
Total Sodium	ug/L	6900	7300													6700	7700
Total Selenium	ug/L	<0.05	<0.05														
Total Strontium	ug/L	78	71													110	100
Total Tin	ug/L	0.11	0.10													<0.03	<0.03
Total Zinc	ug/L	16	12													20	18

dup : duplicate sample

ERI Ref: C0-001

Summary of Results of Duplicate Analysis - March 10, 1994 Sampling

Sample		Stn. 1	dup Stn. 1	Stn. 13	dup Stn. 13	Stn. 15	dup Stn. 15
Parameter	Units						
Alkalinity	mg CaCO ₃ /L			42	44		
Hardness	mg/L	27	32				
pH	units	6.3	6.6				
Specific conductance	umhos/cm	81	86				
Total Organic Carbon	mg/L	3.60	2.87			3.84	4.32
Turbidity	NTU	29	30				
Total Sus. Solids	mg/L	71	83				
Total Diss. Solids	mg/L	51	48				
Free Ammonia	mg NH ₃ -N/L	0.33	0.34			0.250	0.240
Nitrate + Nitrite	(NO ₃ +NO ₂)mg/L	1.14	1.20			2.83	3.03
Total Kjeldahl Nitrogen	mg/L	1.33	1.36			0.70	0.75
Total Nitrogen	mg/L	2.47	2.56			3.53	3.78
Total Organic Nitrogen	mg/L	1.00	1.02			0.45	0.51
Ortho Phosphate	mg P/L	0.022	0.022			0.105	0.105
Total Diss. Phosphate	mg P/L	0.022	0.022			0.108	0.110
Total Phosphorous	mg P/L	0.127	0.098			0.140	0.123

dup : duplicate sample

Summary of Results of Duplicate Analysis - March 24, 1994 Sampling

Sample		Stn. 1	dup Stn. 1	Stn. 2	dup Stn. 2	Stn. 5	dup Stn. 5	Stn. 9	dup Stn. 9	Stn. 10	dup Stn. 10	Stn. 4	dup Stn. 4	Stn. 11	dup Stn. 11
Parameter	Units														
Alkalinity	mg CaCO ₃ /L									80	82				
Hardness	mg/L	70	70												
pH	units			6.9	6.8										
Specific conductance	umhos/cm	180	180												
Total Organic Carbon	mg/L											4.2	4.5	4.2	5.4
Turbidity	NTU	5.3	4.9												
Total Sus. Solids	mg/L			5	7										
Total Diss. Solids	mg/L			53	50										
Free Ammonia	mg NH ₃ -N/L											0.127	0.124	0.195	0.192
Nitrate + Nitrite	(NO ₃ +NO ₂)mg/L											1.95	1.96	3.19	3.12
Total Kjeldahl Nitrogen	mg/L											0.51	0.49	0.50	0.45
Total Nitrogen	mg/L											2.46	2.45	3.69	3.57
Total Organic Nitrogen	mg/L											0.38	0.37	0.30	0.26
Ortho Phosphate	mg P/L							0.016	0.014						
Total Diss. Phosphate	mg P/L			0.006	0.005										
Total Phosphorous	mg P/L					0.066	0.065								

dup : duplicate sample

Table 1
Commodity Groups Membership Lists

Commodity Group	Address
B.C. Lawn Turf Farms	9010 192nd Street Surrey, B.C. V4N 3W9
B.C. Vegetable Marketing Commission	#201-7560 Vantage Way Delta, B.C. V4G 1H1
B.C. Broiler Hatching Egg Commission	464 Riverside Road S., RR2 Abbotsford, B.C. V2S 4N2
B.C. Mushroom Marketing Board	#201-7560 Vantage Way Delta, B.C. V4G 1H1
B.C. Pork	2010 Abbotsford Way, B.C. V2S 6X8
B.C. Egg Marketing Board	#22-34470 South Fraser Way Abbotsford, B.C. V2S 4P2
B.C. Chicken Marketing Board	#203 572 176 Street Surrey, B.C. V3S 4C8
B.C. Turkey Marketing Board	#218 17704 56th Avenue Surrey, B.C. V3S 1C7
Dairy Producers' Conservation Group	#205-33780 Laurel Street Abbotsford, B.C. V2S 1X4
Sustainable Poultry Farming Group	#302-34252 Marshall Road Abbotsford, B.C. V2S 5E4
Hog Producers' Sustainable Farming Group	2010 Abbotsford Way Abbotsford, B.C. V2S 6X8

Table 2
Matsqui Slough Watershed Soils Map Legend ¹

MAP SYMBOL	SOIL NAME	SOIL MATERIAL	DRAINAGE	CLASSIFICATION
AD	ABBOTSFORD	20 to 50 cm of medium-textured eolian deposits over gravelly glacial outwash	Well to rapid	Orthic Humo-Ferric Podzol
AN	ANNIS	5 to 40 cm of organic material over moderately fine textured floodplain deposits	Poor to very poor; high ground water table	R.Gp
BL	BEHARREL	Moderately fine textured, vertically accreted floodplain deposits	Moderately poor to poor; high ground water table	Humic Luvic Gleysol
DW	DEWDNEY	15 to 50 cm of medium-textured, laterally accreted floodplain deposits over sand	Imperfect; fluctuating ground water table	Gleyed Eluviated Melanic Brunisol
G	GREVELL	Coarse-textured, laterally accreted floodplain deposits	Well to rapid	Orthic Regosol
GV	GLEN VALLEY	More than 160 cm of undecomposed organic material, mainly reeds, sedges and grasses	Very poor; high ground water table	Typic Fibrisol
HD	HAZELWOOD	Fine to moderately fine textured, vertically accreted floodplain deposits	Poor; high ground water table	Orthic Humic Gleysol
HP	HOPEDALE	15 to 50 cm of medium-textured local stream deposits over sand	Poor; high ground water table	Orthic Humic Gleysol
HT	HALLERT	Medium-textured, vertically accreted floodplain deposits containing organic strata	Poor to very poor; high ground water table	Rego Gleysol
LK	LICKMAN	Medium-textured local stream deposits	Moderately well	Eluviated Eutric Brunisol
LM	LUMBUM	More than 160 cm of partially decomposed organic material	Very poor; high ground water table	Typic Mesisol
LX	LAXTON	Moderately coarse to coarse-textured eolian deposits	Well to rapid	Orthic Humo-Ferric Podzol
M	MONROE	Medium-textured, laterally accreted floodplain deposits	Moderately well to well	Eluviated Eutric Brunisol
MH	MARBLE HILL	More than 50 cm of medium-textured eolian deposits over gravelly glacial outwash deposits	Well	Orthic Humo-Ferric Podzol
NN	NIVEN	Moderately fine textured floodplain deposits over organic deposits	Poor to very poor; high ground water table	Rego Gleysol
PE	PAGE	Medium to moderately fine textured floodplain deposits	Poor to moderately poor; high ground water table	Orthic Gleysol
PR	PREST	Medium to moderately fine textured floodplain deposits	Very poor; high ground water table	Rego Gleysol
RD	RYDER	More than 50 cm of medium-textured eolian deposits over glacial till	Well to moderately well	Orthic Humo-Ferric Podzol
SD	SARDIS	Coarse to moderately coarse textured local stream deposits	Moderately well	Orthic Regosol

1. Luttmerding, H.A., 1981. Soils of the Langley-Vancouver Map Area, Volume 3: Description of the Soils. RAB Bulletin 18.

Table 3
Surface Water Sampling Locations and Site Numbers
in the Matsqui Slough Watershed

Site No.	Site Description	GPS Coordinates	
		Northing (metres)	Easting (metres)
1	Willband Creek @ Valley Road	5435384	552033
2	Clayburn Creek @ Clayburn Road	5436898	554538
3	Page Creek @ Beharrell Road	5439920	554724
3B	Page Creek @ Bell Road	-	-
4	Clayburn Creek @ Harris Road	5439244	552198
5	Matsqui Slough @ Riverside Street	5439787	551517
6	Matsqui Slough Tributary @ Riverside Street	5440027	551505
6B	Matsqui Slough Tributary @ Bell Road	-	-

Datum: NAD 83

Coordinate System: UTM-10M

Sites 3B and 6B do not have GPS coordinates since water samples were not collected regularly from these two sites.

Table 4
Field Sampling Dates, Sites and Parameters Measured in the Matsqui Slough Watershed

Sampling Dates	Site No.'s	Parameters											
		Field				Laboratory							
		Temp	D.O.	pH	Conductivity	pH.	Conductivity	Ammonia-Nitrogen	Faecal Coliform	General ¹	Total Metals ²	Oil & Grease	Chloride
October 6, 12, 18, 25, 1993	1 to 6	X	X			X	X	X					
November 1, 8, 15, 24, 1993	1 to 6	X	X			X	X	X					
November 1, 8, 1993	3B	X	X					X					
November 8, 1993	6B	X	X					X					
February 10, 1994	1 to 6	X	X			X	X	X	X	X			
February 22, 1994	1 to 6	X	X	X	X	X	X	X	X	X	X	X	X
March 3, 1994	1 to 6	X	X	X		X	X	X	X	X	X	X	X
March 10, 24, 1994	1 to 6	X	X	X	X	X	X	X	X	X			

1 General = Total Dissolved Solids, Total Suspended Solids, Turbidity, Alkalinity, Hardness, Total Organic Carbon, Nitrate-Nitrite, Total Kjeldahl Nitrogen, Total Nitrogen, Organic Nitrogen, ortho Phosphate, Total Dissolved Phosphate, Total Phosphorus

2 Aluminium, Arsenic, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Sodium, Strontium, Tin, Zinc

Table 5
Well Water Sampling Locations and Site Numbers
in the Matsqui Slough Watershed

Site No.	Site Description	Reported Well Depth
1	34191 Sim Road	6.40 m
2	35045 Beaton Road	3.66 m
3	35162 Sim Road	4.88 m
4	35235 Page Road	6.10 m
5	34974 Fore Road	18.3 m
6	35678 Gallagher Road	3.66 m
7	35511 Gallagher Road	6.10 m
8	6256 Bell Road	6.71 m
9	6915 Beharrell Road	3.66 m
10	35620 Gallagher Road	3.96 m

Table
Summary of Dairy Operations I

Farm ID.	Acres ** (owned and rented)	Animals	Milking Cow Equivs.	Spreading Rate MCE per Hectare	Manure Pit Storage Time (months)	Dry Manure Storage	Main Manure Pit Facility Type	Second Manure Pit Facility Type	Third Manure Pit Facility Type	Fourth Manure Pit Facility Type	Woodwaste Storage	Milk Parlour Discharge	Yard Drainage
1001	40	30	20	1.22	0.51	none	earthen				inside	none	tile
1002	110	175	115	2.59	6.00	none	earthen	conc/unc			inside	tile	tile
1003	130	170	112	2.13	1.37	none	earthen				inside	tile	tile
1004	15	67	44	7.26	1.44	none	earthen				inside	ditch	ditch
1005	150	300	197	3.25	2.44	none	conc/cov	conc/cov	conv/cov	conc/unc	inside	manure	none
1006	80	160	105	3.25	2.55	none	conc/cov	conc/unc	conc/unc		inside	manure	manu
1007	70	120	79	2.79	5.15	none	conc/unc	earthen			covered	manure	none
1008	90	130	86	2.35	3.15	conc/unc	conc/cov				inside	manure	surfa
1009	83	85	56	1.66	0.82	none	conc/unc				inside	manure	surfa
1011	110	100	66	1.48	12.67	none	conc/cov	conc/cov			covered	manure	surfa
1012	80	70	46	1.42	4.52	none	earthen				uncovered	none	manu
1013	45	80	53	2.89	3.44	none	earthen	conc/unc			inside	manure	surfa
1014	40	60	81	5.00	0.82	none	conc/cov				inside	tile	tile
1015	190	200	132	1.71	1.56	none	conc/unc	earthen	earthen		inside	manure	non
1016	38	50	33	2.14	3.24	none	conc/unc				uncovered	manure	manu
1017	100	180	118	2.93	4.61	none	conc/unc	earthen			inside	manure	manu
1018	70	100	66	2.32	3.03	conc/unc	conc/cov				inside	tile	manu
1019	52	110	149	7.05	1.57	conc/unc	conc/unc	conc/unc			inside	manure	manu
1020	47	71	47	2.45	1.55	none	conc/unc				inside	tile	surfa
1021	150	320	211	3.47	2.61	none	conc/unc	conc/unc	earthen		inside	manure	tile
1022	34	62	41	2.96	3.73	field/unc	earthen	conc/unc			inside	manure	manu
1023	80	240	158	4.88	1.75	field/unc	earthen	conc/unc			inside	manure	tile
1024	95	100	66	1.71	1.88	none	conc/unc				inside	manure	manu
1025	130	250	164	3.13	2.75	field/unc	earthen	conc/unc	conc/unc	earthen	inside	manure	tile
1026	72	115	76	2.60	1.24	conc/unc	conc/unc				inside	ditch	ditch
1027	38.4	80	53	3.39	3.65	none	earthen	conc/unc			inside	manure	ditch
1028	70	113	74	2.62	3.06	none	earthen				inside	manure	manu
1029	93.5	90	59	1.56	0.70	none	earthen				inside	manure	manu
1030	50	40	54	2.67	4.65	none	conc/unc	conc/unc			covered	manure	non
1031	120	200	132	2.71	7.00	none	conc/cov				inside	manure	surfa
1032	100	200	132	3.25	16.21	none	earthen	conc/cov			inside	manure	ditch
1033	144	165	109	1.86	1.73	none	conc/unc				inside	manure	ditch
1034	200	300	197	2.44	4.35	none	conc/unc	conc/unc			inside	ditch	surfa
1035	166	220	145	2.15	2.50	none	conc/unc	conc/unc			inside	manure	surfa
1036	146	100	66	1.11	1.78	none	conc/unc				none	tile	surfa
1037	73	135	89	3.01	0.52	none	earthen				covered	manure	surfa
1038	60	120	79	3.25	5.29	none	earthen	conc/unc			inside	ditch	ditch

Notations Used: conc = concrete, cov = covered, NA = Not Applicable, splsh/mech = splash plate and mechanical spreaders, unc = uncovered

* See Table 12 and 15. The ESP was developed by IRC.

** 1 hectare = 2.47 acres

Table 6
itions in the Matsqui Slough Watershed

Yard Drainage	Silage Runoff	Tile		Type of Spreading	Spreading on		Irrigation Source	Handling of Mortalities	Pesticide Container Disposal	Drinking Water Supply	well depth (meter)	ESP *
		Proximity of Watercourse to Storage Facility (meter)	Field Age Household Domestic Sewage (years)		Adjacent Farms (acres)	Type of Irrigation						Percentage Ranking
tile	surface	NA	NA	splash plate		none		contractor	contractor	municipal		57
tile	surface	NA	50	splash plate		none		contractor	transfer stn	well	18	72
tile	manure	NA	100	splsh/mech	15	none		contractor		municipal		56
ditch	none	NA	NA	splash plate		none		contractor		well	?	24
none	manure	NA	1	splash plate	30	none		contractor	returns	well	16	58
manure	none	1	3	splash plate	25	hand move	Page Crk	contractor		well	12	64
none	none	NA	8	splash plate	8	none		contractor		well	60	81
surface	none	35	6	splash plate	45	none		contractor		mntn/well		75
surface	tile	NA	100	splash plate		none		contractor		well	30	61
surface	manure	NA	3	splash plate		none		contractor	contractor	well	25	95
manure	manure	NA	14	splsh/mech	60	none		contractor		municipal		76
surface	surface	NA	18	splash plate	10	reel	well	contractor		well	20	61
tile	surface	NA	?	splash plate		none		contractor		municipal		37
none	manure	NA	5	splash plate	110	none		contractor	contractor	well	18	65
manure	surface	NA	100	splash plate		none		contractor		well	13	71
manure	tile	NA	21	irrigation		wheel	Fraser R.	contractor	contractor	well	22	76
manure	surface	NA	40	mechanical		none		contractor		municipal		72
manure	surface	NA	100	splsh/mech	50	none		contractor	contractor	municipal		37
surface	surface	NA	4	splash plate		none		contractor	contractor	well	18	57
tile	manure	NA	?	splash plate		wheel	well	contractor	transfer stn	well	21	55
manure	surface	NA	50	splsh/mech	8	none		contractor		municipal		55
tile	manure	NA	100	splash plate		none		contractor	contractor	municipal		28
manure	manure	NA	NA	splash plate	56	none		contractor		municipal		65
tile	tile	NA	4	splash plate	10	reel	well	contractor		well	14	48
ditch	manure	2	3	splash plate		none		contractor		well	22	39
ditch	surface	NA	100	splash plate		none		contractor		municipal		51
manure	none	NA	?	splash plate	30	none		contractor		municipal		66
manure	none	NA	?	splash plate	60	none		contractor		well	20	61
none	none	NA	?	splash plate	100	none		contractor		municipal		75
surface	tile	NA	3	splash plate	20	wheel	well	contractor	contractor	well	?	88
ditch	manure	NA	?	?	yes	reel	well	contractor		well	18	81
ditch	surface	37	?	splash plate		none		contractor		well	15	57
surface	manure	61	?	splsh/mech		none		contractor	incineration	well	18	74
surface	manure	49	86	splsh/irriga	56	reel & gun	well	contractor	transfer stn	well	12	68
surface	surface	NA	?	?		none		contractor	contractor	municipal		57
surface	none	24	?	?	20	line	ditch	contractor	transfer stn	municipal		47
ditch	none	NA	?	splash plate		none		contractor	contractor	well	13	65

Table 7
Summary of Hog Operations in the Matsqui Slough Watershed

Farm ID.	Acres **		Sow Equivs. (SE)	Spreading Rate SE/Hectare	Manure Pit		Number of Storage Facilities	Manure Disposal	Woodwaste Storage	Proximity of Field Age		Type of Irrigation	Irrigation Source	Handling Mortalities	Pesticide Container Disposal	Drinking Water Supply	well depth (meter)	ESP *
	(owned and rented)	Animals			Storage Time (months)	Pit Facility Type				Watercourse to Storage (meter)	Household Domestic Sewage (years)							Percentage Ranking
1050	95	330	330	6.44	5.65	earthen	four	on farm/ngbr	none	20	?	reel & gun	Clayburn Crk.	contractor	contractor	municipal		48
1051	37	270	270	18.02	4.24	conc/unc	three	on farm	none	40	14	reel & gun	Matsqui Slgh.	contractor	contractor	well	5.49	46
1052	30	1500	150	6.18	4.30	conc/unc	two	on farm/ngbr	none	16	?	none		contractor		well	6.10	45
1053	150	500	500	8.23	4.24	conc/cov	two	on farm	none	NA	?	none		contractor	landfill	municipal		51

Notations Used: conc = concrete, cov = covered, NA = Not Applicable, ngbr = neighbour, unc = uncovered

* See Table 13. The ESP was developed by IRC.

** 1 hectare = 2.47 acres

Table 8
Summary of Poultry Operations in the Matsqui Slough Watershed

Farm ID.	Acres ** (owned and rented)	Animals	Broiler Equivs. (BE)	Spreading Rate BE/Hectare	Manure Disposal	Dry Manure Storage	Woodwaste Storage	Proximity of Watercourse to Storage (meter)	Tile Field Age Household Domestic Sewage (years)	Type of Irrigation	Irrigation Source	Handling of Mortalities	Pesticide Container Disposal	Drinking Water Supply	well depth (meter)	ESP * Percentage Ranking
1017	100	14000	21700	536	on farm	none	inside	65	21	wheel	Fraser R.	contractor	contractor	well	6.71	88
1060	10	20000	20000	4940	neighbour	conc/cov	inside	NA	?	none		contractor		municipal		100
1061	40	7000	10850	673	on farm	none	inside	40	12	none		composting		municipal		86
1062	6	60000	60000	24700	neighbour	conc/cov	inside	NA	14	none		contractor		well	6.10	100
1063	13	33750	33750	6413	on farm	conc/cov	inside	65	17	none		contractor		well	42.7	40
1064	15	3000	4650	766	on farm	field/unc	inside	NA	2	none		contractor		well	4.88	62
1065	11	35000	35000	8117	on farm	conc/unc	inside	NA	1	none		contractor		well	4.88	31
1066	13	40000	40000	7600	neighbour	none	inside	61	9	none		incineration		municipal		100
1067	10	15000	15000	3705	on farm	field/cov	inside	NA	0	none		contractor		well	4.27	22
1068	10	14300	22165	5475	neighbour	none	inside	65	?	drip	Clayburn Crk	contractor		municipal		100

Notations Used: conc = concrete, cov = covered, NA = Not Applicable, unc = uncovered

* See Table 14. The ESP was developed by IRC.

** 1 hectare = 2.47 acres

Table 9
Environmental Sustainability Parameter Factors and Rankings
for Dairy Operations in the Matsqui Slough Watershed

Farm ID.	Manure Pit Storage Time Rank	MCE per Hectare Rank	Dry Manure Storage Rank	Manure Pit Facility Type Rank	Woodwaste Storage Rank	Milk Parlour Discharge Rank	Yard Drainage Rank	Silage Runoff Rank	Proximity of Watercourse to Storage Facility Rank	Ranking Out of 231	ESP * Percentage Ranking
1001	75	0	0	15	0	0	3	6	0	99	57
1002	15	18	0	15	0	8	3	6	0	65	72
1003	75	0	0	15	0	8	3	0	0	101	56
1004	75	54	0	15	0	20	12	0	0	176	24
1005	60	36	0	0	0	0	0	0	0	96	58
1006	60	18	0	0	0	0	0	0	6	84	64
1007	15	18	0	5	5	0	0	0	0	43	81
1008	45	0	5	0	0	0	6	0	2	58	75
1009	75	0	0	5	0	0	6	3	0	89	61
1011	0	0	0	0	5	0	6	0	0	11	95
1012	30	0	0	15	10	0	0	0	0	55	76
1013	45	18	0	15	0	0	6	6	0	90	61
1014	75	54	0	0	0	8	3	6	0	146	37
1015	75	0	0	5	0	0	0	0	0	80	65
1016	45	0	0	5	10	0	0	6	0	66	71
1017	30	18	0	5	0	0	0	3	0	56	76
1018	45	0	5	0	0	8	0	6	0	64	72
1019	75	54	5	5	0	0	0	6	0	145	37
1020	75	0	0	5	0	8	6	6	0	100	57
1021	60	36	0	5	0	0	3	0	0	104	55
1022	45	18	20	15	0	0	0	6	0	104	55
1023	75	54	20	15	0	0	3	0	0	167	28
1024	75	0	0	5	0	0	0	0	0	80	65
1025	60	18	20	15	0	0	3	3	0	119	48
1026	75	18	5	5	0	20	12	0	6	141	39
1027	45	36	0	15	0	0	12	6	0	114	51
1028	45	18	0	15	0	0	0	0	0	78	66
1029	75	0	0	15	0	0	0	0	0	90	61
1030	30	18	0	5	5	0	0	0	0	58	75
1031	0	18	0	0	0	0	6	3	0	27	88
1032	0	18	0	15	0	0	12	0	0	45	81
1033	75	0	0	5	0	0	12	6	2	100	57
1034	30	0	0	5	0	20	6	0	0	61	74
1035	60	0	0	5	0	0	6	0	2	73	68
1036	75	0	0	5	0	8	6	6	0	100	57
1037	75	18	0	15	5	0	6	0	4	123	47
1038	15	18	0	15	0	20	12	0	0	80	65

* The ESP was developed by IRC.

Table 10
Environmental Sustainability Parameter Factors and Rankings for
Hog Operations in the Matsqui Slough Watershed

Farm ID.	Manure Pit Storage		Manure Pit Facility	Woodwaste Storage	Proximity of Watercourse to Storage Facility		ESP *
	Time	SE/Hectare	Type			Ranking	Percentage
	Rank	Rank	Rank	Rank	Rank	(out of 170)	Ranking
1050	15	54	15	0	4	88	48
1051	30	54	5	0	2	91	46
1052	30	54	5	0	4	93	45
1053	30	54	0	0	0	84	51

* The ESP was developed by IRC.

Table 11
Environmental Sustainability Parameter Factors and Rankings for
Poultry Operations in the Matsqui Slough Watershed

Farm ID.	BE per Hectare Rank	Manure Disposal Rank	Dry Manure Storage Rank	Woodwaste Storage Rank	Proximity of Watercourse to Storage Facility Rank	Ranking (out of 116)	ESP *
							Percentage Ranking
1017	0	14	0	0	0	14	88
1060	0	0	0	0	0	0	100
1061	0	14	0	0	2	16	86
1062	0	0	0	0	0	0	100
1063	56	14	0	0	0	70	40
1064	0	14	30	0	0	44	62
1065	56	14	10	0	0	80	31
1066	0	0	0	0	0	0	100
1067	56	14	20	0	0	90	22
1068	0	0	0	0	0	0	100

* The ESP was developed by IRC.

Table 12
Environmental Sustainability Factors and Factor Ranges for
Dairy Operations in the Matsqui Slough Watershed

Factor	Range	Rank	Weighting	Weighted Ranks
Manure Pit Storage Time ¹	> 6 months	0	15	0
	5 - 6 months	1		15
	4 - 5 months	2		30
	3 - 4 months	3		45
	2 - 3 months	4		60
	< 2 months	5		75
Milking Cow Equivalents ² (MCE) Per Hectare	≤ 2.5	0	18	0
	2.5 to 3.25	1		18
	3.25 to 4	2		36
	> 4	3		54
Dry Manure Storage	none	0	5	0
	concrete/covered	0		0
	concrete/uncovered	1		5
	field/covered	2		10
	field/uncovered	4		20
Manure Pit Facility Type	concrete/covered	0	5	0
	concrete/uncovered	1		5
	steel/uncovered	1		5
	earthen	3		15
	earthen/seepage	5		25
Woodwaste Storage	none	0	5	0
	inside	0		0
	covered outside	1		5
	uncovered	2		10
Milk Parlour Discharge	none	0	4	0
	manure pit	0		0
	tile field	2		8
	field surface	3		12
	ditch	5		20
Yard Drainage	none	0	3	0
	manure pit	0		0
	tile field	1		3
	field surface	2		6
	ditch	4		12
Silage Runoff	none	0	3	0
	manure pit	0		0
	tile field	1		3
	field surface	2		6
	ditch	3		9
Proximity of Watercourse to Storage Facility	> 60 m	0	2	0
	30 to 60 m	1		2
	15 to 30 m	2		4
	< 15 m	3		6

1. Manure Pit Storage Times were calculated allowing a one foot freeboard and using factors of 77 L/d/MCE for animal wastes, 27.3 L/d/MCE for milk parlour discharges to the manure pit and 1091 mm/6 months for rainfall for uncovered facilities.
2. Milking Cow Equivalents = Total number of dairy animals/1.52

Table 13
Environmental Sustainability Factors and Factor Ranges for
Hog Operations in the Matsqui Slough Watershed

Factor	Range	Rank	Weighting	Weighted Ranks	Relative % or Priority ²
Manure Pit Storage Time ¹	contract or neighbour	0	15	0	44.1%
	> 6 months	0		0	
	5 - 6 months	1		15	
	4 - 5 months	2		30	
	3 - 4 months	3		45	
	2 - 3 months	4		60	
	< 2 months	5		75	
Sow Equivalents (SE) ³ Per Hectare	contract or neighbour	0	18	0	31.8%
	≤ 2.1	0		0	
	2.1 to 2.7	1		18	
	2.7 to 3.3	2		36	
	> 3.3	3		54	
Manure Pit Facility Type	concrete/covered	0	5	0	14.7%
	concrete/uncovered	1		5	
	steel/uncovered	1		5	
	earthen	3		15	
	earthen/seepage	5		25	
Woodwaste Storage	none	0	5	0	5.9%
	inside	0		0	
	covered outside	1		5	
	uncovered	2		10	
Proximity of Watercourse to Storage Facility	> 60 m	0	2	0	3.5%
	30 to 60 m	1		2	
	15 to 30 m	2		4	
	< 15 m	3		6	
Total				170	100%

1. Manure Pit Storage Times were calculated allowing a one foot freeboard and using factors of 72 L/d/SE for animal wastes, and 1091 mm/6 months for rainfall for uncovered facilities.
2. Calculated from Factor Maximum Priority/Overall Total Priority
3. Finisher = 0.12 Sow Equivalents

Table 14
Environmental Sustainability Factors and Factor Ranges for
Poultry Operations in the Matsqui Slough Watershed

Factor	Range	Rank	Weighting	Weighted Ranks	Relative % or Priority ²
Broiler Equivalents (BE) Per Hectare ¹	contract haulier/neighbour	0	14	0	48.3%
	≤ 1130	0		0	
	1131 to 1514	1		14	
	1515 to 1899	2		28	
	1900 to 2279	3		42	
	> 2280	4		56	
Manure Disposal	contract haulier	0	14	0	12.1%
	neighbouring farms	0		0	
	on farm ³	1		14	
Dry Manure Storage	none	0	10	0	25.9%
	concrete/covered	0		0	
	concrete/uncovered	1		10	
	field/covered	2		20	
	field/uncovered	3		30	
Woodwaste Storage	none	0	5	0	8.6%
	inside	0		0	
	covered outside	1		5	
	uncovered	2		10	
Proximity of Watercourse to Storage Facility	> 60 m	0	2	0	5.1%
	30 to 60 m	1		2	
	15 to 30 m	2		4	
	< 15 m	3		6	
Total				116	100%

1. Broiler Equivalents; layers x 1.55, pullets x 0.94, and turkeys x 2.26
2. Calculated from Factor Maximum Priority/Overall Total Priority
3. Manure storage is longer for on farm disposal with potential for contamination

Table 15
Comparison of Ministry of Agriculture, Fisheries and Foods and ESP
Priority Ratings of Environmental Concerns on Dairy Farm Operations

Ministry of Agriculture, Fisheries and Food ¹			Integrated Resource Consultants		
Factor	Priority ²	Relative % of Priority	Factor	Maximum Priority ²	Relative % or Priority ³
Winter Spreading (Lack of Enough Manure Storage)	10	23.8%	Manure Pit Storage Time (5 x 15)*	75	32.5%
Over Application on Manure	8	19.0%	Milking Cow Equivalents (MCE/hectare) (3 x 18)*	54	23.4%
Yard Runoff that Pollutes	7	16.7%	Manure Pit Facility Type (5 x 5)*	25	10.8%
Milkhouse Effluent to Ditches	6	14.3%	Dry Manure Storage (4 x 5)*	20	8.7%
Silage Effluent to Ditches	5	11.9%	Milk Parlour Discharge (5 x 4)*	20	8.7%
Fall Spreading of Manure on Bare Soils	4	9.5%	Yard Drainage (4 x 3)*	12	5.2%
Milkhouse Effluent to Tile Field Without a Permit	2	4.8%	Woodwaste Storage (2 x 5)*	10	4.3%
			Silage Runoff (3 x 3)*	9	3.9%
			Proximity of Watercourse to Storage Facility (3 x 2)*	6	2.5%
			Overall Total	231	100%

1. Van Kleeck, 1994, 26th Annual Dairy Producers' Short Course Presentation

2. A high priority number has the largest negative impact, a low priority number has the smallest negative impact

3. Calculated from Factor Maximum Priority/Overall Total Priority

* Values from Table 12

Table 16
Statistical Summary of Farm Types and Operating Conditions
for the Matsqui Slough Watershed

	COMMODITY GROUP			
	DAIRY	HOG	POULTRY	PRODUCE/ NURSERIES
Number of Survey Participants	37	4	10	13
Total Hectares	1361	126	92	218
Average hectares	37	32	9.2	17
Range	6.1 to 81	12.1 to 60.7	2.4 to 16	0.4 to 48.6
Total Animals	5108	2600	242050	
Average Animals	138	650	24205	
Range	30 to 320	270 to 1500	3000 to 60000	
Average Animal Equivalents*	95 MCE	313 SE	26311 BE	
Average Animal Equivalents/Hectare	2.8 MCE/Hectare	9.7 SE/Hectare	6293 BE/Hectare	
Average liquid manure storage capacity (months)	3.4	4.6	(1)	
Range (months)	0.51 to 16.2	4.2 to 5.7		
Main Storage Facility Type	41% earthen 41% conc/unc 19% conc/cov	50% conc/unc 25% conc/cov 25% earthen	40% field/unc 40% none 1% conc/unc 1% field/cov	
Farms that have more than one storage facility	51%	100%		
Farms that have a storage facility within 30m of a natural watercourse	16%	75%	10%	
Spreading Practice	87% splash plate 16% mechanical 5.4% irrigation 51% on farm/neighbour	50% on farm 50% on farm/neighbour	40% neighbour 30% on farm 30% on farm/neighbour	
Percent of farms using irrigation	24%	50%	20%	69.2%
Irrigation source	67% Well water 11% Fraser River 11% Irrigation ditch 11% Page Creek	50% Clayburn Creek 50% Matsqui Slough	50% Clayburn Creek 50% Fraser River	56% ditch 11% Clayburn Crk 11% municipal 11% Page Creek 11% spring
Percent of farms using pesticides	43%	75%	10%	92%
Disposal of containers	63% contractor 25% transfer stn 6% incineration 6% return	67% contractor 33% landfill or transfer station	100% contractor	42% contractor 25% landfill 17% incinerate 17% recycle
Percent of farms using chemical fertilizers	78%	50%	30%	85%
Total hectares	872	21	16	162
Domestic Sewage	95% tile fields 5% municipal	100% tile fields	100% tile fields	

Notation Used: conc=concrete, cov =covered, earth =earthen, unc = uncovered

* See Table 12 for MCE, Table 13 for SE and Table 14 for BE

(1) Poultry operation do not produce liquid manure, they just produce dry manure.

Table 17
Matsqui Slough Watershed Surface Water Quality - Fall Sampling 1993

Site 1: Willband Creek @ Valley Ave.					Site 2: Clayburn Creek @ Clayburn Rd.			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	12.2	7.9	74	0.446	11.0	10.6	96	< 0.005
Oct 12	12.0	7.1	66	0.038	10.5	10.8	97	0.008
Oct 18	11.8	10.0	92	0.094	10.5	11.4	102	0.009
Oct 25	7.8	10.6	89	0.091	6.2	12.2	99	< 0.005
Nov 1	8.3	9.8	83	0.078	7.0	12.2	101	0.012
Nov 8	6.8	11.1	91	0.093	5.3	12.8	101	0.016
Nov 15	6.8	10.1	83	0.559	5.7	12.3	98	0.034
Nov 24	1.9	11.2	81	0.134	-1.0	14.1	94	0.012
Dec 15	8.0	9.7	82	0.139	7.1	12.0	99	0.019
Average	8.4	9.7	82	0.186	6.9	12.0	99	0.013
Std Dev.	3.3	1.4	8	0.184	3.7	1.1	3	0.010
Minimum	1.9	7.1	66	0.038	-1.0	10.6	94	< 0.005
Maximum	12.2	11.2	92	0.559	11.0	14.1	102	0.034

Site 3: Page Creek @ Beharrell Rd.					Site 3B: Page Creek @ Bell Rd.			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	12.5	2.5	23	0.011				
Oct 12	11.0	1.2	11	< 0.005				
Oct 18	12.0	0.9	8	0.018				
Oct 25	8.8	2.0	17	0.110				
Nov 1	8.0	2.5	21	0.077	8.6	7.9	68	
Nov 8	4.8	4.5	35	0.101				
Nov 15	5.2	5.5	43	0.083	5.9	9.1	73	
Nov 24	-0.1	6.6	45	0.138				
Dec 15	7.8	6.5	55	0.105				
Average	7.8	3.6	29	0.072	7.3	8.5	71	
Std Dev.	4.0	2.2	16	0.049	1.9	0.8	4	
Minimum	-0.1	0.9	8	< 0.005	5.9	7.9	68	
Maximum	12.5	6.6	55	0.138	8.6	9.1	73	

* Detection Limit 0.005 mg/L

Table 17 - continued
Matsqui Slough Watershed Surface Water Quality - Fall Sampling 1993

Site 4: Clayburn Creek @ Harris Rd.					Site 5: Matsqui Slough @ Riverside St.			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	12.0	6.8	63	0.139	12.3	3.8	36	0.139
Oct 12	12.2	7.4	69	0.165	12.1	5.5	51	0.088
Oct 18	12.2	7.1	66	0.285	12.1	5.8	54	0.319
Oct 25	8.0	8.2	69	0.190	8.4	6.5	55	0.233
Nov 1	9.1	7.9	69	< 0.005	9.0	4.5	39	0.226
Nov 8	5.0	10.1	79	0.197	4.5	9.4	73	0.233
Nov 15	6.3	9.7	79	0.416	6.5	10.0	81	0.297
Nov 24	-0.4	11.6	78	0.149	-0.3	11.6	79	0.206
Dec 15	7.3	8.9	74	0.113	7.8	8.0	67	0.133
Average	8.0	8.6	72	0.184	8.0	7.2	59	0.208
Std Dev.	4.1	1.6	6	0.115	4.1	2.7	17	0.076
Minimum	-0.4	6.8	63	< 0.005	-0.3	3.8	36	0.088
Maximum	12.2	11.6	79	0.416	12.3	11.6	81	0.319

Site 6: Matsqui Slough Trib. @ Riverside St.					Site 6B: Matsqui Slough Trib. @ Bell Rd.			
Date (1993)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Dissolved Ammonia Nitrogen * (mg/L)
Oct 6	12.0	2.4	22	1.230				
Oct 12	13.5	2.9	28	0.973				
Oct 18	11.6	3.7	34	0.895				
Oct 25	8.0	4.8	41	0.981				
Nov 1	8.2	1.4	12	3.180				
Nov 8	6.0	3.8	31	1.430				
Nov 15	7.0	7.3	60	0.664	6.6	6.1	50	
Nov 24	1.0	4.8	34	0.766				
Dec 15	7.9	7.7	65	0.338				
Average	8.4	4.3	36	1.162	6.6	6.1	50	
Std Dev.	3.7	2.1	17	0.819				
Minimum	1.0	1.4	12	0.338	6.6	6.1	50	
Maximum	13.5	7.7	65	3.180	6.6	6.1	50	

* Detection Limit 0.005 mg/L

Table 18
Matsqui Slough Watershed Surface Water Quality - Winter Sampling 1994

Site 1: Willband Creek @ Valley Ave.									
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	5.2	4.0	8.5	8.0	5.5	6.2	1.7	4.0	8.5
Dissolved Oxygen (mg/L)	11.2	11.0	6.7	10.4	10.4	9.9	1.7	6.7	11.2
% Saturation Dissolved Oxygen	88%	84%	57%	88%	82%	80%	12%	57%	88%
pH (field)	no data	6.6	6.3	6.6	6.7	6.5	0.1	0	6.7
pH (lab)	6.9	6.4	6.1	6.3	6.8	6.5	0.3	6.1	6.9
Conductivity (field) (umhos/cm)	no data	105	no data	60	135	100	31	60	135
Conductivity (lab) (umhos/cm)	370	150	110	81	180	178	102	81	370
Total Dissolved Solids (mg/L)	220	110	86	51	140	121	57	51	220
Total Suspended Solids (mg/L)	40	7	7	71	7	26	26	7	71
Turbidity (NTU)	7.5	6.0	7.1	29.0	5.3	11.0	9.0	5.3	29.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	70	48	34	28	66	49	17	28	70
Hardness - CALC (mg/L)	73	36	39	27	70	49	19	27	73
Total Organic Carbon (mg/L)	4.50	3.20	4.40	3.60	4.00	3.94	0.49	3.20	4.50
Faecal Coliform (MPN/100 ml)	80	50	23	1000	170	109	371	23	1000
Free Ammonia (mg NH3-N/L)	0.103	0.115	0.159	0.330	0.039	0.149	0.098	0.039	0.330
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	1.790	1.090	0.942	1.140	1.520	1.296	0.312	0.942	1.790
Total Kjeldahl Nitrogen (mg/L)	0.46	0.40	0.65	1.33	0.42	0.65	0.35	0.40	1.33
Total Nitrogen (mg/L)	2.25	1.49	1.59	2.47	1.94	1.95	0.37	1.49	2.47
Organic Nitrogen (mg/L)	0.36	0.29	0.49	1.00	0.46	0.52	0.25	0.29	1.00
Ortho Phosphate (mg P/L)	0.007	0.013	0.038	0.022	0.014	0.019	0.011	0.007	0.038
Total Dissolved Phosphate (mg P/L)	0.019	0.018	0.039	0.022	0.015	0.023	0.008	0.015	0.039
Total Phosphorus (mg P/L)	0.062	0.040	0.043	0.127	0.040	0.062	0.033	0.04	0.127
Chloride (mg/L)		20.0	9.5			14.8	5.3	9.5	20.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 18 - continued
Matsqui Slough Watershed Surface Water Quality - Winter Sampling 1994

Parameter	Site 2: Clayburn Creek @ Clayburn Rd.					Average	Std. Dev	Minimum	Maximum
	Feb 10	Feb 22 *	March 3 *	March 10	March 24				
Temperature (field) (C)	2.0	4.0	8.1	6.0	4.0	4.8	2.1	2.0	8.1
Dissolved Oxygen (mg/L)	12.4	13.0	12.4	12.4	13.4	12.7	0.4	12.4	13.4
% Saturation Dissolved Oxygen	90%	99%	105%	100%	102%	99%	5%	90%	105%
pH (field)	no data	6.4	7.3	6.5	7.1	6.8	0.4	6.4	7.3
pH (lab)	6.8	6.5	6.3	6.4	6.9	6.6	0.2	6.3	6.9
Conductivity (field) (umhos/cm)	no data	40	no data	40	40	40	0	40	40
Conductivity (lab) (umhos/cm)	80	62	49	59	62	62	10	49	80
Total Dissolved Solids (mg/L)	59	50	53	41	53	51	6	41	59
Total Suspended Solids (mg/L)	5	3	36	30	5	16	14	3	36
Turbidity (NTU)	2.2	5.2	15.0	25.0	2.5	10.0	8.8	2.2	25.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	34	18	12	18	22	21	7	12	34
Hardness - CALC (mg/L)	27	16	16	20	23	20	4	16	27
Total Organic Carbon (mg/L)	1.20	1.90	1.90	4.20	1.50	2.14	1.06	1.20	4.20
Faecal Coliform (MPN/100 ml)	30	80	22	30	14	29	23	14	80
Free Ammonia (mg NH3-N/L)	0.009	< 0.005	0.100	0.007	< 0.005	0.024	0.038	< 0.005	0.100
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	1.350	1.840	1.930	1.590	1.390	1.620	0.233	1.350	1.930
Total Kjeldahl Nitrogen (mg/L)	0.20	0.36	0.31	0.31	0.19	0.27	0.07	0.19	0.36
Total Nitrogen (mg/L)	1.55	2.20	2.24	1.90	1.58	1.89	0.29	1.55	2.24
Organic Nitrogen (mg/L)	0.19	0.36	0.30	0.30	0.19	0.27	0.07	0.19	0.36
Ortho Phosphate (mg P/L)	0.003	0.005	0.013	0.007	0.006	0.007	0.003	0.003	0.013
Total Dissolved Phosphate (mg P/L)	0.007	0.007	0.014	0.007	0.006	0.008	0.003	0.006	0.014
Total Phosphorus (mg P/L)	0.012	0.023	0.035	0.055	0.006	0.026	0.017	0.006	0.055
Chloride (mg/L)		4.4	3.0			3.7	0.7	3.0	4.4
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 18 - continued
Matsqui Slough Watershed Surface Water Quality - Winter Sampling 1994

Site 3: Page Creek @ Beharrell Rd.

Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	3.0	4.0	8.6	7.0	6.0	5.7	2.0	3.0	8.6
Dissolved Oxygen (mg/L)	5.1	9.6	8.0	6.0	7.6	7.3	1.6	5.1	9.6
% Saturation Dissolved Oxygen	38%	73%	69%	49%	61%	58%	13%	38%	73%
pH (field)	no data	6.2	6.3	6.4	6.4	6.3	0.1	6.2	6.4
pH (lab)	6.7	6.2	6.1	6.2	6.5	6.3	0.2	6.1	6.7
Conductivity (field) (umhos/cm)	no data	75	no data	90	90	85	7	75	90
Conductivity (lab) (umhos/cm)	170	120	85	130	120	125	27	85	170
Total Dissolved Solids (mg/L)	120	110	92	91	120	107	13	91	120
Total Suspended Solids (mg/L)	12	6	9	4	6	7	3	4	12
Turbidity (NTU)	16.0	12.0	13.0	11.0	9.0	12.2	2.3	9.0	16.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	60	27	22	42	44	39	13	22	60
Hardness - CALC (mg/L)	59	39	31	46	56	46	10	31	59
Total Organic Carbon (mg/L)	4.54	11.60	8.80	6.25	8.30	7.90	2.39	4.54	11.60
Faecal Coliform (MPN/100 ml)	17	170	130	240	80	94	76	17	240
Free Ammonia (mg NH3-N/L)	0.220	0.073	0.090	0.105	0.105	0.119	0.052	0.073	0.220
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	1.070	5.300	2.600	1.490	1.660	2.424	1.523	1.070	5.300
Total Kjeldahl Nitrogen (mg/L)	0.49	1.05	0.97	0.71	0.55	0.75	0.22	0.49	1.05
Total Nitrogen (mg/L)	1.56	6.35	3.57	2.20	2.21	3.18	1.72	1.56	6.35
Organic Nitrogen (mg/L)	0.27	0.98	0.88	0.60	0.45	0.64	0.26	0.27	0.98
Ortho Phosphate (mg P/L)	0.031	0.061	0.030	0.031	0.024	0.035	0.013	0.024	0.061
Total Dissolved Phosphate (mg P/L)	0.059	0.072	0.035	0.032	0.032	0.046	0.016	0.032	0.072
Total Phosphorus (mg P/L)	0.089	0.084	0.040	0.062	0.067	0.068	0.017	0.040	0.089
Chloride (mg/L)		5.8	3.5			4.7	1.2	3.5	5.8
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 18 - continued
Matsqui Slough Watershed Surface Water Quality - Winter Sampling 1994

Site 4: Clayburn Creek @ Harris Rd.									
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	5.2	5.0	8.2	7.0	5.0	6.1	1.3	5.0	8.2
Dissolved Oxygen (mg/L)	11.2	11.2	7.2	10.4	10.6	10.1	1.5	7.2	11.2
% Saturation Dissolved Oxygen	88%	88%	61%	86%	83%	81%	10%	61%	88%
pH (field)	no data	no data	6.3	6.9	7.0	6.7	0.3	6.3	7.0
pH (lab)	7.0	6.2	6.1	6.4	6.5	6.4	0.3	6.1	7.0
Conductivity (field) (umhos/cm)	no data	85	no data	85	90	87	2	85	90
Conductivity (lab) (umhos/cm)	340	130	80	130	130	162	91	80	340
Total Dissolved Solids (mg/L)	210	110	70	91	110	118	48	70	210
Total Suspended Solids (mg/L)	41	24	35	29	53	36	10	24	53
Turbidity (NTU)	17.0	16.0	21.0	13.0	19.0	17.2	2.7	13.0	21.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	52	33	24	42	46	39	10	24	52
Hardness - CALC (mg/L)	58	28	26	37	49	40	12	26	58
Total Organic Carbon (mg/L)	2.98	6.40	5.10	3.84	4.20	4.50	1.17	2.98	6.40
Faecal Coliform (MPN/100 ml)	70	300	900	130	80	181	313	70	900
Free Ammonia (mg NH3-N/L)	0.270	0.228	0.280	0.108	0.127	0.203	0.072	0.108	0.280
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	1.670	4.290	1.910	1.640	1.950	2.292	1.007	1.640	4.290
Total Kjeldahl Nitrogen (mg/L)	0.72	0.97	0.86	0.64	0.51	0.74	0.16	0.51	0.97
Total Nitrogen (mg/L)	2.39	5.26	2.77	2.28	2.46	3.03	1.13	2.28	5.26
Organic Nitrogen (mg/L)	0.45	0.74	0.58	0.53	0.38	0.54	0.12	0.38	0.74
Ortho Phosphate (mg P/L)	0.013	0.050	0.078	0.051	0.025	0.043	0.023	0.013	0.078
Total Dissolved Phosphate (mg P/L)	0.036	0.058	0.078	0.051	0.030	0.051	0.017	0.03	0.078
Total Phosphorus (mg P/L)	0.105	0.114	0.133	0.085	0.117	0.111	0.016	0.085	0.133
Chloride (mg/L)		13.0	5.5			9.3	3.8	5.5	13.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 18 - continued
Matsqui Slough Watershed Surface Water Quality - Winter Sampling 1994

Site 5: Matsqui Slough @ Riverside St.									
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	2.3	4.5	8.2	7.0	6.0	5.6	2.0	2.3	8.2
Dissolved Oxygen (mg/L)	10.4	10.8	7.5	10.2	10.2	9.8	1.2	7.5	10.8
% Saturation Dissolved Oxygen	76%	83%	64%	84%	82%	78%	8%	64%	84%
pH (field)	no data	6.1	6.2	6.7	7.0	6.5	0.3	6.1	7.0
pH (lab)	6.9	6.2	6.1	6.5	6.6	6.5	0.3	6.1	6.9
Conductivity (field) (umhos/cm)	no data	80	no data	90	100	90	8	80	100
Conductivity (lab) (umhos/cm)	180	140	85	140	140	137	30	85	180
Total Dissolved Solids (mg/L)	120	120	72	89	110	102	19	72	120
Total Suspended Solids (mg/L)	30	18	32	12	12	21	9	12	32
Turbidity (NTU)	19.0	20.0	23.0	11.0	11.0	16.8	4.9	11.0	23.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	62	34	22	46	50	43	14	22	62
Hardness - CALC (mg/L)	63	36	27	44	57	45	13	27	63
Total Organic Carbon (mg/L)	2.76	7.50	5.70	9.65	5.40	6.20	2.29	2.76	9.65
Faecal Coliform (MPN/100 ml)	4	900	900	170	50	122	408	4	900
Free Ammonia (mg NH3-N/L)	0.200	0.200	0.260	0.125	0.138	0.185	0.049	0.125	0.260
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	1.500	4.550	1.950	1.630	1.910	2.308	1.134	1.500	4.550
Total Kjeldahl Nitrogen (mg/L)	0.53	0.95	1.00	0.42	0.45	0.67	0.25	0.42	1.00
Total Nitrogen (mg/L)	2.03	5.50	2.95	2.05	2.36	2.98	1.30	2.03	5.50
Organic Nitrogen (mg/L)	0.33	0.75	0.74	0.29	0.31	0.48	0.21	0.29	0.75
Ortho Phosphate (mg P/L)	0.022	0.051	0.078	0.052	0.028	0.046	0.020	0.022	0.078
Total Dissolved Phosphate (mg P/L)	0.058	0.051	0.082	0.057	0.036	0.057	0.015	0.036	0.082
Total Phosphorus (mg P/L)	0.078	0.109	0.148	0.068	0.066	0.094	0.031	0.066	0.148
Chloride (mg/L)		10.0	5.5			7.8	2.3	5.5	10.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 18 - continued
Matsqui Slough Watershed Surface Water Quality - Winter Sampling 1994

Site 6: Matsqui Slough Trib. @ Riverside St.									
Parameter	Feb 10	Feb 22 *	March 3 *	March 10	March 24	Average	Std. Dev	Minimum	Maximum
Temperature (field) (C)	6.0	4.0	8.9	8.5	6.0	6.7	1.8	4.0	8.9
Dissolved Oxygen (mg/L)	4.9	7.0	4.5	4.0	7.2	5.5	1.3	4	7.2
% Saturation Dissolved Oxygen	39%	53%	39%	34%	58%	45%	9%	34%	58%
pH (field)	no data	6.5	6.4	6.8	6.9	6.6	0.2	6.4	6.9
pH (lab)	7.0	6.4	6.4	6.5	6.7	6.6	0.2	6.4	7.0
Conductivity (field) (umhos/cm)	no data	140	no data	200	180	173	25	140	200
Conductivity (lab) (umhos/cm)	280	220	190	270	240	240	33	190	280
Total Dissolved Solids (mg/L)	180	170	150	170	180	170	11	150	180
Total Suspended Solids (mg/L)	72	36	30	28	26	38	17	26	72
Turbidity (NTU)	41.0	54.0	48.0	49.0	56.0	49.6	5.2	41.0	56.0
Alkalinity to pH 4.5 (mg (CaCO3/L)	130	77	80	120	120	105	22	77	130
Hardness - CALC (mg/L)	110	58	72	110	120	94	24	58	120
Total Organic Carbon (mg/L)	1.91	8.00	6.70	3.11	3.60	4.66	2.30	1.91	8.00
Faecal Coliform (MPN/100 ml)	14	300	900	5000	900	443	1821	14	5000
Free Ammonia (mg NH3-N/L)	0.700	0.811	1.140	1.210	0.576	0.887	0.247	0.576	1.210
Nitrate+Nitrite ((NO3-N+NO2-N)mg/L))	0.439	5.830	2.410	0.523	1.140	2.068	2.009	0.439	5.830
Total Kjeldahl Nitrogen (mg/L)	1.00	1.22	2.09	1.37	0.68	1.27	0.47	0.68	2.09
Total Nitrogen (mg/L)	1.44	7.05	4.50	1.89	1.82	3.34	2.15	1.44	7.05
Organic Nitrogen (mg/L)	0.30	0.41	0.95	0.16	0.10	0.38	0.30	0.10	0.95
Ortho Phosphate (mg P/L)	0.015	0.021	0.041	0.007	< 0.001	0.017	0.014	< 0.001	0.041
Total Dissolved Phosphate (mg P/L)	0.023	0.028	0.048	0.007	0.004	0.022	0.016	0.004	0.048
Total Phosphorus (mg P/L)	0.096	0.266	0.318	0.192	0.107	0.196	0.087	0.096	0.318
Chloride (mg/L)		11.0	9.5			10.3	0.8	9.5	11.0
Oil & Grease (mg/L)		< 1.0	< 1.0			< 1.0		< 1.0	< 1.0

* Samples also collected for Total Metals Analysis

Note: Average Faecal Coliforms & pH = geometric mean (GM)

Table 19
Water Quality Canadian Guidelines and Provincial Criteria for General Parameters

Parameter	CCREM Guidelines ¹				Provincial Criteria ² (Maximum Concentration)			
	Irrigation (all soils)	Live Stock Watering	Drinking Water (Raw)	Freshwater Aquatic Life	Irrigation (all soils)	Live Stock Watering	Drinking Water (Raw)	Freshwater Aquatic Life
Alkalinity, mg/L CaCO ₃								10 to 20, moderate sensitivity to acid inputs > 20, low sensitivity to acid inputs
Ammonia mg/L-N				pH 6.5/10°C = 2.2				pH 6.5/7°C = 26.2 ⁴ pH 6.5/7°C Avg 30 day Conc. = 1.90 ⁴
Chloride, mg/L	100 to 700				100 to 700 (Diss.)			
Dissolved Oxygen mg/L				4.0, 1 day minimum for cold water, other life stages				
Faecal Coliforms / 100 mL	100		0		≤200 GM ³		0	
Nitrate mg/L		100	10			100	10	200
Nitrite mg/L			1			10	1	0.06
pH				6.5 to 9.0	4.5 to 9.0			6.5 to 9.0
Total Dissolved Solids mg/L	500 to 3500	3000			500 to 3500	1000 to 3000		

Diss = Dissolved. GM = geometric mean.

¹ CCREM, 1987, Canadian Water Quality Guidelines.

² MOELP, 1994. Approved and Working Criteria for Water Quality - 1994.

³ For crops eaten raw.

⁴ pH 6.5 and 7°C approximates winter conditions in Table 18

Table 20
Water Quality Canadian Guidelines and Provincial Criteria for Metals

Parameter	CCREM Guidelines ¹			Provincial Criteria ² (Maximum Concentration)		
	Irrigation (all soils)	Live Stock Watering	Freshwater Aquatic Life	Irrigation (all soils)	Live Stock Watering	Freshwater Aquatic Life
Aluminum µg/L	5000	5000	100 @ pH ≥ 6.5 5 @ pH < 6.5	5000	5000	100 (Diss.) @ pH ≥ 6.5 52 to 74 for pH 6.1 to 6.4 ³
Arsenic µg/L	100	500	50	100 to 2000	500	50
Cadmium µg/L	10	20	0.2 @ 0 to 60 mg/L CaCO ₃ 0.8 @ 60 to 120 mg/L CaCO ₃	10	20	0.2 @ 0 to 60 mg/L CaCO ₃ 0.8 @ 60 to 120 mg/L CaCO ₃
Calcium mg/L		1000				4 to 8, moderate sensitivity to acid inputs > 8, low sensitivity to acid inputs
Chromium µg/L	100	1000	2, phyto- & zooplankton 20, fish	100	1000	2, phyto- & zooplankton 20, fish
Cobalt µg/L	50	1000		50	1000	50
Copper µg/L	200 - 1000	1000	2.0 @ 0 to 120 mg/L CaCO ₃	200	300	2 to 13.3 for 0 to 120 mg/L CaCO ₃
Iron µg/L			300	5000		300
Lead µg/L	200	100	1.0 @ 0 to 60 mg/L CaCO ₃ 2.0 @ 60 to 120 mg/L CaCO ₃	200	100	3 to 103 for 0 to 120 mg/L CaCO ₃
Manganese µg/L	200			200		100 to 1000
Mercury µg/L		3.0	0.1	2.0	3.0	0.1
Molybdenum µg/L	10 to 50	500		50	50 to 80	2000
Nickel µg/L	200	1000	25 @ 0 to 60 mg/L CaCO ₃ 65 @ 60 to 120 mg/L CaCO ₃	200	1000	25 @ 0 to 60 mg/L CaCO ₃ 65 @ 60 to 120 mg/L CaCO ₃
Phosphorus µg/L						5 to 15 (lake)
Selenium µg/L	20 to 50	50	1.0	20 to 50	50	1.0
Zinc µg/L	1000 @ pH < 6.5 5000 @ pH > 6.5	50000	30	1000 @ pH < 6.5 5000 @ pH > 6.5	50000	30

Notes: All water quality guidelines concentrations are for total metals, unless indicated otherwise. Diss = Dissolved.

For winter survey the hardness ranged from 16 to 120 mg/L CaCO₃.

¹ CCREM, 1987, Canadian Water Quality Guidelines.

² MOELP, 1994. Approved and Working Criteria for Water Quality - 1994.

³ For the winter survey the pH ranged from 6.1 to 7.0.

Table 21
Fish Habitat Classification and Measured Dissolved Oxygen in the Matsqui Slough Watershed

Site	Site Description	Fish Habitat Category	Dissolved Oxygen (mg/L)						
			Provincial Criteria ¹	Minimum		Mean		Coefficient of Variance ² %	
				Fall	Winter	Fall	Winter	Fall	Winter
1	Willband Creek @ Valley Road	I	6 to 11	7.1	6.7	9.7	9.9	13	15
2	Clayburn Creek @ Clayburn Road	I	6 to 11	10.6	12.4	12.0	12.3	8	7
3	Page Creek @ Beharrell Road	III	3 to 8	0.9	5.1	3.6	7.3	59	54
4	Clayburn Creek @ Harris Road	IV	3 to 6	6.8	7.2	8.6	10.1	17	18
5	Matsqui Slough @ Riverside Street	IV	3 to 6	3.8	7.5	7.2	9.8	35	30
6	Matsqui Slough Tributary @ Riverside Street	IV	3 to 6	1.4	4.0	4.3	5.5	46	40

1 MOELP, 1994. Approved and Working Criteria for Water Quality - 1994, Table 17

2 Coefficient of variance = standard deviation/mean

Table 22
Matsqui Slough Watershed Surface Water Quality for Total Metals
Winter Sampling 1994

Total Metals (ug/L)	Site 1: Willband Creek @ Valley Ave.			Site 2: Clayburn Creek @ Clayburn Rd.			Site 3: Page Creek @ Beharrell Rd.		
	Feb 22	March 3	Average	Feb 22	March 3	Average	Feb 22	March 3	Average
Aluminium	180	330	255	140	1000	570	430	550	490
Arsenic	4.00	2.60	3.30	0.43	0.89	0.66	0.87	0.80	0.84
Cadmium	0.11	0.05	0.08	< 0.03	< 0.03	< 0.03	0.12	0.11	0.12
Calcium	13000	15000	14000	7000	6900	6950	14000	12000	13000
Chromium	7.1	4.1	5.6	1.5	2.6	2.1	2.0	2.8	2.4
Cobalt	0.24	0.41	0.33	0.08	0.58	0.33	1.00	0.88	0.94
Copper	2.3	3.8	3.1	< 0.5	2.2	< 1.2	7.2	7.1	7.2
Iron	720	890	805	180	1100	640	1000	1400	1200
Lead	1.00	0.96	0.98	< 0.05	0.52	0.27	0.26	0.34	0.30
Magnesium	3400	4600	4000	1500	2000	1750	3900	4200	4050
Manganese	100	160	130	12	43	28	74	110	92
Mercury	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Molybdenum	0.73	0.70	0.72	0.20	0.25	0.23	1.10	1.40	1.25
Nickel	2.0	1.8	1.9	0.7	1.9	1.3	9.1	8.3	8.7
Phosphorus	< 20	80	< 45	< 20	20	< 15	40	120	80
Potassium	1200	2200	1700	700	880	790	2700	2600	2650
Selenium	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.12	0.05	0.09
Sodium	9000	6900	7950	2800	3500	3150	3000	3600	3300
Strontium	84	78	81	42	37	40	74	55	65
Tin	0.04	0.11	0.08	0.03	0.06	0.05	0.03	0.04	0.04
Zinc	19.0	16.0	17.5	5.1	11.0	8.1	16.0	20.0	18.0

Table 22 - continued
Matsqui Slough Watershed Surface Water Quality for Total Metals
Winter Sampling 1994

Total Metals (ug/L)	Site 4: Clayburn Creek @ Harris Rd.			Site 5: Matsqui Slough @ Riverside St.			Site 6: Matsqui Slough Trib. @ Riverside St.		
	Feb 22	March 3	Average	Feb 22	March 3	Average	Feb 22	March 3	Average
Aluminium	400	1400	900	610	1200	905	650	870	760
Arsenic	1.50	1.80	1.65	1.50	1.80	1.65	3.00	3.20	3.10
Cadmium	0.06	0.06	0.06	< 0.03	0.15	< 0.08	0.15	0.20	0.18
Calcium	12000	11000	11500	13000	12000	12500	20000	23000	21500
Chromium	1.6	5.4	3.5	1.8	5.4	3.6	1.0	0.5	0.8
Cobalt	0.90	0.96	0.93	0.97	1.10	1.04	1.40	1.30	1.35
Copper	20.0	6.0	13.0	5.4	6.8	6.1	7.3	9.0	8.2
Iron	590	1700	1145	970	1700	1335	3200	5000	4100
Lead	0.47	0.87	0.67	2.10	0.98	1.54	0.55	0.63	0.59
Magnesium	3800	3700	3750	4200	4100	4150	8100	12000	10050
Manganese	52	87	70	71	100	86	370	720	545
Mercury	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Molybdenum	0.39	0.52	0.46	0.56	0.88	0.72	0.78	0.54	0.66
Nickel	6.7	5.5	6.1	8.2	8.2	8.2	11.0	9.3	10.2
Phosphorus	100	200	150	60	240	150	250	560	405
Potassium	2900	2800	2850	3200	3200	3200	6900	6600	6750
Selenium	0.06	< 0.05	< 0.04	0.11	< 0.05	< 0.07	0.15	0.05	0.10
Sodium	6000	4900	5450	4900	5300	5100	4100	5400	4750
Strontium	74	55	65	76	63	70	100	97	99
Tin	0.05	0.07	0.06	0.04	0.05	0.05	0.05	< 0.03	< 0.03
Zinc	13.0	14.0	13.5	55.0	17.0	36.0	26.0	26.0	26.0

TABLE 23
RUNOFF CHARACTERISTICS ¹

Parameter	Seattle ² Washington	Lake Ellyn ³ Michigan	Peak Conc ⁴ USA	Alberta Surface ⁵ Water Quality Objectives
Conductivity, $\mu\text{ohm/cm}$	12.9			
Turbidity, JTU	7.0			25
Dissolved Oxygen, mg/L	9.0			5.0
Biochemical Oxygen Demand, mg/L	30.4	18.0		
Chemical Oxygen Demand, mg/L	99.0			
Chloride, mg/L	11.6	34.7		
Sulphate, mg/L	20.0			
Nitrogen, mg/L				1.0
Organic	1.71			
Ammonia	0.35	0.18		
Nitrite	0.13			
Nitrate	0.74			
Phosphorus, mg/L				0.15
Hydrolyzable	0.36	0.08		
Ortho	0.11			
Lead, $\mu\text{g/L}$	360	224	460	50
Iron, mg/L	1.99			0.3
Mercury, $\mu\text{g/L}$	0.17			0.1
Arsenic, $\mu\text{g/L}$			50.5	10
Copper, $\mu\text{g/L}$		41	100	20
Cadmium, $\mu\text{g/L}$	15.0		14	10
Zinc, $\mu\text{g/L}$	120	171	2,400	50
Phenols, $\mu\text{g/L}$			115	5
Solids, mg/L				
Settleable	121			
Suspended	160	196		Background + 10
Total Dissolved Solids, mg/L	144			
Coliforms, org./100mL				
Total	26,000			2,400
Fecal	1,200			200

- Notes: 1. Alberta Environment, 1987. Stormwater Management Guidelines.
2. Kibler, 1982. Urban Stormwater Hydrology.
3. Hey and Schaefer, 1984. An Evaluation of the Water Quality Effects of Detention Storage and Source Control.
4. Cole *et al*, 1984. Preliminary Findings of the Priority Pollutant Monitoring Program.
5. Alberta Environment, 1977.

Table 24
Time of Travel Estimates from Water Quality Sampling Sites
to the Mouth of the Matsqui Slough

Site No.	Site Description	Distance of Sampling Site to the Mouth of the Matsqui Slough * (km)	Time-of-Travel (hours)	
			Dry Velocity (0.15 m/s)	Wet Velocity (0.3 m/s)
1	Willband Creek @ Valley Road	8.25	15.2	7.6
2	Clayburn Creek @ Clayburn Road	8.50	15.7	7.8
3	Page Creek @ Beharrell Road	5.25	9.7	4.9
3B	Page Creek @ Bell Road	3.25	6.0	3.0
4	Clayburn Creek @ Harris Road	3.50	6.5	3.3
5	Matsqui Slough @ Riverside Street	2.00	3.7	1.9
6	Matsqui Slough Tributary @ Riverside Street	1.75	3.2	1.6
6B	Matsqui Slough Tributary @ Bell Road	3.25	6.0	3.0

* As measured from a topographic map (Mission, 92 G/1, 5th Edition, Energy, Mines and Resources Canada, NAD 27)

Table 25
Comparison of "Wet" versus "Dry" Watershed Averaged Water Quality Data

Parameter	"Wet" Sampling Days	"Dry" Sampling Days
Ammonia (mg/L)	0.278	0.319
Suspended Solids (mg/L)	21	27
Total Aluminum ($\mu\text{g/L}$)	647	----
Total Cadmium ($\mu\text{g/L}$)	0.088	----
Total Iron ($\mu\text{g/L}$)	1538	----
Total Lead ($\mu\text{g/L}$)	0.73	----
Total Mercury ($\mu\text{g/L}$)	< 0.05	----
Total Selenium ($\mu\text{g/L}$)	0.058	----
Total Zinc ($\mu\text{g/L}$)	20	----
Faecal Coliforms (MPN/100 mL)	193	87

Note: Metals were sampled on February 22, and March 3, 1994, both which are classified as "wet" sampling days.

Table 26
Comparison of "Wet" versus "Dry" Site Averaged Water Quality Data

Parameter	Site 1		Site 2		Site 3	
	"Wet" Sampling Days	"Dry" Sampling Days	"Wet" Sampling Days	"Dry" Sampling Days	"Wet" Sampling Days	"Dry" Sampling Days
Ammonia (mg/L)	0.235	0.090	0.023	0.009	0.061	0.127
Suspended Solids (mg/L)	28	24	37	5	6	9
Faecal Coliforms (MPN/100 mL)	105	117	38	30	174	37

Table 27
Matsqui Slough Watershed Ground Water Quality - Winter 1994

Site 1: 34191 Sim Road - Well Depth 6.40 m							Site 2: 35045 Beaton Road - Well Depth 3.66 m					
Date (1994)	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)
March 14	6.61	< 0.005	< 2	< 2			13.9	0.007	< 2	< 2		
March 16	6.52	< 0.005	< 2	< 2	0	0	14.1	0.006	< 2	< 2	0	0
Average	6.57	< 0.005	< 2	< 2	0	0	14.0	0.007	< 2	< 2	0	0

Site 3: 35162 Sim Road - Well Depth 4.88 m							Site 4: 35235 Page Road - Well Depth 6.10 m					
Date	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)
March 14	12.5	< 0.005	< 2	< 2			11.2	< 0.005	< 2	< 2		
March 16	12.2	< 0.005	< 2	< 2	0	0	11.0	< 0.005	< 2	< 2	0	0
Average	12.4	< 0.005	< 2	< 2	0	0	11.1	< 0.005	< 2	< 2	0	0

Site 5: 34974 Fore Road - Well Depth 18.3 m							Site 6: 35678 Gallagher Road - Well Depth 3.66 m					
Date	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)
March 14	< 0.02	< 0.005	< 2	< 2			4.31	< 0.005	< 2	< 2		
March 16	< 0.02	< 0.005	< 2	< 2	0	0	4.33	< 0.005	< 2	< 2	0	0
Average	< 0.02	< 0.005	< 2	< 2	0	0	4.32	< 0.005	< 2	< 2	0	0

Table 27 - continued
Matsqui Slough Watershed Ground Water Quality - Winter 1994

Site 7: 35511 Gallagher Road - Well Depth 6.10 m							Site 8: 6256 Bell Road - Well Depth 6.71 m					
Date	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)
March 14	6.68	< 0.005	< 2	< 2			18.5	< 0.005	< 2	< 2		
March 16	6.53	< 0.005	< 2	< 2	0	0	17.6	< 0.005	< 2	< 2	0	0
Average	6.61	< 0.005	< 2	< 2	0	0	18.1	< 0.005	< 2	< 2	0	0

Site 9: 6915 Beharrell Road - Well Depth 3.66 m							Site 10: 35620 Gallagher Road - Well Depth 3.96 m					
Date	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)	Dissolved Nitrate (mg/L)	Dissolved Nitrite (mg/L)	Total Coliform (MPN)	Faecal Coliform (MPN)	E. Coli (MPN)	Klebsiella (MPN)
March 14	7.00	< 0.005	< 2	< 2			7.10	0.011	< 2	< 2		
March 16	26.4	< 0.005	< 2	< 2	0	0	7.35	0.008	< 2	< 2	0	0
Average	16.7	< 0.005	< 2	< 2	0	0	7.23	0.010	< 2	< 2	0	0

Table 28

Relative Abundance of Fish Species at Water Quality Sites in the Matsqui Slough Watershed

SITE	coho salmon	chinook salmon	chum salmon	rainbow/steelhead trout	cutthroat trout	"trout" (unidentified)	northern squawfish	redside shiner	goldfish	"cyprinid"	largescale sucker	3 spine stickleback	coastrange sculpin	lamprey ammocoete	TOTALS:
Matsqui Slough Watershed															
1 (Willband Creek at Valley Avenue)															
OCT18						2						5			7
NOV24				1								1			2
DEC15	1													1	2
FEB10	1											3			4
MAR03															0
2 (Clayburn Creek at Clayburn Road)															
OCT18				10	10										20
NOV24	2			3	2										7
DEC15	2			1	2										5
FEB10	4			3	2										9
MAR03				6											6
3 (Page Creek at Beharrell Road)															
OCT18												2			2
NOV24											1	10			11
DEC15										1		6			7
FEB10	3						1	1			10	15			30
MAR03												3			3
4 (Clayburn Creek at Harris Road)															
OCT18												5			5
NOV24												1			1
DEC15															0
FEB10												3			3
MAR03															0
5 (Matsqui Slough at Riverside Street)															
OCT18												5			5
NOV24															0
DEC15															0
FEB10												2			2
MAR03															0
6 (Matsqui Slough trib at Riverside Street)															
OCT18															0
NOV24											3	1			4
DEC15															0
FEB10									1		2	2			5
MAR03															0
Estimated Total Captures =	13	0	0	24	16	2	1	1	1	1	16	64	0	1	140
Percent Composition =	9.3%	0.0%	0.0%	17.1%	11.4%	1.4%	0.7%	0.7%	0.7%	0.7%	11.4%	45.7%	0.0%	0.7%	100.0%
Ranking =	5	12	12	2	3	6	7	7	7	7	3	1	12	7	

Table 29
Matsqui Slough Watershed Fisheries Survey Results

Date: October 18, 1993

Weather: overcast, cool most of day

Site	Location	Fish Captured	Notes
1	Wilband Creek at Valley Avenue	2 trout plus stickleback	D.O. 10mg/L. Sand and silt substrate
2	Clayburn Creek at Clayburn Road	Rainbow and Cutthroat abundant, probable chum and coho habitat	Gravel cobble substrate Riffle-pool sequences below Clayburn Road
3	Page Creek. at Beharrell Road	2 juvenile stickleback in plunge pool below adjustable aerator gate	D.O. above gate 0.9 mg/L below gate D.O. 4.4 mg/L
4	Clayburn Creek at Harris Road	A few stickleback	sand silt substrate D.O. 7.1 mg/L
5	Matsqui Slough at Riverside Street	A few stickleback	sand silt substrate, D.O. 5.8 mg/L
6	Matsqui Slough Trib at Riverside Street	No fish captured	Mud/sand substrate, oil slick present along with "dairy odor"

Date : November 24, 1993

Weather: sunny; cold (below 0) - variable wind

Site	Location	Fish Captured	Notes
1	Wilband Creek at Valley Avenue	1 rainbow (10cm), 1 stickleback	D.O. = 11.2mg/L. - T = 1.4 C
2	Clayburn Creek at Clayburn Road	2 cutthroat (1 @ 30+ cm), 3 rainbow, 2 coho juveniles 4-5 chum carcasses ~ 1km d/s Homestead Nursery	D.O. = 14.1mg/L. - T = -1.0 C
3	Page Creek. at Beharrell Road	10+ stickleback, 1 sucker below gate	D.O. above gate at 6.6 mg/L - T = -0.5 C
4	Clayburn Creek at Harris Road	1 stickleback	D.O. = 11.6mg/L. - T = -0.4 C
5	Matsqui Slough at Riverside Street	No fish captured	D.O. = 11.6mg/L. - T = -0.3 C
6	Matsqui Slough Trib at Riverside Street	1 stickleback, 3 suckers	D.O. = 4.8mg/L. - T = 1.0 C oil film under ice

Table 29 - continued **Matsqui Slough Watershed Fisheries Survey Results**

Date : December 15, 1993

Weather: sunny; mild; no wind

Site	Location	Fish Captured	Notes
1	Wilband Creek at Valley Avenue	1 coho pre-smolt 90mm, 1 lamprey 175 mm	D.O. = 8.0mg/L. - T = 9.7 C hi turbidity, hi water level
2	Clayburn Creek at Clayburn Road	2 cutthroat ~75mm, 1 rainbow 100 mm, 2 coho 55-60 mm	D.O. = 7.1mg/L. - T = 12.0 C hi turbidity, hi velocity
3	Page Creek. at Beharrell Road	6 adult + juv stickleback, 1 sm. cyprinid below gate	D.O. = 7.8mg/L. - T = 6.5 C hi turbidity, hi velocity
4	Clayburn Creek at Harris Road	No fish captured (smaller area shocked due to high water)	D.O. = 7.3mg/L. - T = 8.9 C hi turbidity, hi velocity
5	Matsqui Slough at Riverside Street	No fish captured (smaller area shocked due to high water)	D.O. = 7.8mg/L. - T = 8.0 C hi turbidity, hi water level
6	Matsqui Slough Trib at Riverside Street	No fish captured (smaller area shocked due to high water)	D.O. = 7.9mg/L. - T = 7.7 C hi turbidity, hi water level

Date : February 10, 1994

Weather: overcast/drizzle in AM; sunny breaks in PM: no wind; snow on ground

Site	Location	Fish Captured	Notes
1	Wilband Creek at Valley Avenue	1 coho pre-smolt 80mm, 3 stickleback	D.O. = 5.2mg/L. - T = 11.2 C hi turbidity, hi water level
2	Clayburn Creek at Clayburn Road	2 cutthroat 50-70mm, 3 rainbow 60-80mm, 4 coho 60-90mm	D.O. = 2.0mg/L. - T = 12.4 C hi turbidity, hi water level
3	Page Creek. at Beharrell Road	3 CO 70-90mm, 1 redside shiner 70mm, 1 squawfish 50mm, ~15 Stik, ~10 largescale sucker(LSSK)	D.O. = 3.0mg/L. - T = 5.1 C hi turbidity, hi water level
4	Clayburn Creek at Harris Road	3 stickleback	D.O. = 2.5mg/L. - T = 11.8 C hi turbidity, hi water level
5	Matsqui Slough at Riverside Street	2 stickleback	D.O. = 2.3mg/L. - T = 10.4 C hi turbidity, hi water level
6	Matsqui Slough Trib at Riverside Street	2 stickleback, 2 small LSSK, 1 goldfish(?)	D.O. = 6.0mg/L. - T = 4.9 C hi turbidity, hi water level

Table 29 - continued
Matsqui Slough Watershed Fisheries Survey Results

Weather: overcast, calm AM; rain beginning 11:00;
sunny PM (heavy rain earlier in week)

Date : March 3, 1994

Site	Location	Fish Captured	Notes
1	Wilband Creek at Valley Avenue	0 fish; limited area sampled	D.O. = 8.5mg/L. - T = 6.7 C - pH = 6.3 fairly clear; v. hi level (2' above culvert top)
2	Clayburn Creek at Clayburn Road	6 rainbow 60-125mm	D.O. = 8.1mg/L. - T = 12.4 C - pH = 7.3 more turbid than usual, v. high & fast
3	Page Creek. at Beharrell Road	3 stickleback	D.O. = 8.6mg/L. - T = 8.0 C - pH = 6.3 yellowish clear, v. high & fast
4	Clayburn Creek at Harris Road	0 fish; limited area sampled	D.O. = 8.2mg/L. - T = 7.2 C - pH = 6.3 v. turbid, v. high
5	Matsqui Slough at Riverside Street	0 fish; limited area sampled under bridge L bank; oil slick coming from L bank culvert	D.O. = 8.2mg/L. - T = 7.5 C - pH = 6.2 v. turbid, v. high
6	Matsqui Slough Trib at Riverside Street	0 fish; limited area sampled	D.O. = 8.9mg/L. - T = 4.5 C - pH = 6.4 v. turbid, v. high