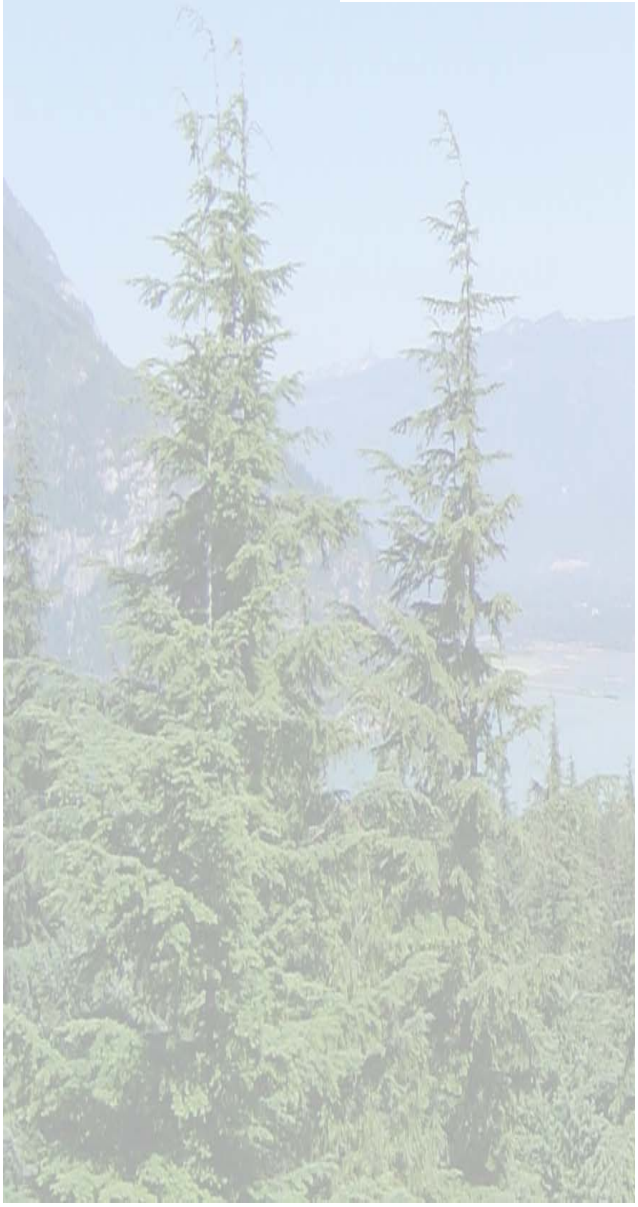
Ministry of Environment

LOWER MAINLAND REGION

Water Quality Assessment of Watercourses Used for Irrigation of Ready-To-Eat Produce in Cloverdale, BC

Summer 2002 – Spring 2004



ENVIRONMENTAL QUALITY

Water Quality Assessment of Watercourses Used for Irrigation of Ready-To-Eat Produce in Cloverdale, BC

Summer 2002 – Spring 2004

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Preface

This report is one in a series of water, groundwater, and air quality reports that are being issued by the Lower Mainland Regional Office in fiscal year 2006/07. It is the intention of the Regional Office to publish water, ground water and air quality reports on our website (http://wlapwww.gov.bc.ca/sry/p2/eq/index.htm) in order to provide the information to industry and local government, other stakeholders and the public at large. By providing such information in a readily understood format, and on an ongoing basis, it is hoped that local environmental quality conditions can be better understood, and better decisions regarding water, groundwater and air quality management can be made.

Acknowledgements

The author would like to thank the following for their considerable contributions:

- The members of the Cloverdale Irrigation Water Quality Committee for their input throughout the project and for their time spent reviewing this report,
- The City of Surrey and the Township of Langley for allowing the use of their mapping layers to generate maps for this report,
- The Community Mapping Network (http://www.shim.bc.ca) for mapping information,
- The Surrey Dyking District staff, the staff of the Vegetable Marketing Commission, and the Cloverdale Irrigation Water Quality Committee members for their assistance with identifying sampling locations,
- The Greater Vancouver Sewerage and Drainage District for supplying rainfall data, and
- Environment Canada for carrying out the bacterial source tracking analysis in 2002 as an in-kind contribution (see appendix 1 for results and discussion on bacterial source tracking).

EXECUTIVE SUMMARY

Background

Numerous studies conducted have demonstrated the extensive health benefits of consuming fruits and vegetables as part of a healthy lifestyle. As awareness of the benefits of fruit and vegetable consumption has grown, so has the understanding of how produce can be a source of food-borne illness under certain conditions. There have been fruit and vegetable associated disease outbreaks documented in many areas of the world. The number of foodborne illness outbreaks associated with fresh fruits and vegetables have increased in Canada over the past several years (CFIA, 2003).

Locally the lowland area of the Serpentine and Nicomekl watersheds, is referred to as the "salad bowl" of British Columbia due to its important role in producing field vegetables for the province.

An outbreak of gastrointestinal illness, traced to consumption of spinach grown in the Cloverdale area occurred in the summer of 2001. In this case, local surface water had been used to wash produce. The water had been contaminated with fecal material containing *Shigella*. As a result of this outbreak and its investigation, a Ready-To-Eat Produce Committee was formed by the BC Centre for Disease Control. (Ready-to-Eat produce are crops that are typically eaten raw by consumers.)

In the summer of 2002 the BC Vegetable Marketing Commission carried out some generic *E. coli* testing in watercourses in and around the Cloverdale fresh produce growing area. This single set of samples gave indications of elevated generic *E. coli* levels in some of the watercourses used to irrigate Ready-to-Eat crops. These results were brought forward to a sub-committee of the Ready-to-Eat Produce Committee, called the Cloverdale Irrigation Water Quality Committee. This committee has representatives from a number of organizations including the Ministry of Agriculture and Lands, the Fraser Health Authority, the Canadian Food Inspection Agency, the BC Centre for Disease Control, Health Canada, the BC Vegetable Marketing Commission and the Ministry of Environment (MoE). The aim of this committee is to work together towards assessing any threats to irrigation water quality in the Cloverdale area.

One of the actions identified by this committee was to have MoE collect a more comprehensive set of water quality samples on the watercourses in Cloverdale used for irrigating Ready-to-Eat produce.

The BC MoE Irrigation Water Criterion (Guideline) for Ready-to-Eat Produce

The BC Ministry of Environment irrigation water criterion for *E.coli* for Ready-to-Eat produce is 77 *E.coli*/100ml, which is based on a swimming water criterion. Currently there is a lack of epidemiological research available to clearly quantify the relationship between irrigation water quality, the potential for produce contamination, and the subsequent risk of disease incidence in consumers. There has not been any data to directly link the MoE criterion of *77 E. coli*/100ml to food borne illness.

Health Canada has provided an opinion that 1000 *E. coli* per 100ml is acceptable for irrigation water used on Ready-to-Eat produce provided that "Good Agricultural Practices (GAPs)" are being followed on farms. However there is a lack of information regarding the extent to which GAPs are being used on farms in Cloverdale. Examples of GAPs include washing produce in potable water and using appropriate irrigation-to-harvest intervals. A number of crops grown in this area are not regulated crops and, as such, there is limited information on agricultural practices on these farms in particular. As a result of this uncertainty, this report assesses water quality results relative to the current Ministry of Environment irrigation water criterion for *E. coli* for Ready-to-Eat produce to provide a gauge for the level at which these watercourses have been impacted by fecal pollution sources, in addition to consideration of the Health Canada opinion level, federal CCME (Canadian Council of Ministers of the Environment) and Manitoba guidelines.

Water Quality Sampling Results

E. coli sampling was carried out in the summers of 2002 and 2003 as well as in the spring of 2004. The monitoring data suggested that the Nicomekl River mainstem, the upstream tributaries to the Nicomekl River and the main Nicomekl tributaries in Cloverdale used for irrigation of Ready-to-Eat produce have all been impacted to varying degrees by non-point source pollution.

Recommendations

Recommendations have been provided in this report although it should be noted that these are Ministry of Environment recommendations. The Cloverdale Irrigation Water Quality Committee and the appropriate Health agencies are ultimately the bodies that will determine whether actions or policy related to irrigation water quality and food safety in this produce growing area are warranted.

The monitoring that has been done during this sampling program indicate that the Nicomekl River mainstem, the upstream tributaries and the three main Cloverdale watercourses used for irrigating Ready-to Eat produce have been impacted to varying degrees by non-point source contamination.

Pro-active steps that the MoE recommends include:

i) improving water quality over the long-term through:
   - sanitary surveys to assess all potential contamination sources (agricultural and non-agricultural),
   - area based planning, and
   - stakeholder involvement.

ii) having industry and the public consistently implement best management practices to minimize the potential for pathogens on produce over the short-term and into the future.

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1.0 INTRODUCTION

1.1 Goals and Organization of this Report

The goal of this report is to present the results of the Ministry of Environment *E.coli* sampling undertaken from July to September 2002, August to September 2003, and in March 2004. The report provides the results of bacterial source tracking analyses carried from 2002 to 2004. This bacterial source tracking information is included in the appendix of the report.

The discussion of results is broken down into the following geographical units:

- Upstream tributaries to the Nicomekl River,
- The Nicomekl mainstem through the City of Langley and Cloverdale,
- Cloverdale Tributaries to the Nicomekl River

Following background information sections, the Results section reviews the *E. coli* results relative to the BC MoE, CCME (Canadian Council of Ministers of the Environment), and Manitoba irrigation water criteria for crops eaten raw. The results are also reviewed relative to a Health Canada opinion paper level of 1000 *E.coli*/100ml. There is a discussion of spatial and temporal trends in the data using the BC MoE criterion as a reference threshold and a discussion of the results relative to precipitation. Recommendations are also included.

1.2 Water Quality Issues and the Initiation of a Sampling Program

The City of Surrey is an important agricultural area, with approximately one-third of its land zoned for agricultural use (Zytaruk, 2002). The lowland area of the Serpentine and Nicomekl watersheds is often referred to as the "salad bowl" of BC due to its important role in producing field vegetables for the province (Odermatt, 1997). In a workshop held in 1997, the Provincial Potato and Fresh Vegetable Specialist from the Ministry of Agriculture, Fisheries and Food estimated that in the lowlands the total annual value of agricultural production was in the order of $63.2 million with vegetable crops representing the largest contribution at approximately $22 million (Odermatt, 1997). Since these estimates were made and even since the most recent census data was collected there may have been some changes in terms of crop values in the lowlands. Berry production may have increased, while there have been some declines in field vegetable production (Smith, 2005). Figure 1 shows a field vegetable crop being grown in the Nicomekl lowlands.

Figure 1. Lettuce crop being grown in the Nicomekl Watershed

In June of 2002 the BC Vegetable Marketing Commission carried out some limited water quality testing in watercourses in and around the main vegetable growing area in Cloverdale. This water

quality sampling gave indications of elevated levels of the bacteria, *Escherichia coli (E. coli)*, in watercourses that provide water for irrigation of vegetable and berry crops.

E. coli is a bacteria that lives in the gut of mammals and its presence in the environment is a strong indicator of mammalian fecal pollution. Fecal pollution can come from manure on agricultural lands, leakage from septic systems, sanitary sewer line malfunctions, or wildlife. *E. coli* serves as a good indicator of fecal bacterial pathogens that can cause gastrointestinal disease. However, *E. coli* is of less value as an indicator organism for viruses and protozoa that can also cause gastrointestinal illness.

When irrigation waters or produce wash waters are polluted with fecal material there is an increased risk of pathogens contaminating the produce that is being sold to consumers. This occurred in the 2001 growing season when a serious outbreak of gastrointestinal illness was traced back to spinach from a farm in the Nicomekl lowlands. In this case the wash water used to rinse the spinach was contaminated.

Irrigation water contamination is of particular concern for "Ready-To-Eat" crops that are routinely eaten raw. These "Ready-To-Eat" crops include such vegetables as lettuce, spinach, cabbage, strawberries, cauliflower, broccoli and fresh herbs.

Pathogens may survive on produce where the plant's physical characteristics provide refuge from environmental conditions or when the producer/processor or consumer does not wash produce thoroughly in potable water. Irrigation water containing pathogens can enter the heads of salad greens from overhead irrigation and the pathogens can be concentrated there in the moist core, protected from UV light and environmental conditions (Warrington, 1988).

Since Cloverdale is a key area for production of Ready-To-Eat produce, the elevated generic *E. coli* levels were of concern. The results were brought forward to a multi-agency round table group to review the sampling information and identify a course of action. The Cloverdale Irrigation Water Quality Committee has representatives from the BC Centre for Disease Control, the Canadian Food Inspection Agency, the Fraser Health Authority, Health Canada, the Ministry of Agriculture and Lands, the BC Vegetable Marketing Commission and the Ministry of Environment (MoE).

One of the actions identified by the Committee was to carry out more intensive sampling during the remainder of the 2002 growing season to better characterize the *E. coli* levels in:

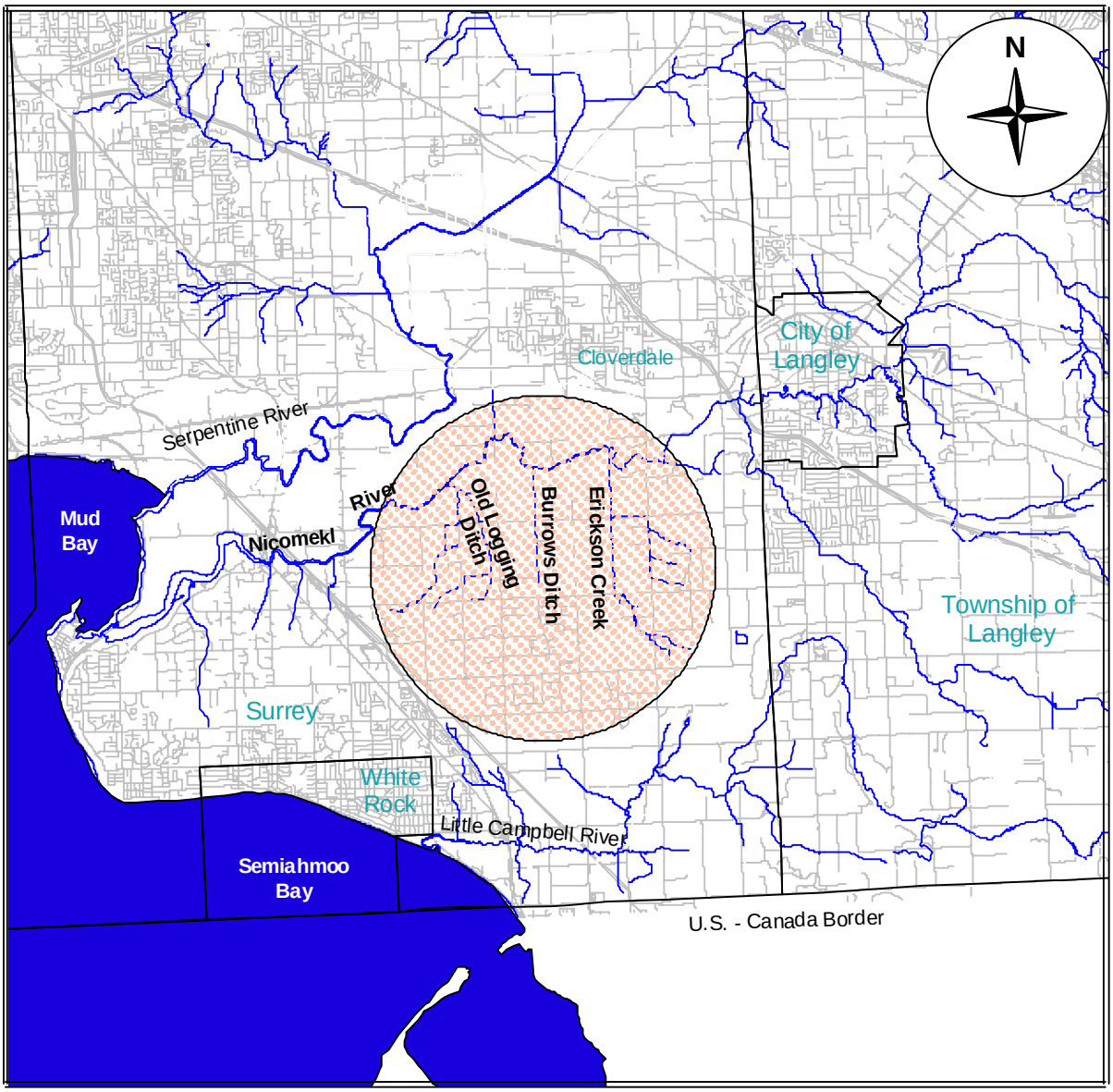
1) Cloverdale watercourses being used for irrigation of Ready-To-Eat crops,
2) the Nicomekl River that provides pumped water to these systems and
3) selected upstream tributaries to the Nicomekl River in the City of Langley.

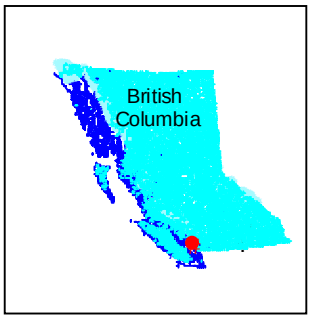
The Ready-to-Eat produce growing area of interest extracts its irrigation water primarily from watercourses of the Nicomekl watershed. Figure 2 shows the location of the Nicomekl River and the Cloverdale irrigation water study area.

This water quality sampling was designed to assist in identifying:

- pollution "hot spots" where *E. coli* levels are in excess of criteria, and
- type of fecal pollution present, through Environment Canada's bacterial source tracking analysis on a preliminary number of samples.

The monitoring that was carried out in 2003 and 2004 focused on the sites where *E. coli* levels had exceeded the BC MoE "Ready-To-Eat" irrigation water criterion in the 2002 sampling, and where further bacterial source tracking information would be helpful. Figure 3, 4 and 5 show the location of the sites. Table 1 provides a description for the sites and identifies when each site was sampled.



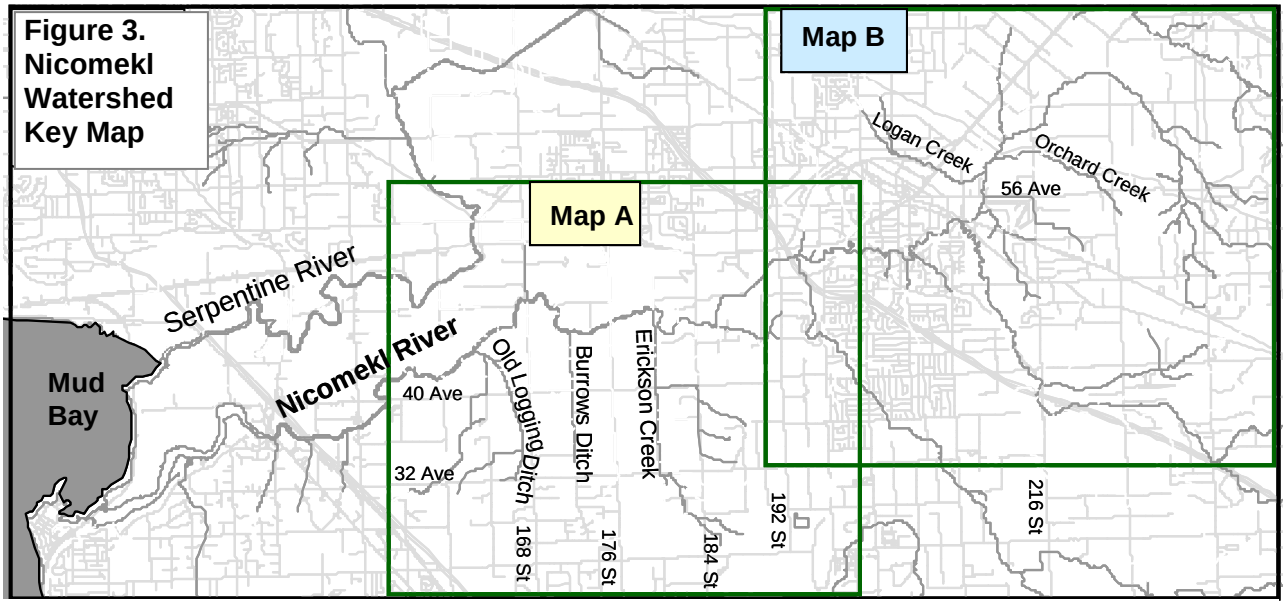


Legend

- Local Government Boundaries and U.S. - Canada Border
- Watercourses
- Road ways

2 0 2 Kilometers

Figure 2. Location of Nicomekl River and Irrigation Water Study Area



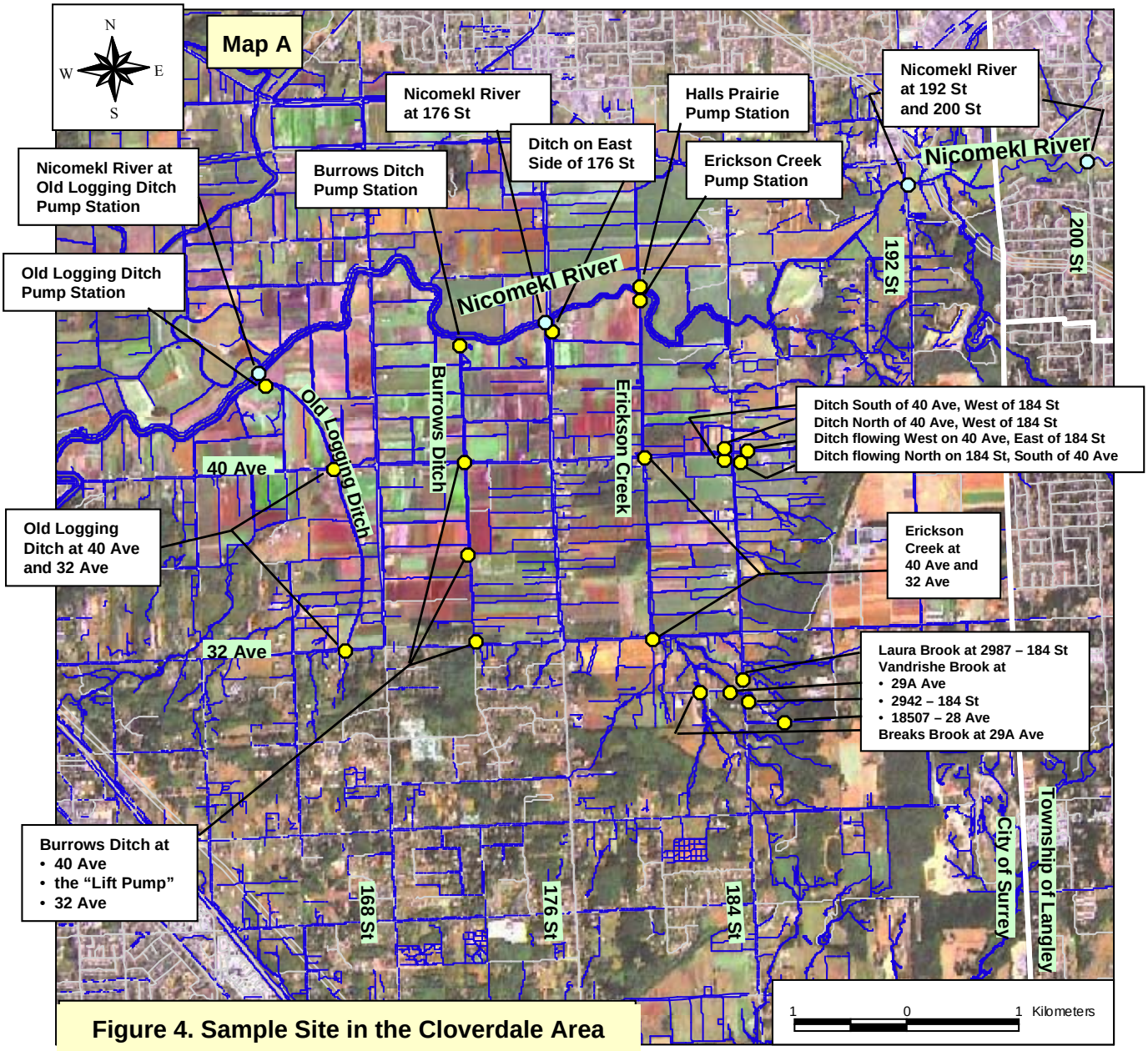


Figure 4. Sample Site in the Cloverdale Area

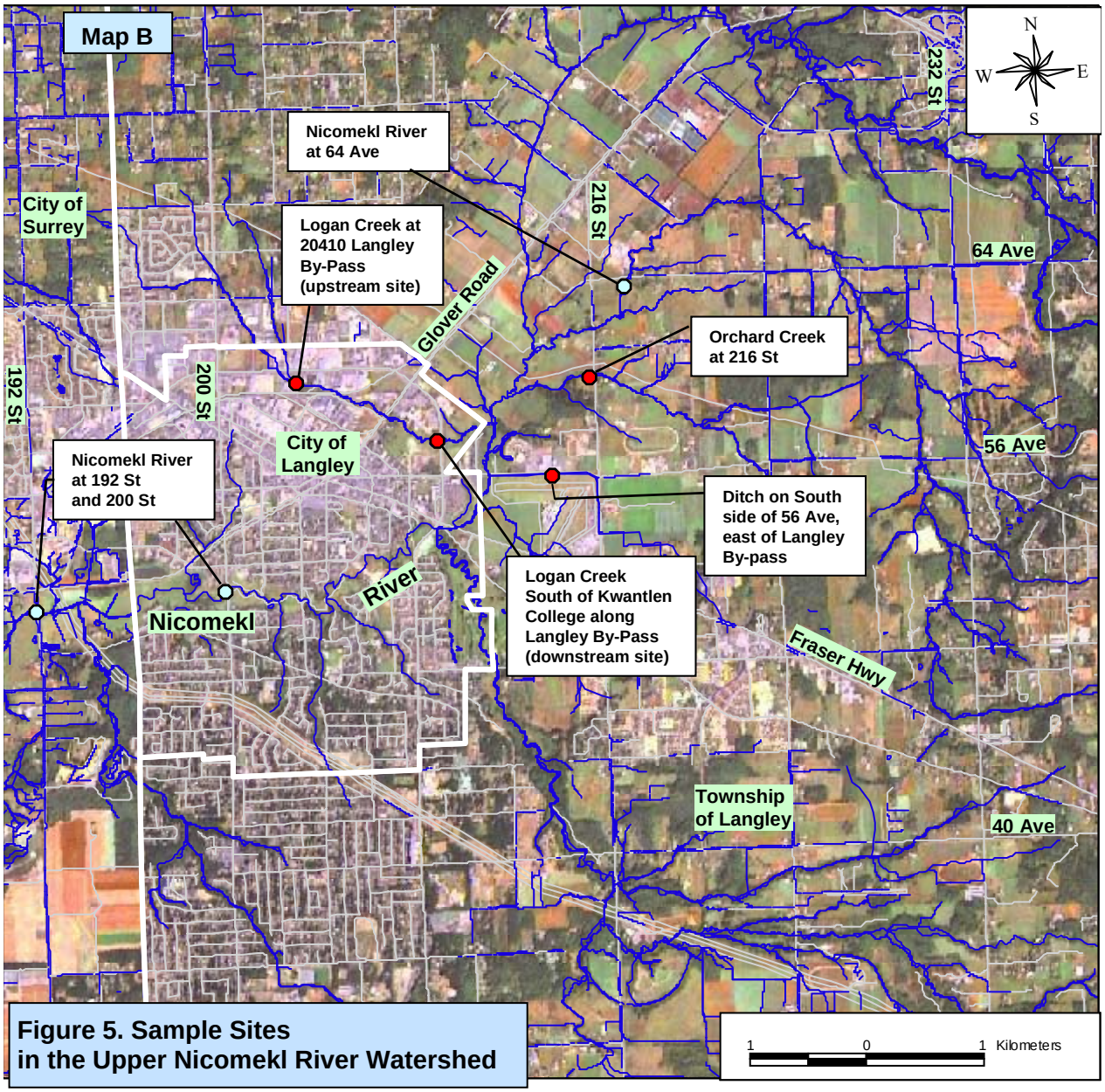


Figure 5. Sample Sites in the Upper Nicomekl River Watershed

Legend

- Sample sites on Upper Nicomekl River Tributaries
- Sample sites on Nicomekl River Mainstem
- Sample sites on Cloverdale tributaries to the Nicomekl River
- Municipal Government Boundaries
- Watercourses (combined water layers from DFO fish presence, City of Surrey watercourse mapping and Township of Langley watercourse mapping)
- Roads

Table 1. Site Locations for 2002, 2003 and 2004 Water Quality Sampling

Site Locations	Summer 2002 *E. coli* sampling	Summer 2003 *E. coli* sampling	Spring 2004 *E. coli* sampling	Summer 2002 Bacterial Source Tracking *	Summer 2003 Bacterial Source Tracking *	Spring 2004 Bacterial Source Tracking *	EMS ID
Upper Nicomekl River Tributaries							
Logan Creek at 20410 Langley By-Pass (upstream site)	n= 5			n=1			
Logan Creek south of Kwantlen College along the Langley Bypass (downstream site)	n= 5						
Orchard Creek at 216th Street	n= 5			n=1			
Ditch on the South Side of 56 Ave, east of the Langley Bypass	n= 5			n=1			
Nicomekl River Mainstem							
Nicomekl River at 64 Ave	n= 4			n=1			
Nicomekl River at 200 St	n= 5	n= 5	n= 5	n=1	n= 4	n= 3	E207022
Nicomekl River at 192 St	n= 5			n=1			
Nicomekl River at 176 St	n=14			n=1			
Nicomekl River at Old Logging Ditch Pump Station	n= 5						
Cloverdale Tributaries to the Nicomekl River							
Halls Prairie Pump station	n= 5			n=1			
Ditch on East Side of 176 St, South of Nicomekl River	n= 5						
Old Logging Ditch at Pump Station	n=13						
Old Logging Ditch at 40 Ave	n= 5						
Old Logging Ditch at 32 Ave	n=14			n=1			
Burrows Ditch at Pump Station	n=14						
Burrows Ditch at 40 Ave	n=14	n= 5	n= 5		n= 4	n= 3	E253251
Burrows Ditch at the Lift Pump	n=13	n= 5	n= 5	n=1	n= 4	n= 3	E253250
Burrows Ditch at 32 Ave		n= 5	n= 5		n= 4	n= 3	E253249
Erickson Creek at the Pump Station	n=14	n= 5	n= 5		n= 3	n= 3	
Erickson Creek at 40 Ave	n=15	n= 5	n= 5	n=1	n= 3	n= 3	E253253
Erickson Creek at 32 Ave	n=14	n= 5	n= 5	n=1	n= 3	n= 3	E253254
Vandrishe Brook at 29A Ave	n= 9	n= 5	n= 5		n= 3	n= 3	E253255
Vandrishe Brook at 2942 – 184 St	n= 3						
Vandrishe Brook at 18507 – 28 Ave	n= 3						
Laura Brook at 2987 – 184 St	n= 9						
Breaks Brook at 29A Ave	n= 6						
Ditch Flowing North on 184 St, South of 40 Ave	n=10						
Ditch Flowing West on 40th Ave, East of 184 St	n= 9						
Ditch North of 40 Ave, West of 184 St		n= 5	n= 5		n= 3	n= 3	E253256
Ditch South of 40 Ave, West of 184 St		n= 5	n= 5		n= 3	n= 3	E253257

Shading indicates site has been sampled. Number indicates umber of times site was sampled. * For BST results see Appendix 1

1.3 *E. coli* use as an Indicator Organism

When water is contaminated with fecal material it can carry an array of pathogens including bacteria, viruses, fungi, protozoa and parasitic worms. In most cases it is too difficult or expensive to test for all the disease-causing organisms. A practical method of assessing the level of contamination is to choose one type of organism as an "indicator" of the presence of specific pathogens.

Warrington (1999) states in his technical report " Water Quality Criteria for Microbial Indicators", that:

> **"**to be acceptable as an indicator of the microbiological quality of water an indicator should satisfy the following ideal requirements:
>
> - be present when pathogens are present and absent when pathogens are absent, and
> - occur in a constant ratio to the pathogen,
> - be consistently and exclusively associated with the source or sources of pollution at a higher concentration than the pathogens,
> - be present in sufficient numbers to give a good density estimate of those pathogens present at unacceptably high risk levels,
> - behave very much like the pathogens with regard to natural and man-made components of the environment which might tend to affect pathogen densities, and be non-pathogenic,
> - be easily, accurately, precisely and economically quantifiable and not subject to false positive tests.**"**

Historically the coliform group of bacteria has been used as an indicator of gastrointestinal disease-causing organisms originating from fecal material. However this large and varied group of bacteria includes species that can originate from sources other than fecal material. The test for the "Fecal Coliform" subgroup of bacteria detects primarily *Escherichia coli (E. coli*), but it also detects *Klebsiella* and occasionally other genera. *Klebsiella* counts can be high in watercourses receiving effluent from food, dairy, and pulp and paper mills giving a positive fecal coliform count when fecal contamination may not be present (Warrington, 1988). In addition, *Klebsiella* and other coliforms such as *Enterobacter* may persist and grow in water rich in organic material (Health Canada, 1991).

E. coli makes up 90 – 96% of total coliforms in human fecal matter (Warrington, 1988) and in the average cow feces there are around 2.2×10^9 *E. coli*/g out of a total of 2.9×10^9 total coliforms/g (Warrington, 1990). *E. coli* is generally the most predominant coliform in warm-blooded animal intestines (Health Canada, 1991).

For sampling fresh water suspected to be contaminated with fecal material, generic *E. coli* is being used increasingly as the favored indicator of bacterial pathogens that can cause gastrointestinal disease. The United States Environmental Protection Agency (US EPA, 1986) has recommended that *E. coli* be used for monitoring freshwater bathing beaches instead of fecal coliforms. *E. coli* levels correlate better to bacterial gastrointestinal disease-causing pathogens in fresh water than do fecal coliform levels.

During this 2002 to 2004 Cloverdale study, generic *E. coli* was used as an "indicator" of gastrointestinal disease-causing pathogens. Although *E. coli* is considered a good "indicator" of bacterial pathogens that cause gastrointestinal illness, it should be recognized that *E. coli* may not be an appropriate indicator of viruses and protozoa that can cause gastrointestinal illness or of pathogens that cause other types of disease.

1.4 Water Quality Criteria and Objectives for *E. coli*

"Approved Water Quality Guidelines", which can also be called "Criteria", are developed at both the Federal and Provincial levels. Canadian Environmental Quality Guidelines are produced by the Canadian Council of Ministers of the Environment (CCME), which is made up of environmental ministers from the Federal, Provincial and Territorial governments. Health Canada and Environment Canada are the federal government departments that provide technical support to working groups developing guidelines for the CCME. These Canadian Environmental Quality Guidelines apply throughout the country and relate to water uses such as drinking water, recreation, aquatic life and agricultural use.

In BC the Ministry of Environment (MoE) develops criteria (guidelines) for priority substances for the protection of a variety of water uses. These water uses include drinking water, aquatic life, recreation and agricultural uses. The MoE criteria apply throughout B.C. and they provide a starting point for developing Water Quality Objectives. Water Quality Objectives are area specific guidelines that are developed based on Provincial and Federal criteria/guidelines, and local conditions.

Criteria and Objectives provide benchmarks for assessing water quality and they represent safe levels of substances for various water uses. Generally water quality for a particular parameter (e.g. nitrate) is not considered a problem for a specific water use (e.g. aquatic life) if the concentration of that substance is lower than the criteria or appropriate local objective for that water use.

The BC MoE criterion for irrigation of crops eaten raw is 77 E. coli/100ml. The "crops eaten raw", or Ready-to-Eat criterion, refers to water used for sub-surface, surface or spray irrigation of produce that may be eaten raw, which may not be adequately washed or processed sufficiently to kill pathogens (Warrington, 1988).

The background on the current BC MoE criterion is detailed in the following two documents:

> Ministry of Environment and Parks. 1988. Water Quality Criteria for Microbiological Indicators: Overview Report. Water Management Branch. Government of BC. Available on the web at: http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/microbiology.html
>
> Warrington, P.D. 1988. Water Quality Criteria for Microbiological Indicators: Technical Appendix. Ministry of Environment and Parks. Province of British Columbia. Available on the web at: http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/microbiologytech.pdf

The BC MoE criterion is based on a geometric mean, rather than a standard mean. Since microbes tend to be associated with particulate material, it is possible to have clumps of bacteria collected, which can lead to higher variability in the data. The geometric mean is used because it dampens the influence of individual high or low values. It is calculated by multiplying together a minimum of 5 individual bacterial sample results collected over a 30 day period and then taking the n^{th} root of this value. The formula for the geometric mean is shown below:

$$GM_{\bar{y}} = \sqrt[n]{y_1 y_2 y_3 \ldots y_n}$$

Where n is the number of dates sampled,
y_1 is the first sampling result,
y_2 is the second sampling result….

When water quality criteria are being developed a literature search is carried out to assess information on topics such as the substance's acute and chronic toxicity, mode of toxic action, and environmental behaviour (MELP, 1995). Information from other jurisdictions is also assessed; and at times, additional testing may also be carried out.

When the "crops eaten raw" criterion was developed it was felt that, ideally, water used for this purpose should meet drinking water criteria. There is the potential for pathogens in the irrigation water to collect on the plant, survive, and be ingested along with the produce. However, at the time the criterion was set there was limited epidemiological research to quantify the relationship between irrigation water quality, produce contamination and the potential for disease outbreaks. As a result a primary-contact (swimming) recreation criterion was adopted for the "crops eaten raw" criteria (Warrington, 1988). The primary-contact recreation criterion was developed for swimming, diving, wading and water sports where submergence may occur. While the need for a guideline is evident, there has not been any data to directly link the specific MoE criterion of 77 *E.coli*/100ml to foodborne illness.

In terms of guidelines for irrigation of Ready-to-Eat produce there is still uncertainty about the relationship between irrigation water quality, the potential for produce contamination and the subsequent risk of disease in consumers. Table 2a provides a summary of surface irrigation water guidelines for crops that are eaten raw. Table 2b provides a summary of guidelines and standards from other jurisdictions for wastewater re-use for irrigation of crops that are eaten raw. They provide some indication of the variance that exists in guidelines (criteria) for this water use and also allow for a comparative assessment of the MoE guideline.

Health Canada has provided an opinion that 1000 E. coli/100ml is acceptable for irrigation water used on Ready-to-Eat produce provided that "Good Agricultural Practices (GAPs)" are being followed on farms and by processors. However there is a lack of information regarding the extent to which these GAPs are being used on farms in Cloverdale. A number of crops grown in this area are non-regulated crops (for example: zucchini, field lettuce, herbs) and, as such, there is limited information on agricultural practices on these farms in particular.

As a result of this uncertainty, this report assesses water quality results relative to the current BC MoE irrigation water criterion for *E.coli* for Ready-to-Eat produce to provide a gauge for the level at which these watercourses have been impacted by fecal pollution sources. The water quality results have also been assessed relative to the Health Canada opinion level as well as the federal CCME (Canadian Council of Ministers of the Environment) guideline for irrigation of crops that are eaten raw and the Manitoba surface water greenhouse irrigation guideline. These guidelines/opinion levels were selected from Table 2a since they are *E. coli* levels and the data available is *E.coli* data, rather than fecal coliform data. Regardless of guideline selected, it should be noted that the relationship between guideline level and epidemiological data has not been well established or is not available. The need for a guideline is apparent, and it may be necessary to amend the guideline as more scientific information becomes available.

Table 2A & B. Guidelines for Irrigation of Vegetable Crops with Surface Water (A) & Wastewater (B)

Table 2a: Guidelines for Irrigation of Vegetable Crops with Surface Water		**Irrigation with Surface Water CR – Crops Eaten Raw GI – General Irrigation**		
Location	**Statement and Conditions**	**E. coli**	**Fecal Coliforms**	**Reference**
British Columbia	Water used for sub-surface, surface or spray irrigation of produce which may be eaten raw, cannot be adequately washed or is not processed sufficiently to kill pathogens: • Fecal coliform level should not exceed 200/100ml as a geometric mean calculated from at least 5 samples in a 30-day period. • *E. coli* level should not exceed 77/100ml as a geometric mean calculated from at least 5 samples in a 30-day period. Water used to irrigate areas where there is no public or livestock access and the crops are not eaten raw – fecal coliform or E. coli level should not exceed 1000/100ml as a geometric mean calculated from at least 5 samples in a 30-day period.	(CR) 77/100ml geometric mean (GI) 1000/100ml geometric mean	(CR) 200/100ml geometric mean (GI) 1000/100ml geometric mean	(Ministry of Environment and Parks, 1988)
Alberta	For vegetable crop irrigation, a geometric mean of not less than five samples taken over not more than a 30-day period should not exceed 1000 organisms per 100ml for total coliforms, nor 200 organisms per 100ml for fecal coliforms, nor exceed these numbers in more than 20 percent of samples examined during any month, nor exceed 2400 organisms per 100 ml total coliforms on any day.		(CR) 200/100ml and not to exceed this number in more than 20% of samples	(Science and Standards Branch, 1999)
Saskatchewan	These levels are specifically intended to afford protection of consumers of raw fruits and vegetables irrigated with surface waters. Higher levels of bacteria may be acceptable for irrigation of crop species which are utilized for livestock feed or which undergo extensive processing or cooking prior to consumption.		(CR) 100/100ml	SERM, 1997
Manitoba	Surface water for greenhouse irrigation of fruits and vegetables, including those that may be eaten raw. Refers to all periods when greenhouse irrigation is likely to occur and when workers or the public may come in contact with irrigation water.	(CR) 200/100 ml fecal coliform or E. coli	(CR) 200/100 ml fecal coliform or E. coli	(Williamson , 2002; Armstrong, 2005)
CCME (Canadian Council of Ministers of the Environment - National guidelines)	Maximum concentrations of 100 fecal coliforms (E.coli)/100ml and 1000 total coliform bacteria per 100ml in irrigation water from surface water. These guidelines are considered tentative in light of discussions on the use of appropriate indicator organisms and concerns are resolved regarding consumption of raw produce which has been irrigated with water containing microbiological agents.	(CR and GI) 100/100ml fecal coliforms or *E. coli*	(CR and GI) 100/100ml *f*ecal coliforms or *E. coli*	(CCREM, 1987)
Health Canada (**opinion paper**)	Provided that Good Agricultural Practices (GAPs) are being consistently followed by fruit and vegetable producers	(CR) 1000/100ml		Oudit, 2003.
United States (US EPA)	This guideline appears to be based on the detection of pathogens in river water from field studies at the time the guideline was set.		1000/100ml geometric mean	(US EPA, 1972)
Alaska	For crops eaten raw, the geometric mean of samples taken in a 30-day period may not exceed 20 FC/100ml and not more than 10% of the samples may exceed 40 FC/100ml. For general irrigation and stock watering, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100ml, and not more than 10% of the samples may exceed 400 FC/100ml.		(CR) 20/100ml geometric mean (+ no more than 10% may exceed 40/100ml) (GI) 200/100ml geometric mean (+ no more than 10% may exceed 400/100ml)	(DEC, 2003)
Australia and New Zealand	Raw human food crops in direct contact with irrigation water (e.g. via sprays, irrigation of salad vegetables) <10 fecal coliforms/100ml. Raw human food crops not in direct contact with irrigation water (edible product separated from contact with water e.g. by peel, use of trickle irrigation); or crops sold to consumers cooked or processed <1000 fecal coliforms/100ml. Median value of fecal coliforms should be used, based on a number of readings from a regular monitoring program. Investigations of likely causes are warranted when 20% of results exceed four times the median guideline value.		<10/100ml for crops in direct contact with irrigation water (e.g. spray irrigation of salad vegetables) <1000/100ml for crops not in direct contact with irrigation water.	(ANZECC and ARMCANZ, 2000a)

Table 2b: Guidelines for Ready-to-Eat crop Irrigation with Wastewater

Jurisdiction	Statement and Conditions	Irrigation with Wastewater – Crops Eaten Raw: Fecal Coliforms	Irrigation with Wastewater – Crops Eaten Raw: Treatment Requirements	Reference
British Columbia	For crops that are eaten raw, reclaimed water to be used for irrigation must have: • a median value of less than or equal to 2.2 fecal coliforms/100ml as determined from the bacteriological results of the last 7 samples for which analysis have been completed, and • must not exceed 14 fecal coliforms/100ml in any sample. See the Environmental Management Act, Municipal Sewage Regulation for the official and full requirements for treatment, effluent quality, and monitoring for use of reclaimed water on food crops eaten raw.	2.2/100ml median and 14/100ml single maximum	Secondary treatment, chemical addition, filtration, disinfection and emergency storage as per Municipal Sewage Regulation	(BC MWLAP, 1999)
Alberta	Only certain crops can be irrigated with municipal wastewater. The authorized crops include only forages, coarse grains, turf and oil seeds. Any other crops to be considered must be supported by scientific studies that ensure there are no associated human health risks. The treatment effluent quality standard for fecal coliform for wastewater irrigation is less than 200/100ml calculated as a geometric mean of weekly or daily samples in a calendar month, depending on whether storage is provided. This fecal coliform standard applies to golf courses and parks only.	See Note in Statements and Conditions		(Alberta Environment, 2000)
United States (US EPA)	The guideline for agricultural reuse for food crops not commercially processed where surface or spray irrigation is used on any food crop, including crops eaten raw is no detectable fecal coliforms/100ml. This would be a median value determined from the bacteriological results of the last 7 days for which analysis have been completed. The number of fecal coliform organisms should not exceed 14/100ml in any sample. Note: Over 20 States have regulations or guidelines for wastewater reuse in irrigation. A number of these do not allow the use of spray irrigation on crops that will be eaten raw. The document listed in the reference column provides a full summary of the requirements in each state.	No detectable fecal coliforms/100ml Median value 14/100ml single maximum	Secondary, Filtration, Disinfection	(USEPA and USAID, 2004)
Australia and New Zealand	Raw human food crops in direct contact with reclaimed water (e.g. via sprays, irrigation of salad vegetables) <10 fecal coliforms/100ml median value. Raw human food crops not in direct contact with reclaimed water (edible product separated from contact with water e.g. by peel, use of trickle irrigation); or crops sold to consumers cooked or processed <1000 fecal coliforms/100ml median value.	<10/100ml for crops in direct contact with irrigation water (e.g. spray irrigation of salad vegetables) <1000/100ml for crops not in direct contact with irrigation water.	A high level of treatment is required for crops consumed raw, compared with lower level contact applications such as fodder and horticulture. For direct contact of water with crops consumed raw - tertiary treatment with pathogen reduction. For no direct contact of water with crops - secondary treatment with pathogen reduction.	(ANZECC and ARMCANZ, 2000b)
World Health Organization	Irrigation of crops likely to be eaten uncooked	1000/100ml	A series of stabilization ponds designed to achieve the microbiological quality indicated or equivalent treatment.	(Blumenthal et al., 2000a)
France	Adopted recommendations similar to WHO, with analogous categories and microbioligcal guidelines, but included additonal rules of application. The bacteriological guideline must be met and the irrigation techniques used must avoid wetting of fruit and vegetables.	1000/100ml See note on irrigation techniques		(Blumenthal et al,, 2000b)

2.0 OVERVIEW OF THE STUDY AREA

2.1 Drainage Features

The three main watercourses that are used for irrigation of Ready-To-Eat produce in lowland areas around Cloverdale are shown in Figure 2. Old Logging Ditch, Burrows Ditch, and Erickson Creek are tributaries to the Nicomekl River.

The Nicomekl River is a low gradient system that originates in the Township of Langley and flows down a shallow plateau to the lowland areas and then out to Mud Bay which is part of the larger Boundary Bay ecosystem. This 33 km long river drains an area of 175.2 km^2 and has a mean annual flow of 3.47m^3/s (Fisheries and Oceans, 1999).

Historically the Serpentine-Nicomekl lowlands were a broad estuarine floodplain (Peace Arch News, 1998). This flat area was subject to tides and formed part of Mud Bay. Since settlement, significant drainage alteration work has been conducted in this area, including draining the natural tidal marsh for agriculture (Peace Arch News, 1998), and installing dykes and a sea dam at the mouth of the Nicomekl River to prevent salt water from flowing upstream during high tide and to protect against flooding. The Nicomekl River mainstem has been dyked up to east of 192 Street in Surrey, and flow control structures have been installed on tributaries to the mainstem within this dyked length.

The main Nicomekl River tributaries used for irrigation of Ready-To-Eat produce in Cloverdale have drainage control structures in place at their mouths. Pump stations at the mouth move tributary water through the dyke to the Nicomekl mainstem when tributary water levels are considered to be too high. During the growing season irrigation pumps, located at the mouth of these tributaries, pull water from the Nicomekl mainstem into the tributaries. Smaller pump stations along the edges of these tributary watercourses are used to draw water for irrigating adjacent crops.

2.2 Biological Resources

In addition to irrigating crops, waters of the Nicomekl River and its many tributaries provide habitat for a number of fish species including cutthroat trout and coho salmon populations. However drainage control structures, water quality conditions and habitat alterations create increased stress on these species. In the past there were a number of recorded fish kills in the autumn related to low dissolved oxygen levels in the Nicomekl mainstem. These low dissolved oxygen levels were likely indirectly due to high nutrient loading from agricultural runoff and other sources. Coupled with increased temperature and sunlight, these nutrient inputs have supported heavy algal blooms in the mainstem. In late summer and early fall, low dissolved oxygen conditions can develop when oxygen is consumed during the decomposition of algal blooms. This situation can be aggravated by the tidally controlled sea dam, which can inhibit flushing. An extension of warm temperatures into the fall period can reduce the amount of oxygen dissolved in the river water, and further exacerbate the problem, at a time when spawning coho salmon are entering the river.

Erickson Creek, Burrows Ditch and Old Logging Ditch are all considered to be “fish bearing” watercourses. These watercourses have been channelized and along most of their length native stream-side vegetation has been removed. Around 32 Avenue there are small sections of Erickson Creek and Old Logging ditch where the channel is in a more natural condition. Salmonids have been observed in Erickson Creek during the time of this water quality sampling program, particularly at 32 Avenue.

In addition to supporting fish populations, the Nicomekl lowlands also provides habitat for many birds including great blue herons, a variety of raptors, waterfowl and song birds. Water from tributaries in the Nicomekl watershed feed the Nicomekl mainstem which in turn feeds Boundary Bay, an internationally important bird habitat on the Pacific Flyway.

Boundary Bay and its smaller basins, Mud Bay, Semiahmoo Bay and Drayton Harbor, support a diverse array of flora and fauna including eelgrass, shellfish and herring. The mouth of the Nicomekl River is home to the last known bed of native Pacific oysters in North America (Fisheries and Oceans, 1999). Concerns about water quality in Boundary Bay have prompted the formation of a US-Canada “Shared Waters” committee (the Transboundary Watershed Alliance, formerly Shared Waters Roundtable) under the former Georgia Basin Action Plan, to work towards improved water quality. Shellfish harvesting has been closed in Boundary Bay, Mud Bay and Semiahmoo Bay in Canadian waters due to high fecal coliform counts. Historically Boundary Bay contributed over 50% of British Columbia’s annual commercial oyster harvest. On the American side of the border, there has been a recent re-classification to provide for a conditional re-opening of shellfish harvesting in portions of Drayton Harbor, following extensive efforts by local groups to reduce sources of fecal contamination to the harbor.

While the primary focus of this study was to collect data related to Ready-to-Eat produce irrigation water quality, results showing elevated *E. coli* levels in the Nicomekl watershed would be of concern in the larger context of Boundary Bay as well, and would add to the need for actions to improve water quality.

2.3 Anthropogenic Land and Water Use

Figure 6. Examples of Agricultural Land Uses in the Nicomekl Watershed

Agriculture is the dominant land use in the Nicomekl watershed, occurring on 69% of the basin area (Fisheries and Oceans, 1999). In the Township of Langley, the headwaters of the Nicomekl River flow through agricultural areas. Land uses in the City of Langley are predominantly urban, but as the river exits the City the surrounding land use returns to agriculture in the lowland areas.

Figure 6 shows some of the agricultural land uses in the Nicomekl watershed. Agricultural land classifications for the Nicomekl watershed are shown in Figure 7. Figure 8 provides an aerial view of the area.

In the upper watershed, in the Township of Langley, land classifications indicate that agricultural land uses are dominated by "extensive livestock"* operations, forage or pasture, and nursery or tree farms. In the Cloverdale area, as shown in Figure 7, the agricultural land uses appear to be primarily field vegetables and berries, with some dairy and "extensive livestock"* operations.

The Old Logging Ditch basin appears to be dominated by field vegetable production, while the Burrows drainage contains a mix of field vegetable production, berry production, and some livestock operations. The Erickson Creek drainage is a patchwork of agricultural land uses that include field vegetables, forage, pasture, dairy, "extensive livestock"* and "intensive livestock"* operations.

Anthropogenic water uses in the Nicomekl Watershed include irrigation and livestock watering in agricultural areas. In Boundary Bay, which the Nicomekl River feeds into, water is heavily used for recreational boating and swimming during summer months. Boundary Bay, Mud Bay and Semiahmoo Bay were historically used for shellfish harvesting but have been closed to harvesting since 1962 due to high fecal coliform counts. Illegal shellfish harvesting has been known to occur in these waters despite health warnings.

* Intensive livestock operations refer to livestock that are exclusively raised inside an animal housing structure (e.g. poultry, swine, duck, fur and rabbit farms). Extensive livestock operations have active animal housing facilities, but livestock are not permanently confined in barns. Extensive livestock operations generally have one or more of (but not limited to) the following varieties of livestock: dairy cattle, dry cows, beef cattle, horses, sheep and goats.

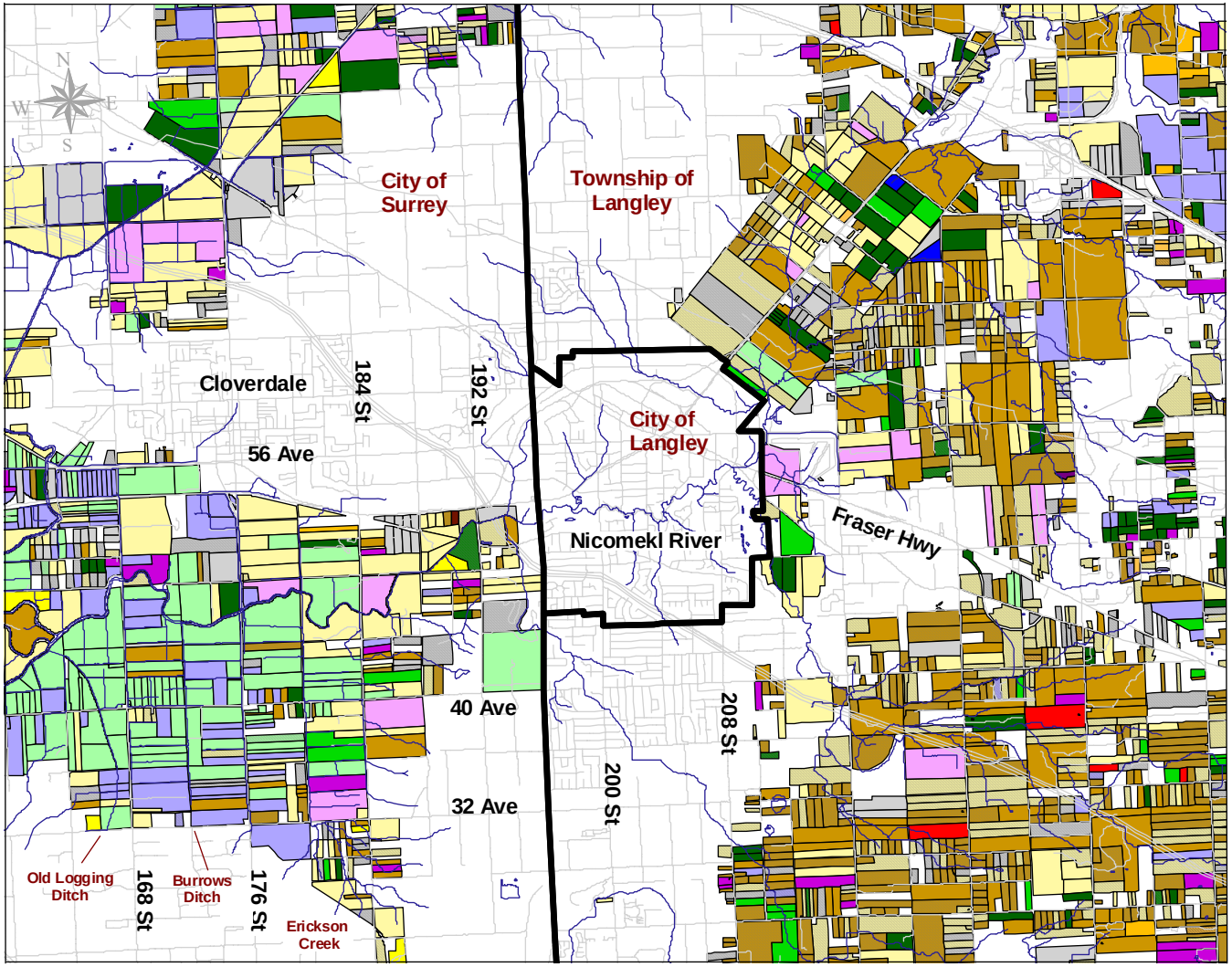


Figure 7. City of Surrey and Township of Langley Agricultural Land Use Classification Maps for the Nicomekl Watershed

City of Surrey and Township of Langley - Agricultural Use

- Berries or vineyard
- Field vegetables
- Field flowers
- Nursery or tree farm
- Cultivated or fallow
- Forage or pasture
- Extensive livestock
- Feedlot
- Stable/riding facility
- Dairy
- Intensive livestock
- Freshwater aquaculture
- Greenhouse operation
- Miscellaneous agriculture
- Mushroom farm
- Unused farm land
- secondary use - Berries or vineyard
- secondary use - Field vegetables
- secondary use - Field flowers
- secondary use - Nursery or tree farm
- secondary use - Cultivated or fallow
- secondary use - Forage or pasture
- secondary use - Extensive livestock
- secondary use - Dairy
- secondary use - Miscellaneous agriculture
- secondary use - Unused farm land

1 0 1 Kilometers

Agricultural land use classification maps
City of Surrey
Township of Langley, 1:20K

Ministry of Water, Land and Air Protection
Lower Mainland Region
October 23, 2003

BRITISH COLUMBIA

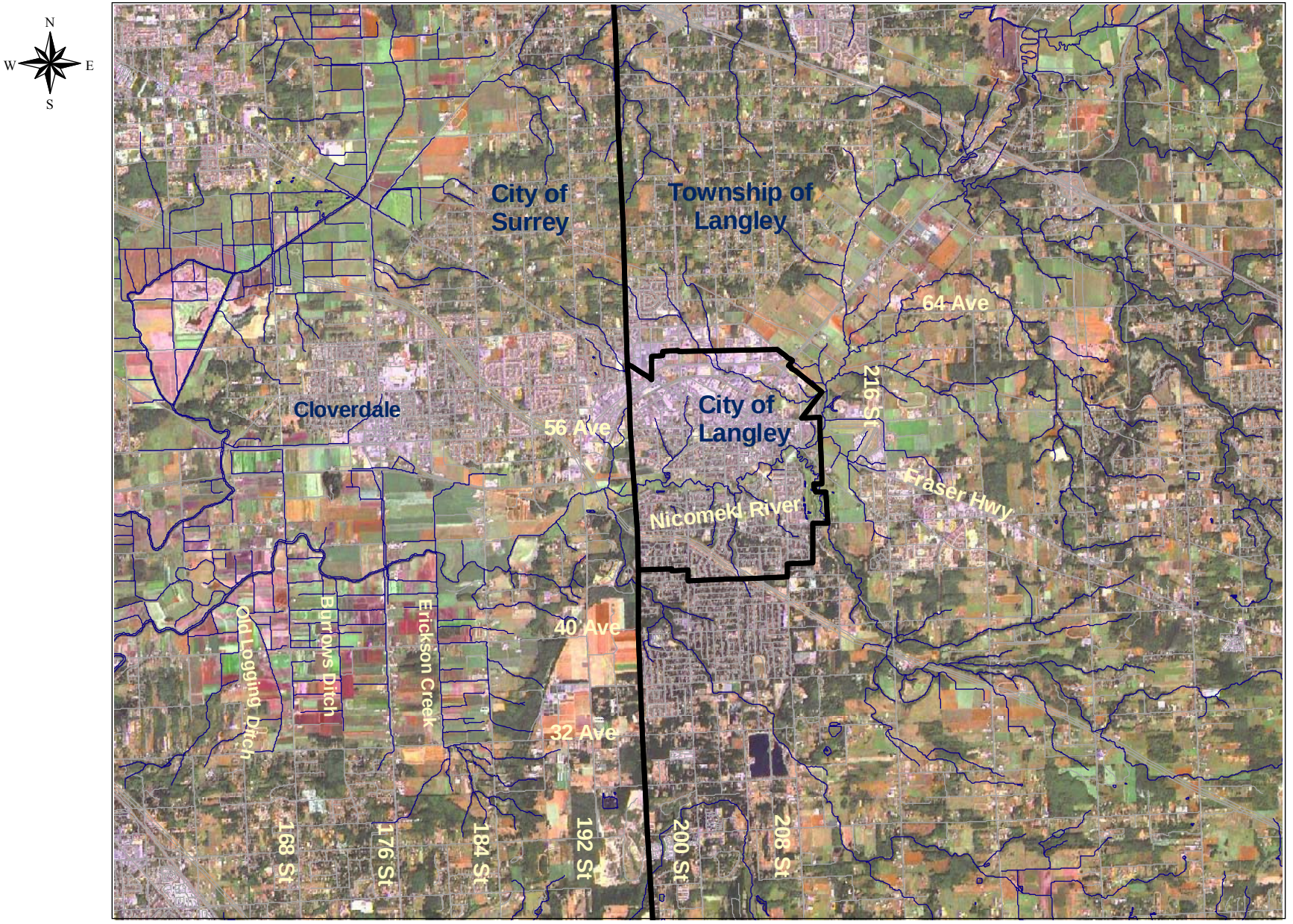


Figure 8. Aerial Photo of the Nicomekl Watershed

1 0 1 Kilometers

Ministry of Water,
Land and Air Protection
Lower Mainland Region
October 23, 2003

BRITISH COLUMBIA

Figure 9 shows the water demand from the Nicomekl River in the summer months based on 1998 existing licences as well as licences that were under review at that time. (This data is from a report prepared by Ron Kistritz and funded by the City of Surrey for its Serpentine-Nicomekl Lowland Flood Control Projects.)

This data shows that the highest demand for irrigation water, based on water licences, occurs in June, July and August. The demand is lower in April, May and September.
Figure 10 shows the amount of irrigated acreage for these watercourses and Figure 11 shows the location of water licences.

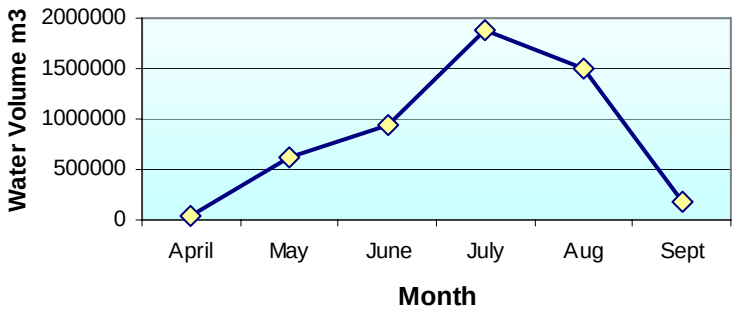


Figure 9. Nicomekl River - Total Water Demand for Crop Irrigation based on Licences Existing and Licences under Review in 1998 (Kistritz, 1998)

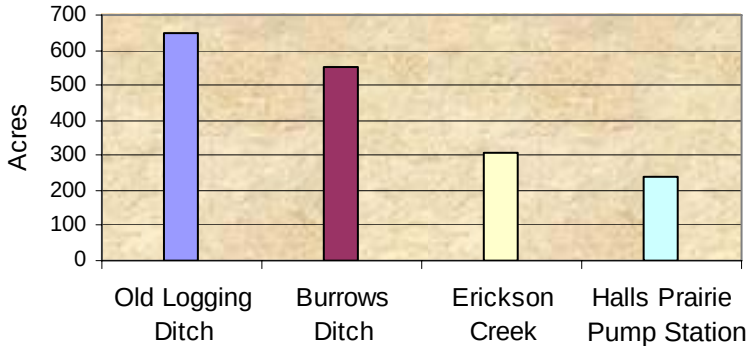


Figure 10. Irrigated Acreage (data from Kistritz, 1998)

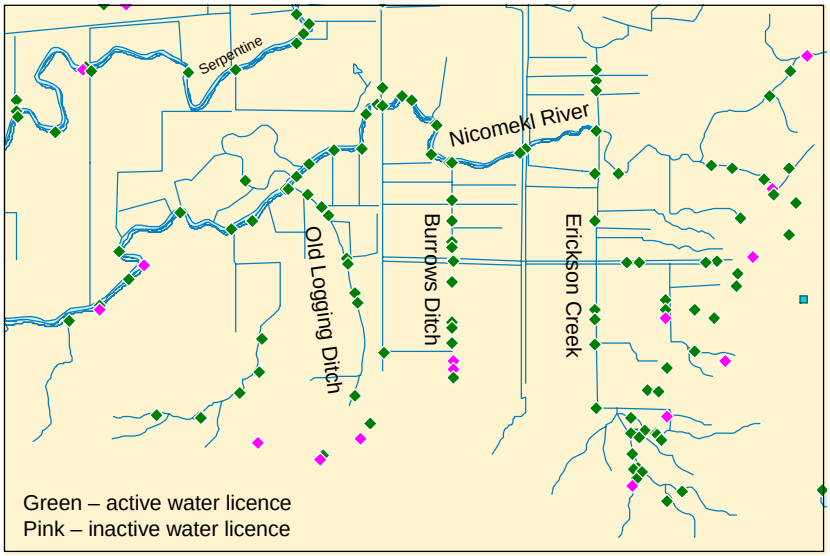


Figure 11. Water Licences (map from Community Mapping Network website)

3.0 DATA COLLECTION

3.1 Field and Laboratory Methodology

E. coli Sampling

Water samples were collected for analysis of *E. coli* levels during the following periods:

- July 2 to July 15, 2002 – at 20 sites,
- July 22 to Aug 20, 2002 – at 13 sites,
- Aug 28 to Sept 11, 2002 – at 15 sites,
- Aug 27 to Sept 18, 2003 – at 10 sites
- Mar 3 to Mar 31, 2004 – at 10 sites

Sampling was also conducted in the spring of 2003, but that data has been left out of this report due to quality control and assurance concerns with the contracted laboratory during that time period.

During the sampling program from 2002 to 2004, *E. coli* samples were collected in sterilized 500 ml polyethylene bottles supplied by the laboratory. Samples were taken from just below the water surface. All samples were kept on ice in coolers and were taken to the laboratory by couriers or by Ministry staff so that analysis was initiated within 48 hours of the sample collection time.

All the samples collected were analyzed using the Membrane Filtration (MF) technique as described in the British Columbia Environmental Laboratory Manual (MWLAP, 2003). In 2002 samples were analyzed by Cantest Ltd. and in 2003 and 2004 samples were analyzed by JR Laboratories Inc.

To compare *E. coli* data to the criteria, geometric means have been calculated using the formula shown in section 1.3 of this report. Where there was enough data "running geometric means" have been calculated. When calculating running geometric means each new date sampled allows the thirty day period to shift so that the oldest data point in the set is dropped to take in the new date. This provides geometric means over a broader range of dates and provides some insight into trends over time.

Sampling locations were selected based on recommendations of members of the Cloverdale Irrigation Water Quality Committee. Sites were selected based on indications of water quality from previous sampling, proximity to vegetable growing areas, potential irrigation use by growers, and accessibility.

Bacterial Source Tracking

Bacterial source tracking analyses can aid in identifying the source of fecal contamination in water samples. In July 2002, as part of this sampling program, one bacterial source tracking sample was collected at each of twelve sites. In September 2003 and March 2004 bacterial source tracking samples were collected on three dates at ten sites.

It is recognized that the method used is an emerging science and at the time of analysis it was not able to detect fecal contamination for other animals such as poultry and horses, or to quantify the degree of contamination associated with a specific source. For this reason, the results of the bacterial source tracking, as well as information on the method used, have not been included in the report assessment; however, they are recorded in Appendix A. The information is still included along with this report since bacterial source tracking may, in the future, be considered one tool that can be used to manage non-point source pollution. Control of non-point source pollution is a focus of MoE in the Cloverdale area.

3.2 Quality Assurance/Quality Control (QA/QC)

Laboratory blanks (trip blanks), field blanks and triplicates were used throughout the *E. coli* sampling program in 2002, 2003 and 2004. Trip blanks filled with deionized water traveled in the coolers from the MoE laboratory to the field and on to the laboratory that provided analysis. The purpose of trip blanks is to assess the quality of the deionized water, and control for potential container contamination as well as any contamination that could occur in transit. Field blanks of deionized water are poured in the field. In addition to controlling for the factors addressed by trip blanks, field blanks also control for contamination of samples by the sampler. Triplicate results consist of three samples taken at the exact same time and location. Comparison of these values gives an indication of the combined variability due to environmental conditions, field error and lab error.

The quality assurance/quality control data is included in Appendix A. Field data for *E. coli* levels collected in the spring of 2003 has been left out of this report because triplicate data varied widely. The laboratory had exceeded acceptable sample holding times so this data could not be used with confidence.

3.3 Limitations of the Data

The data collected through this sampling program is “grab sample” data which means that samples are collected at one moment in time rather than continuously. As a result, there may have been times when these watercourses had bacterial counts outside of the ranges reported, but those levels were undetected because a sample was not collected at that specific time.

Sampling locations for each watercourse were not selected randomly. Locations were selected based on recommendations by members of the multi-agency committee addressing this issue. Sites were selected based on indications of water quality from previous sampling, proximity to vegetable growing areas and accessibility. For this reason analysis has focused on site character rather than watercourses as a whole.

Samples were taken just below the surface of the water column. At this point, a study has not been conducted on the potential differences in water quality throughout the irrigation canal water column or on the depth of the extraction pumps.

As with many studies resources can be limited. The data set for a number of sites in this study may be considered small from a statistical perspective for trend analysis or for comparing geometric means between sites. Caution has therefore been exercised in making such comparisons.

Flow estimates, using velocity and width/depth approximations, were made at the time of sample collection in 2002, where there was consistent flow in the most upstream tributary sites. These estimates are crude instantaneous estimates of flow. Since many watercourses in the vegetable growing areas have control structures on them, measurement of flow could not be collected when watercourses were impounded. The complex interplay between the sea dam, tributary pump stations and irrigation pumps limits the amount of analysis that can be done on pollutant loading without more resources and modeling tools. Pollutant loading information that has been calculated has been included in Appendix A.

For “Limitations of the Data” section for bacterial source tracking please see Appendix A.

4.0 WATER QUALITY RESULTS AND DISCUSSION

The bacteriological data collected during 2002, 2003 and 2004 is provided in Appendix A. Summary information comparing calculated geometric means to the BC MoE, CCME and Manitoba criteria for irrigation of Ready-to-Eat produce is provided below. (The Manitoba criterion is a green house irrigation water criterion.) The data has also been compared to the Health Canada opinion paper level of 1000 *E. coli*/100ml.

4.1 Summary of *E.coli* Data relative to Irrigation Water Criteria for Ready-To-Eat Produce

Upstream Tributaries to the Nicomekl River

Three tributaries to the upper Nicomekl River were analyzed for *E. coli* in July of 2002. Logan Creek was sampled at 20410 Langley By-Pass (upstream site) and South of Kwantlen College at the Langley By-Pass (downstream site). Orchard Creek was sampled at 216th Street, and another tributary that parallels 56th Avenue was sampled east of the Langley Bypass. These sites were sampled five times between July 2 and July 15, 2003 and a geometric mean was calculated for each site. Figure 12 shows the geometric means for these sites relative to the 77/100ml BC MoE *E.coli* criterion for Ready-to-Eat produce. All four of the sites exceeded the BC MoE and the CCME criteria during the period of sampling. The upper Logan Creek site, the Orchard Creek site, and the "Ditch" on the South side of 56th Avenue also exceeded the Manitoba criterion. Table 3 below shows the range in *E. coli* counts measured over the period from July 2 to July 15, 2003 and compares the calculated geometric means to selected criteria/opinion levels.

Table 3. Summary Data for Upper Nicomekl River Tributaries sampled in July 2002

Irrigation Water Quality Guidelines (Criteria)/opinions for *E. coli for Crops Eaten Raw* :

1. BC MoE 77/100 ml geometric mean (met = ☐ not met= ■)
2. CCME (National guideline) 100/100ml geometric mean (met= ☐ not met= ■)
3. Manitoba 200/100ml geometric mean (met= ☐ not met= ■)
4. Health Canada opinion paper 1000/100ml geometric mean (met= ☐ not met= ■)*

✓ **means all these guidelines/opinions were met**

*Note: Health Canada opinion of 1000/100ml based on stipulation that Good Agricultural Practices (GAPs) are being used on farms consistently

Site	Date	Sample Size (n)	Range	Geometric Mean	Conclusion
Upper Nicomekl Tributaries					(see legend above)
Logan Creek at 20410 Langley Bypass	July 2 - July 15, 2002	5	510 - 1180	771	■ ■ ■ ☐
Logan Creek at Langley Bypass, South of Kwantlen College	July 2 - July 15, 2002	5	62 - 920	112	■ ■ ☐ ☐
Orchard Creek at 216 St	July 2 - July 15, 2002	5	250 - 1520	838	■ ■ ■ ☐
Ditch on South Side of 56 Ave, East of Langley Bypass	July 2 - July 15, 2002	5	88 - 1270	295	■ ■ ■ ☐

Nicomekl River through the City of Langley and Cloverdale

In the summer of 2002, the Nicomekl River was sampled at 200th Street, 192nd Street, 176th Street and near the confluence with the Old Logging Ditch. Table 4 shows the *E. coli* geometric means from these sites for 30 day periods during the sampling program and compares these to the selected criteria/opinion levels.

From July 2 to July 15, 2002, the geometric mean for *E. coli* exceeded three of the four criteria/opinion levels at 200th Street and at 192nd Street, but did not exceed any of these criteria/opinion levels near the location where Old Logging Ditch meets the Nicomekl River. The geometric mean calculated for the period of July 2 to July 31 for the Nicomekl River at 176th Street exceeded the BC MoE and the CCME criteria. During the period that the 176th Street site was monitored from July 2 to Sept 11, 2002, two out of six running geometric means exceeded the BC MoE Ready-To-Eat irrigation water criterion.

In 2003, the Nicomekl mainstem was monitored five times at 200th Street between August 27 and Sept 17, 2003. In 2004, the 200th Street site was monitored between March 3 and March 31, 2004. The geometric mean for 2003 and for 2004 exceeded the BC MoE, CCME, and Manitoba irrigation water criteria for Ready-to-Eat produce at the 200th Street site. Table 4 provides summary data on the sampling.

Table 4. Summary Data for Nicomekl Mainstem Sites Sampled in 2002, 2003 and 2004

Irrigation Water Quality Guidelines (Criteria)/opinions for *E. coli for Crops Eaten Raw* :

1. BC MoE 77/100 ml geometric mean (met = ☐ not met= ■)
2. CCME (National guideline) 100/100ml geometric mean (met= ☐ not met= ■)
3. Manitoba 200/100ml geometric mean (met= ☐ not met= ■)
4. Health Canada opinion paper 1000/100ml geometric mean (met= ☐ not met= ■)*

✓ **means all these guidelines/opinions were met**

*Note: Health Canada opinion of 1000/100ml based on stipulation that Good Agricultural Practices (GAPs) are being used on farms consistently

Site	Date	Sample Size (n)	Range	Geometric Mean	Conclusion
Nicomekl River Mainstem					(see legend above)
At 200 St	July 2 - July 15, 2002	5	220 - 930	470	■ ■ ■ ☐
	Aug 27 – Sept 17, 2003	5	148 - 590	237	■ ■ ■ ☐
	Mar 3 – Mar 31, 2004	5	87 - 720	230	■ ■ ■ ☐
At 192 St	July 2 - July 15, 2002	5	76 - 870	257	■ ■ ■ ☐
At 176 St	July 2 - July 31, 2002	8	6 - 910	105	■ ■ ☐ ☐
	July 11 - Aug 8, 2002	6	6 - 910	79	■ ☐ ☐ ☐
	July 22 - Aug 20, 2002	6	6 - 118	50	☐ ☐ ☐ ☐ ✓
	July 31 - Aug 28, 2002	5	32 - 118	59	☐ ☐ ☐ ☐ ✓
	Aug 8 - Sept 5, 2002	5	32 - 100	57	☐ ☐ ☐ ☐ ✓
	Aug 15 – Sept 11, 2002	5	32 - 130	67	☐ ☐ ☐ ☐ ✓
Adjacent to Old Logging Ditch Pump Station	July 2 - July 15, 2002	5	26 - 53	35	☐ ☐ ☐ ☐ ✓

Cloverdale Watercourses

Hall's Prairie Pump Station and "176 St. Ditch"

The "Hall's Prairie Ditch" at the pump station and the "176th Street Ditch" near the confluence with the Nicomekl River were sampled on five dates between July 2 and July 15, 2002. During this monitoring period both of these sites had geometric means that exceeded the BC MoE and CCME criteria. The geometric mean calculated for the Halls Prairie pump station also exceeded the Manitoba criterion. Table 5 provides the range for individual *E. coli* counts collected during this sampling period.

Table 5. Summary Data for "Hall's Prairie Ditch" and the "176th Street Ditch"

Irrigation Water Quality Guidelines (Criteria)/opinions for *E. coli for Crops Eaten Raw* :

1. BC MoE 77/100 ml geometric mean (met = ☐ not met= ■)
2. CCME (National guideline) 100/100ml geometric mean (met= ☐ not met= ■)
3. Manitoba 200/100ml geometric mean (met= ☐ not met= ■)
4. Health Canada opinion paper 1000/100ml geometric mean (met= ☐ not met= ■)*

✓ **means all these guidelines/opinions were met**

*Note: Health Canada opinion of 1000/100ml based on stipulation that Good Agricultural Practices (GAPs) are being used on farms consistently

Site	Date	Sample Size (n)	Range	Geometric Mean	Conclusion
Cloverdale Watercourses					(see legend above)
Halls Prairie Pump Station	July 2 - July 15, 2002	5	108 - 1240	354	■ ■ ■ ☐
Ditch on East side of 176 St, South of Nicomekl River	July 2 - July 15, 2002	5	94 - 516	170	■ ■ ☐ ☐

Old Logging Ditch and Burrows Ditch

The Old Logging Ditch and Burrows Ditch were sampled at three locations each in the summer of 2002. None of the geometric means calculated for the Old Logging Ditch sites exceeded the criteria/opinion levels for irrigation of Ready-To-Eat produce during the sampling period. During 2002, results from Burrows Ditch met the criteria/opinion levels consistently at two of the sites, "pump station" and "40th Avenue". Four out of five running geometric means during this 2002 sampling period at the "Lift Pump" site exceeded the BC MoE and CCME criteria. Two out of these five running geometric means for the Lift Pump site also exceeded the Manitoba criterion, as shown in Table 6. Table 7 provides the range for individual *E. coli* counts measured at the Old Logging Ditch sites during the 2002 sampling period.

Table 6. Summary of Exceeded *E.coli* Guidelines for Irrigation of Ready-to-Eat Produce in the Three Main Cloverdale Watercourses

	Summer 2002 Running Geometric Means for *E. coli*								2003		2004	
	July 2 to July 15	July 2 to July 31	July 11 to Aug 8	July 15 to Aug 12	July 22 to Aug 20	July 31 to Aug 28	Aug 8 to Sept 5	Aug 15 to Sept 11	Aug 27 to Sept 17	Aug 28 to Sept 18	Mar 3 to Mar 31	Mar 4 to Mar 31
Old Logging Ditch												
Pump Station		✓	✓		✓	✓	✓					
40 Ave	✓											
32 Ave		✓	✓		✓	✓	✓	✓				
Burrows Ditch												
Pump Station		✓	✓		✓	✓	✓	✓				
40 Ave		✓	✓		✓	✓	✓	✓				
Lift Pump							✓				✓	
32 Ave											✓	
Erickson Creek												
Pump Station		✓	✓		✓					✓		
40 Ave							✓					
32 Ave												
Vandrishe Brook												
Laura Brook								✓				
Ditch flowing North along 184 St, South of 40 Ave												
Ditch flowing West along 40 Ave, East of 184 St							✓	✓				
Ditch South of 40 Ave, West of 184 St												
Ditch North of 40 Ave, West of 184 St												

✓ Guidelines for irrigation of crops eaten raw were met
BC MoE 77 *E. coli*/100 ml geometric mean criterion exceeded
CCME (National guideline) 100 *E.coli*/100ml geometric mean exceeded
Manitoba 200 *E.coli*/100 ml geometric mean guideline exceeded
Health Canada opinion level 1000 *E.coli*/100ml (provided Good Agricultural Practices are being followed) exceeded

Table 7. Summary Data for Old Logging Ditch

Irrigation Water Quality Guidelines (Criteria)/opinions for *E. coli for Crops Eaten Raw* :

1. BC MoE 77/100 ml geometric mean (met = ☐ not met= ■)
2. CCME (National guideline) 100/100ml geometric mean (met= ☐ not met= ■)
3. Manitoba 200/100ml geometric mean (met= ☐ not met= ■)
4. Health Canada opinion paper 1000/100ml geometric mean (met= ☐ not met= ■)*
✓ **means all these guidelines/opinions were met**

*Note: Health Canada opinion of 1000/100ml based on stipulation that Good Agricultural Practices (GAPs) are being used on farms consistently

Site	Date	Sample Size (n)	Range	Geometric Mean	Conclusion
Cloverdale Watercourses					
Old Logging Ditch					(see legend above)
Old Logging Ditch at Pump Station	July 2 - July 31, 2002	8	6 - 380	21	☐ ☐ ☐ ☐ ✓
	July 11 - Aug 8, 2002	6	6 - 24	11	☐ ☐ ☐ ☐ ✓
	July 22 - Aug 20, 2002	6	6 - 44	12	☐ ☐ ☐ ☐ ✓
	July 31 - Aug 28, 2002	5	2 - 44	8	☐ ☐ ☐ ☐ ✓
	Aug 8 - Sept 5, 2002	5	2 - 48	12	☐ ☐ ☐ ☐ ✓
Old Logging Ditch at 40 Ave	July 2 - July 15, 2002	5	12 - 63	29	☐ ☐ ☐ ☐ ✓
Old Logging Ditch at 32 Ave	July 2 - July 31, 2002	8	14 - 350	54	☐ ☐ ☐ ☐ ✓
	July 11 - Aug 8, 2002	6	14 - 110	42	☐ ☐ ☐ ☐ ✓
	July 22 - Aug 20, 2002	6	12 - 56	28	☐ ☐ ☐ ☐ ✓
	July 31 - Aug 28, 2002	5	6 - 56	22	☐ ☐ ☐ ☐ ✓
	Aug 8 - Sept 5, 2002	5	6 - 56	18	☐ ☐ ☐ ☐ ✓
	Aug 15 – Sept 11,2002	5	6 - 56	16	☐ ☐ ☐ ☐ ✓

In the summer of 2003, Burrows Ditch was sampled for *E. coli* at 40th Avenue, at the "Lift Pump" and at 32nd Avenue between August 27 and September 17. During this time period all of these sites exceeded the BC MoE irrigation water criterion for Ready-to-Eat produce. The 32nd Avenue site had the highest geometric mean for *E.coli* for the three sites and also exceeded the CCME and Manitoba criteria levels. The geometric means and ranges are shown in Table 8.

In the spring of 2004, Burrows Ditch was sampled for *E. coli* at 40th Avenue, at the Lift Pump, and at 32nd Avenue between March 4 and March 31. During this sampling all the selected criteria/opinion levels were met at the Lift Pump and 32nd Avenue sites, but the BC MoE criterion was exceeded at 40th Avenue.

Table 8. Summary Data for Burrows Ditch

Irrigation Water Quality Guidelines (Criteria)/opinions for *E. coli for Crops Eaten Raw* :

1. BC MoE 77/100 ml geometric mean (met = ☐ not met=■)
2. CCME (National guideline) 100/100ml geometric mean (met=☐ not met=■)
3. Manitoba 200/100ml geometric mean (met= ☐ not met=■)
4. Health Canada opinion paper 1000/100ml geometric mean (met= ☐ not met=■)*
✓ **means all these guidelines/opinions were met**

*Note: Health Canada opinion of 1000/100ml based on stipulation that Good Agricultural Practices (GAPs) are being used on farms consistently

Site	Date	Sample Size (n)	Range	Geometric Mean	Conclusion
Cloverdale Watercourses					
Burrows Ditch – 2002 Data					(see legend above)
Burrows Ditch at Pump Station	July 2 - July 31, 2002	8	6 - 98	30	☐☐☐☐ ✓
	July 11 - Aug 8, 2002	6	6 - 98	37	☐☐☐☐ ✓
	July 22 - Aug 20, 2002	6	6 - 98	25	☐☐☐☐ ✓
	July 31 - Aug 28, 2002	5	6 - 83	25	☐☐☐☐ ✓
	Aug 8 - Sept 5, 2002	5	6 - 83	27	☐☐☐☐ ✓
	Aug 15 – Sept 11, 2002	5	6 - 100	28	☐☐☐☐ ✓
Burrows Ditch at 40 Ave	July 2 - July 31, 2002	8	12 - 156	48	☐☐☐☐ ✓
	July 11 - Aug 8, 2002	6	7 - 96	25	☐☐☐☐ ✓
	July 22 - Aug 20, 2002	6	7 - 96	15	☐☐☐☐ ✓
	July 31 - Aug 28, 2002	5	7 - 96	20	☐☐☐☐ ✓
	Aug 8 - Sept 5, 2002	5	7 - 460	28	☐☐☐☐ ✓
	Aug 15 – Sept 11, 2002	5	8 - 740	71	☐☐☐☐ ✓
	Aug 27 – Sept 17, 2003	5	36 - 320	96	■☐☐☐
	Mar 3 – Mar 31, 2004	5	90 - 180	96	■☐☐☐
Burrows Ditch at the Lift Pump	July 2 - July 25, 2002	7	240 - 612	412	■■■☐
	July 11 - Aug 8, 2002	5	21 - 564	220	■■■☐
	July 22 - Aug 20, 2002	5	21 - 392	136	■■☐☐
	Aug 8 - Sept 5, 2002	5	21 - 360	73	☐☐☐☐ ✓
	Aug 15 – Sept 11, 2002	5	42 - 360	112	■■☐☐
	Aug 27 – Sept 17, 2003	5	49 - 240	81	■☐☐☐
	Mar 3 – Mar 31, 2004	5	6 - 258	41	☐☐☐☐ ✓
Burrows Ditch at 32 Ave	Aug 27 – Sept 17, 2003	5	110 - 1170	366	■■■☐
	Mar 3 – Mar 31, 2004	5	31 - 820	68	☐☐☐☐ ✓

Erickson Creek and Tributaries

In 2002, Erickson Creek and its tributaries were monitored between July 2 and September 11. The sites are listed in Table 9A and 9B along with information on the geometric means, data ranges and status relative to the selected irrigation water criteria/opinion levels. Table 6 provides a summary of the number of geometric means that met or exceeded the selected criteria/opinion levels for each site sampled in the Erickson Creek watershed as well as the Old Logging Ditch and Burrows Ditch watercourses.

On the Erickson Creek mainstem, all three sites sampled in 2002 had geometric means that exceeded the BC MoE and CCME criteria for *E. coli* for irrigation of crops eaten raw. At the 32nd Avenue site, all running geometric means that were calculated exceeded these two criteria. At 40th Avenue, six out of seven running geometric means exceeded the BC MoE and CCME criteria. At 40th Avenue, three out of seven running geometric means also exceeded the Manitoba criterion. At the Pump Station, three out of six running geometric means exceeded the BC MoE and CCME criteria.

On the Erickson Creek tributaries, there were two sites where all the running geometric means from the 2002 sampling period exceeded the BC MoE and CCME criteria. These sites were "Vandrishe Brook at 29A Avenue" and in the "Ditch" which flows North along 184th Street just south of 40th Avenue. Vandrishe Brook also consistently exceeded the Manitoba criterion as well during this 2002 sampling period. The Ditch flowing north along 184th Street, South of 40th Avenue exceeded the Manitoba criterion on one out of four running geometric means. Laura Brook at 2987 – 184th Street exceeded the BC MoE criterion on three out of four running *E. coli* geometric means and exceeded the CCME criterion on two out of four running geometric means during this sampling period. In the "Ditch" flowing west along 40th Avenue just east of 184th Street, two out of four running *E. coli* geometric means exceeded the BC MoE criterion and one out of four exceeded the CCME criterion.

In the summer of 2003, the Erickson Creek mainstem was sampled at the pump station near the confluence with the Nicomekl River, at 40th Avenue, and at 32nd Avenue from August 28 to September 18. Erickson Creek tributaries sampled were Vandrishe Brook at 29A Avenue and two watercourses in the vicinity of 40th Avenue and 184th Street. The only site sampled in 2003 that met all the selected criteria/opinion levels during the sampling period from August 27 to September 11 was the site at the Pump Station near the confluence with the Nicomekl River. The geometric mean for Erickson Creek at 40th Avenue exceeded the BC MoE, CCME and Manitoba criteria levels as did the geometric mean for the two watercourses in the vicinity of 40th Avenue and 184th Street. Of the two watercourses sampled west of 184th Street, the one north of 40th Avenue showed a geometric mean over five times the BC MoE criterion value while the one south of 40th Avenue showed a geometric mean over three times the BC MoE criterion value. The geometric mean from data collected at 32nd Avenue in 2003 exceeded both the BC MoE and CCME criteria.

During the 2003 sampling period, the geometric mean for Vandrishe Brook exceeded all of the selected criteria/opinion levels, in fact, the geometric mean was more than 53 times the BC MoE criterion.

In the spring of 2004, Erickson Creek and its tributaries were sampled at the same locations as in the summer of 2003. During this sampling period, all sites exceeded the BC MoE, CCME and Manitoba criteria levels for irrigation water for *E. coli*. During this time period, Vandrishe Brook also exceeded the Health Canada opinion level.

Geometric means, data ranges and status relative to the selected irrigation water criteria/opinion levels for 2003 and 2004 sampling are shown with the 2002 summary data in Table 9A and 9B.

Tables 9A and B. Summary Data for Erickson Creek (A) and Tributaries (B)

Table 9A: Summary Data for Erickson Creek

Irrigation Water Quality Guidelines (Criteria)/opinions for *E. coli for Crops Eaten Raw* :

1. BC MoE 77/100 ml geometric mean (met = ☐ not met= ■)
2. CCME (National guideline) 100/100ml geometric mean (met= ☐ not met= ■)
3. Manitoba 200/100ml geometric mean (met= ☐ not met= ■)
4. Health Canada opinion paper 1000/100ml geometric mean (met= ☐ not met= ■)*
✓ **means all these guidelines/opinions were met**

*Note: Health Canada opinion of 1000/100ml based on stipulation that Good Agricultural Practices (GAPs) are being used on farms consistently

Site	Date	Sample Size (n)	Range	Geometric Mean	Conclusion
Cloverdale Watercourses					
Erickson Creek Mainstem					(see legend above)
Erickson Creek at Pump Station	July 2 - July 31, 2002	8	0 - 130	36	☐ ☐ ☐ ☐ ✓
	July 11 - Aug 8, 2002	6	0 - 130	49	☐ ☐ ☐ ☐ ✓
	July 22 - Aug 20, 2002	6	0 - 122	46	☐ ☐ ☐ ☐ ✓
	July 31 - Aug 28, 2002	5	64 - 122	102	■ ■ ☐ ☐
	Aug 8 - Sept 5, 2002	5	64 - 650	142	■ ■ ☐ ☐
	Aug 15 – Sept 11, 2002	5	64 - 650	141	■ ■ ☐ ☐
	Aug 28 – Sept 18, 2003	5	23 - 160	60	☐ ☐ ☐ ☐ ✓
	Mar 4 – Mar 31, 2004	5	40 - 4400	292	■ ■ ■ ☐
Erickson Creek at 40 Ave	July 2 - July 31, 2002	8	170 - 1820	450	■ ■ ■ ☐
	July 11 - Aug 8, 2002	6	69 - 850	295	■ ■ ■ ☐
	July 15 - Aug 12, 2002	6	69 - 850	254	■ ■ ■ ☐
	July 22 - Aug 20, 2002	7	60 - 850	165	■ ■ ☐ ☐
	July 31 - Aug 28, 2002	6	60 - 850	125	■ ■ ☐ ☐
	Aug 8 - Sept 5, 2002	6	45 - 140	76	☐ ☐ ☐ ☐ ✓
	Aug 15 – Sept 11, 2002	5	45 - 210	87	■ ☐ ☐ ☐
	Aug 28 – Sept 18, 2003	5	66 - 650	224	■ ■ ■ ☐
	Mar 4 – Mar 31, 2004	5	350 - 2800	655	■ ■ ■ ☐
Erickson Creek at 32 Ave	July 2 - July 31, 2002	8	48 - 474	190	■ ■ ☐ ☐
	July 11 - Aug 8, 2002	6	48 - 202	105	■ ■ ☐ ☐
	July 22 - Aug 20, 2002	6	51 - 352	167	■ ■ ☐ ☐
	July 31 - Aug 28, 2002	5	51 - 352	145	■ ■ ☐ ☐
	Aug 8 - Sept 5, 2002	5	51 - 352	145	■ ■ ☐ ☐
	Aug 15 – Sept 11, 2002	5	84 - 352	190	■ ■ ☐ ☐
	Aug 28 – Sept 18, 2003	5	23 - 680	101	■ ■ ☐ ☐
	Mar 4 – Mar 31, 2004	5	59 - 9800	670	■ ■ ■ ☐

Table 9B: Summary Data for Erickson Creek Tributaries

Irrigation Water Quality Guidelines (Criteria)/opinions for *E. coli for Crops Eaten Raw* :

1. BC MoE 77/100 ml geometric mean (met = ☐ not met= ■)
2. CCME (National guideline) 100/100ml geometric mean (met= ☐ not met= ■)
3. Manitoba 200/100ml geometric mean (met= ☐ not met= ■)
4. Health Canada opinion paper 1000/100ml geometric mean (met= ☐ not met= ■)*
✓ **means all these guidelines/opinions were met**

*Note: Health Canada opinion of 1000/100ml based on stipulation that Good Agricultural Practices (GAPs) are being used on farms consistently

Site	Date	Sample Size (n)	Range	Geometric Mean	Conclusion
Cloverdale Watercourses					
Erickson Creek Tributaries					(see legend above)
Vandrishe Brook at 29A Ave	July 22 - Aug 20, 2002	6	287 - 2100	856	■ ■ ■ ☐
	July 31 - Aug 28, 2002	5	287 - 2100	786	■ ■ ■ ☐
	Aug 8 - Sept 5, 2002	5	250 - 1000	513	■ ■ ■ ☐
	Aug 15 – Sept 11, 2002	5	230 - 1000	491	■ ■ ■ ☐
	Aug 28 – Sept 18, 2003	5	1600 – 11000	4131	■ ■ ■ ■
	Mar 4 – Mar 31, 2004	5	1100 - 3200	2926	■ ■ ■ ■
Laura Brook at 2987-184 St	July 22 - Aug 20, 2002	6	38 - 270	152	■ ■ ☐ ☐
	July 31 - Aug 28, 2002	5	38 - 270	125	■ ■ ☐ ☐
	Aug 8 - Sept 5, 2002	5	32 - 270	88	■ ☐ ☐ ☐
	Aug 15 – Sept 11, 2002	5	16 - 270	74	☐ ☐ ☐ ☐ ✓
Breaks Brook at 29A Ave	July 22 - Aug 20, 2002	6	42 - 80	54	☐ ☐ ☐ ☐ ✓
"Ditch" Flowing North on 184 St, South of 40 Ave	July 22 - Aug 20, 2002	7	76 - 736	207	■ ■ ■ ☐
	July 31 - Aug 28, 2002	6	56 - 300	117	■ ■ ☐ ☐
	Aug 8 - Sept 5, 2002	6	56 - 620	132	■ ■ ☐ ☐
	Aug 15 – Sept 11, 2002	5	56 - 620	151	■ ■ ☐ ☐
"Ditch" Flowing West on 40 Ave, East of 184 St	July 22 - Aug 20, 2002	6	8 - 744	127	■ ■ ☐ ☐
	July 31 - Aug 28, 2002	5	8 - 540	78	■ ☐ ☐ ☐
	Aug 8 - Sept 5, 2002	5	8 - 340	49	☐ ☐ ☐ ☐ ✓
	Aug 15 – Sept 11, 2002	5	8 - 340	70	☐ ☐ ☐ ☐ ✓
"Ditch" North of 40 Ave, West of 184 St	Aug 28 – Sept 18, 2003	5	200 - 930	383	■ ■ ■ ☐
	Mar 4 – Mar 31, 2004	5	67 - 2610	414	■ ■ ■ ☐
"Ditch" South of 40 Ave, West of 184 St	Aug 28 – Sept 18, 2003	5	120 - 470	260	■ ■ ■ ☐
	Mar 4 – Mar 31, 2004	5	41 - 2150	215	■ ■ ■ ☐

4.2 Spatial Trends in the Data

Results of the sampling have shown that there are non-point source pollution concerns in terms of fecal contamination in all three main areas examined - the upstream tributaries to the Nicomekl River, the Nicomekl River mainstem, and the Cloverdale tributaries to the Nicomekl River. The most immediate sources of contamination, relative to vegetable growing areas, appear to be in the upper portion of the Cloverdale tributaries (most notably Erickson Creek), nearer to their headwaters.

Upstream Tributaries to the Nicomekl River

Figure 12 shows the range and median for all 2002 data collected by site. The sites sampled on the upstream tributaries to the Nicomekl River all exceeded the criterion for irrigation of Ready-to-Eat produce and had ranges that were fairly wide.

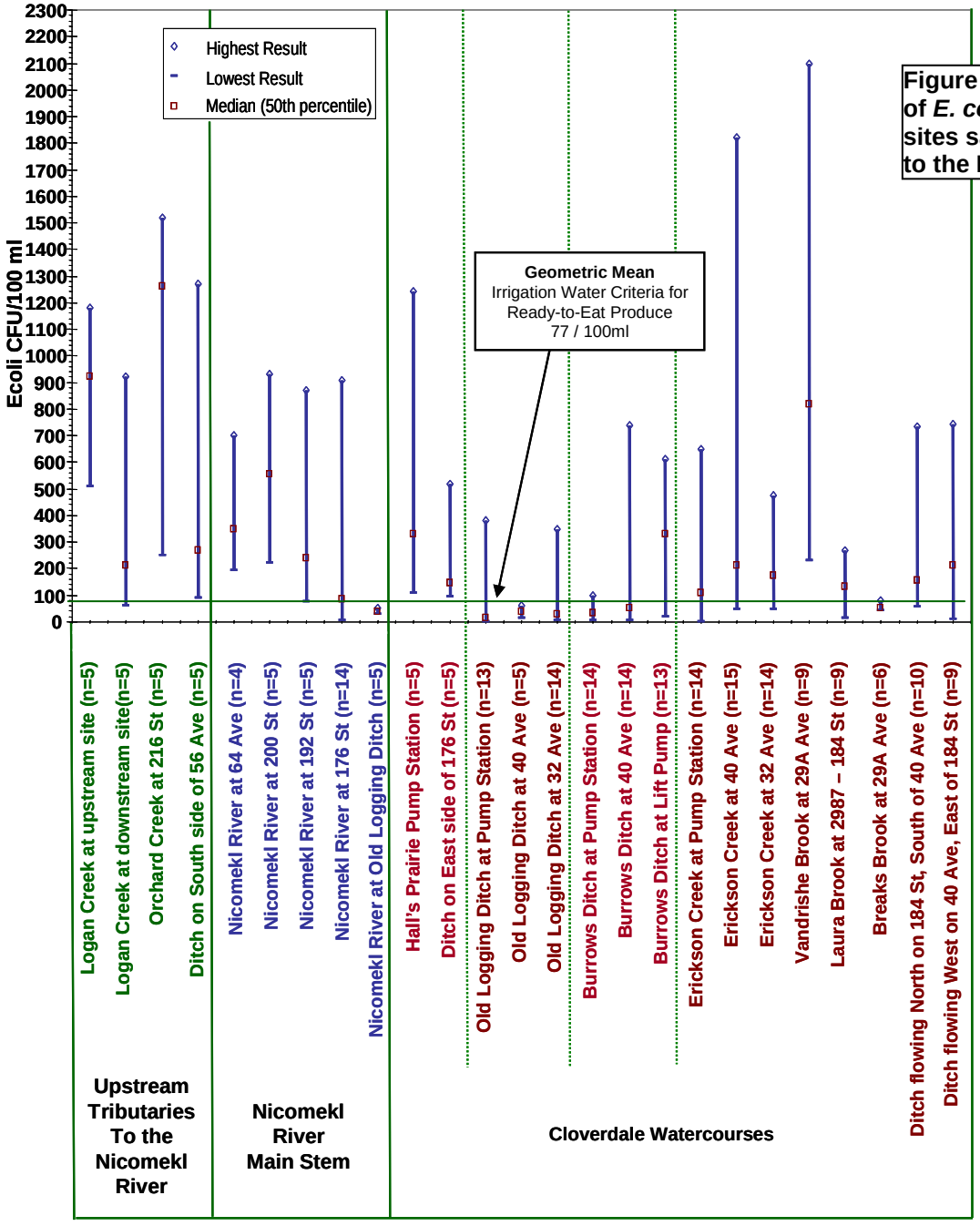


Figure 12. Range and Median of *E. coli* values observed at sites sampled in 2002 relative to the BC MoE criterion

Logan creek was sampled at two sites in 2002; Figure 13 shows the geometric means with 90% confidence intervals. Using 90% confidence intervals *E.coli* levels measured at the upstream site on Logan Creek (at 20410 Langley By-pass) appear to be higher than those measured at the downstream site (south of Kwantlen College on the Langley By-pass). Based on these limited data and this confidence level there may be an indication that the upstream site is closer to the prevalent contaminant source. However, when 95% confidence intervals are used, there is some overlap between these sites and the difference is not as clear. More sampling in this area could help to clarify whether there is a difference between the sites.

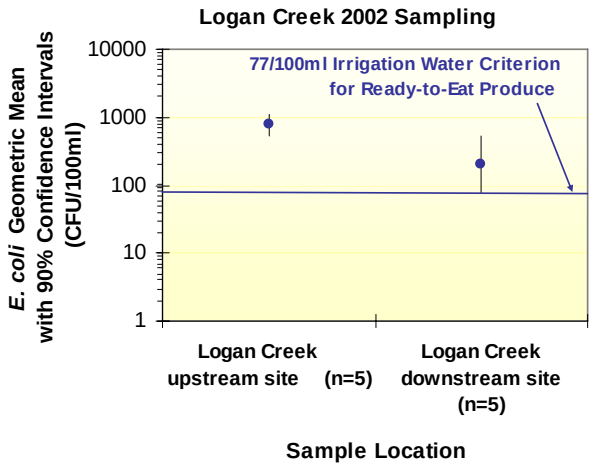


Figure 13. Geometric Means for *E.coli* levels at Logan Creek Sampling Sites in July 2002 relative to the BC MoE criterion

The Nicomekl River Mainstem

Figure 12 shows the range and median of *E. coli* values observed at sites in 2002 on the Nicomekl River mainstem. Figure 14 shows the geometric means for *E. coli* for five Nicomekl River sites sampled from July 2 to July 15, 2002. The 64th Avenue site was sampled four times and all the other sites listed were sampled five times within this July sampling period.

During this period all the sites except for the Nicomekl River at the Old Logging Ditch confluence exceeded the irrigation criterion for Ready-To-Eat produce. The Nicomekl River site at 200th Street had a higher geometric mean than the Nicomekl River near the Old Logging Ditch confluence. The data suggest that the 200th Street site may be closer to the prevalent contaminant sources, which appear to originate from urban as well as rural areas.

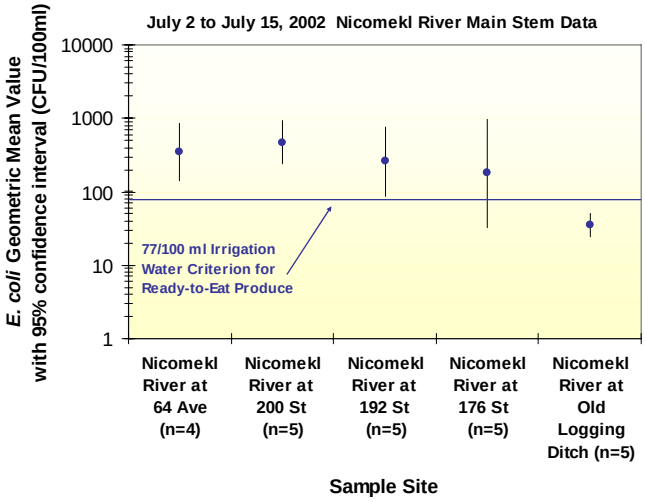


Figure 14. Geometric means for *E.coli* at Nicomekl River Mainstem Sampling Sites relative to the BC MoE criterion

Cloverdale Tributaries to the Nicomekl River Mainstem

In the Cloverdale area the main tributaries used for irrigating Ready-to-Eat produce can receive water from two sources: headwaters and irrigations pumps in the Nicomekl mainstem. Headwaters of these systems provide flow year round. In the summer, these watercourses may become impounded as a result of flap gates that are closed where the watercourse would meet the Nicomekl River. Irrigation pumps draw water from the Nicomekl River and release it to Old Logging Ditch, Burrows Ditch and Erickson Creek for use in irrigating crops.

Figure 15 shows *E. coli* levels at the Nicomekl mainstem site at 176th Street along with *E. coli* levels immediately upstream of the pump stations on the three main watercourses used for irrigating Ready-to-Eat crops. From this diagram it does not appear that higher counts in the Nicomekl mainstem necessarily result in higher levels in the tributary watercourses. Similarly lower counts in the Nicomekl mainstem do not necessarily result in lower counts in the tributary watercourses. This is likely due to differences in the use of the irrigation pumps drawing water into the tributary watercourses, and the influence of pollution sources in the tributary basins. Other factors such as suspension of contaminated solids from the ditch bottom, and the potential for pathogen survival and multiplication in the ditches may also play a role.

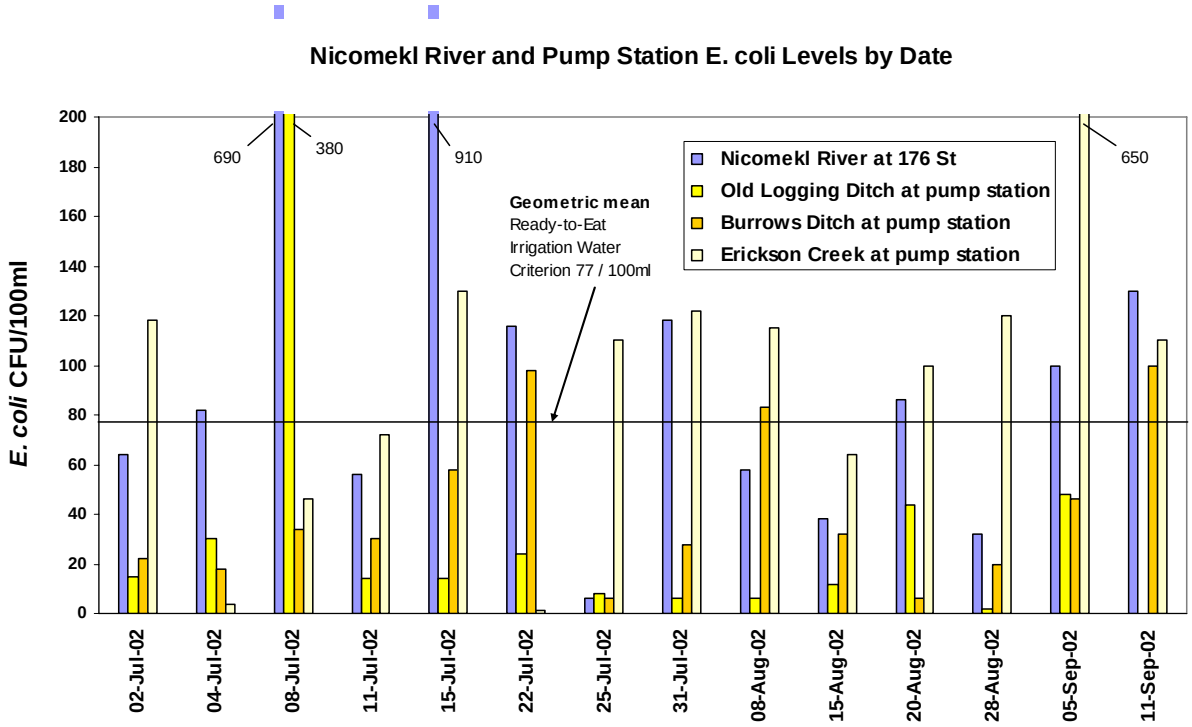


Figure 15. E.coli Results from the Nicomekl River at 176th Street and from the Three Main Irrigation Watercourses in the Cloverdale Ready-to-Eat Growing Area (compared with the BC MoE criterion for irrigation of Ready-to-Eat produce)

Cloverdale Watercourses

According to the land use classification shown in Figure 7, the Old Logging Ditch land uses tend to be focused on field vegetable production. Moving east from there the land use diversity seems to increase on a gradient. Burrows Ditch supports mainly field vegetable and berry production and has some extensive livestock, while Erickson Creek supports a much higher number of types of agricultural land use, many of which are more focused on livestock.

Of these three main watercourses, the water quality has tended to be the best, during this sampling program, at sites on the Old Logging Ditch. Certain sites on Burrows Ditch have exceeded the BC MoE irrigation water criterion for Ready-to-Eat produce during some sampling periods. Erickson Creek has consistently provided results that exceed the BC MoE criterion at many sampling sites.

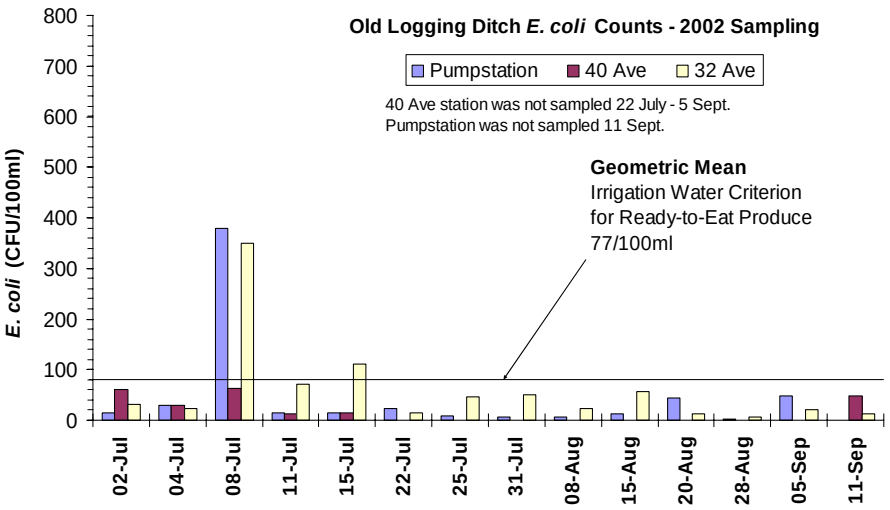


Figure 16. *E. coli* data for Old Logging Ditch sites in 2002 relative to the BC MoE criterion for irrigation of Ready-to-Eat produce

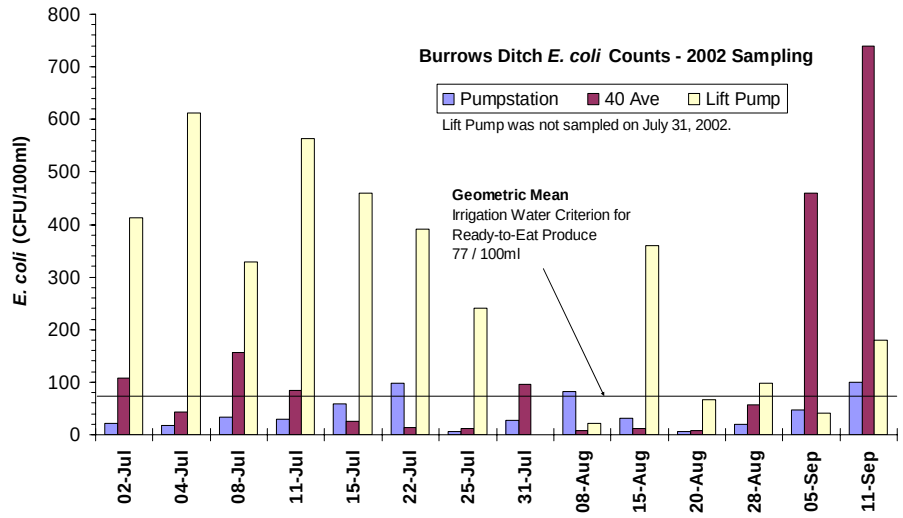


Figure 17. *E. coli* data for Burrows Ditch sites in 2002 relative to the BC MoE criterion for irrigation of Ready-to-Eat produce

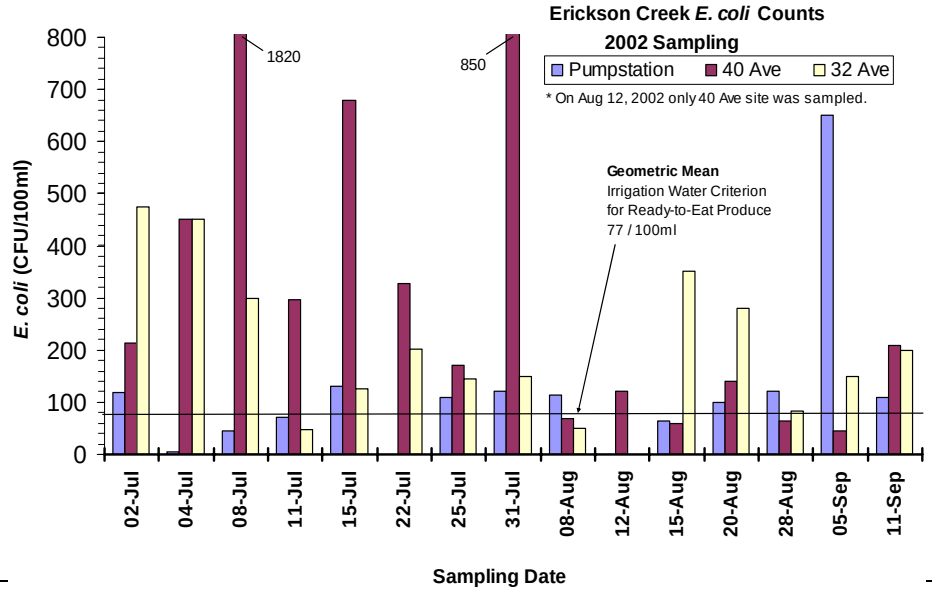


Figure 18. *E. coli* data for Erickson Creek sites in 2002 relative to the BC MoE criterion for irrigation of Ready-to-Eat produce

Figure 12 shows the range and median for all data collected in 2002. Figures 16, 17 and 18 show the *E. coli* data collected in 2002 on Old Logging Ditch, Burrows Ditch and Erickson Creek. Figure 19 provides the geometric means and 95% confidence intervals for the combined 2002 data for these three watercourses by sites sampled.

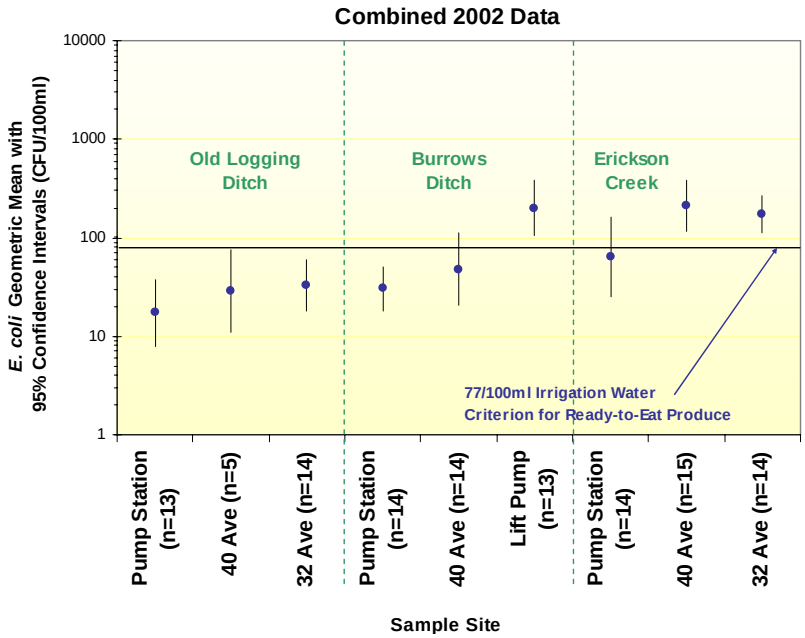


Figure 19. Geometric Means for combined 2002 data - Old Logging Ditch, Burrows Ditch and Erickson Creek - compared to BC MoE criterion for irrigation of Ready-to-Eat produce

Figure 19 shows that in 2002 the geometric means for Old Logging Ditch at the Pump Station, Old Logging Ditch at 40th Avenue, Old Logging Ditch at 32nd Avenue and Burrows Ditch at the Pump Station were lower than the geometric means for Burrows Ditch at the Lift Pump, Erickson Creek at 40th Avenue and Erickson Creek at 32nd Avenue.

Figures 20 and 22 show the *E. coli* data collected in late summer 2003 and spring 2004 for the Burrows Ditch and Erickson Creek respectively. Figures 21 and 23 provide the geometric means and 95% confidence intervals for the 2003 and 2004 sampling for Burrows Ditch and for Erickson Creek respectively. Despite the fact that Erickson Creek samples typically resulted in higher bacterial levels and higher geometric means, when confidence intervals are considered there are no clear trends in terms of certain sites having significantly higher geometric means than others within each sampling period or between sampling periods in 2003 and 2004.

When comparing the late summer sampling from 2003 to the spring sampling in 2004 for the Erickson Creek sites there are a number of high counts observed in the 2004 data that do not seem to be matched in the 2003 data.

Figure 24 shows the *E. coli* results from 2002, 2003 and 2004 for select Erickson Creek tributary sites. In 2003 and 2004, sampling at 184th Street and 40th Avenue was shifted west of 184th Street because there are a number of ditches near this intersection and due to the narrow scope of the study, it was not practical to sample all of them. The new locations west of 184th Street represent the combined flows of a number of ditches draining the area. The results from the sampling at 40th Avenue and 184th Street as well as on Vandrishe Brook at 29A Avenue show that these areas are a concern in terms of fecal contamination of Erickson Creek.

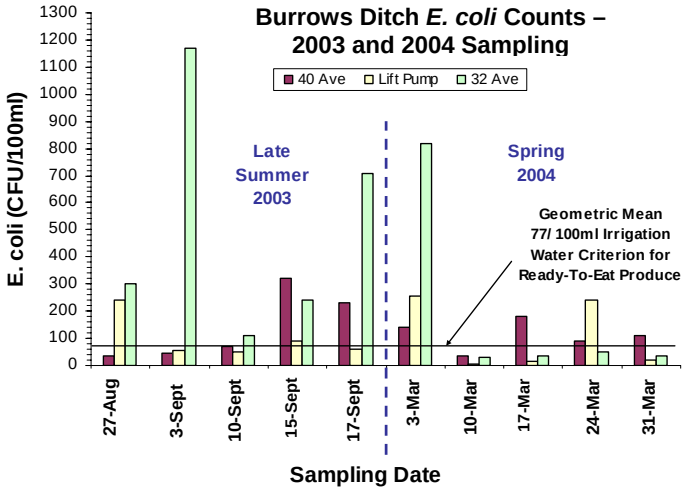


Figure 21. *E. coli* data for Burrows Ditch sites in 2003 and 2004

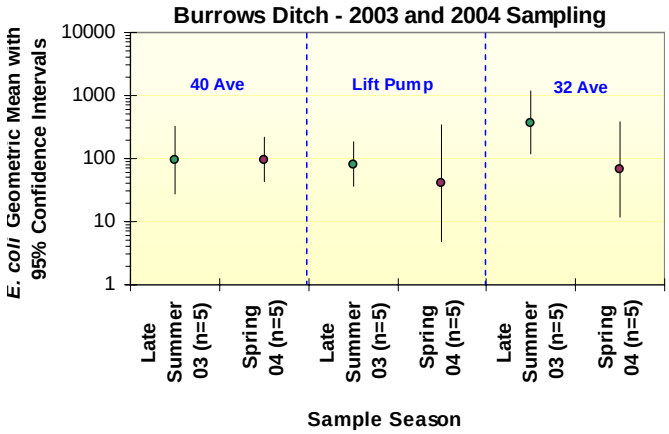


Figure 20. Geometric Means for Burrows Ditch sites in 2003 and 2004

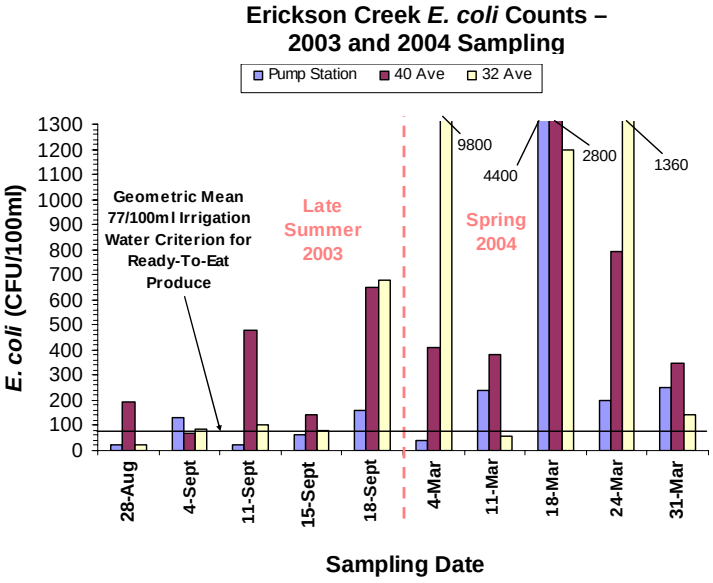


Figure 23. *E. coli* data for Erickson Creek sites in 2003 and 2004

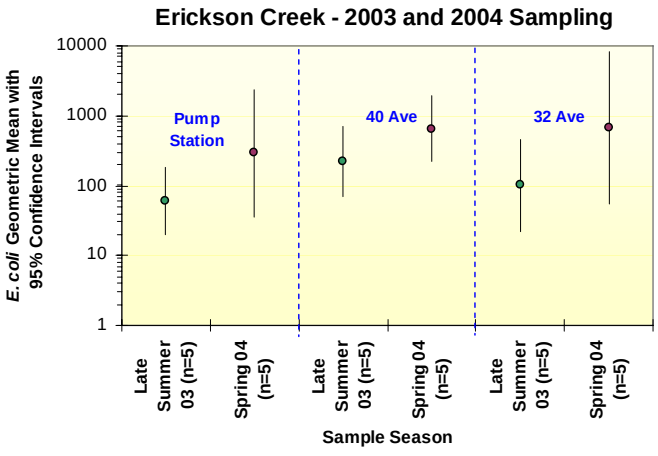
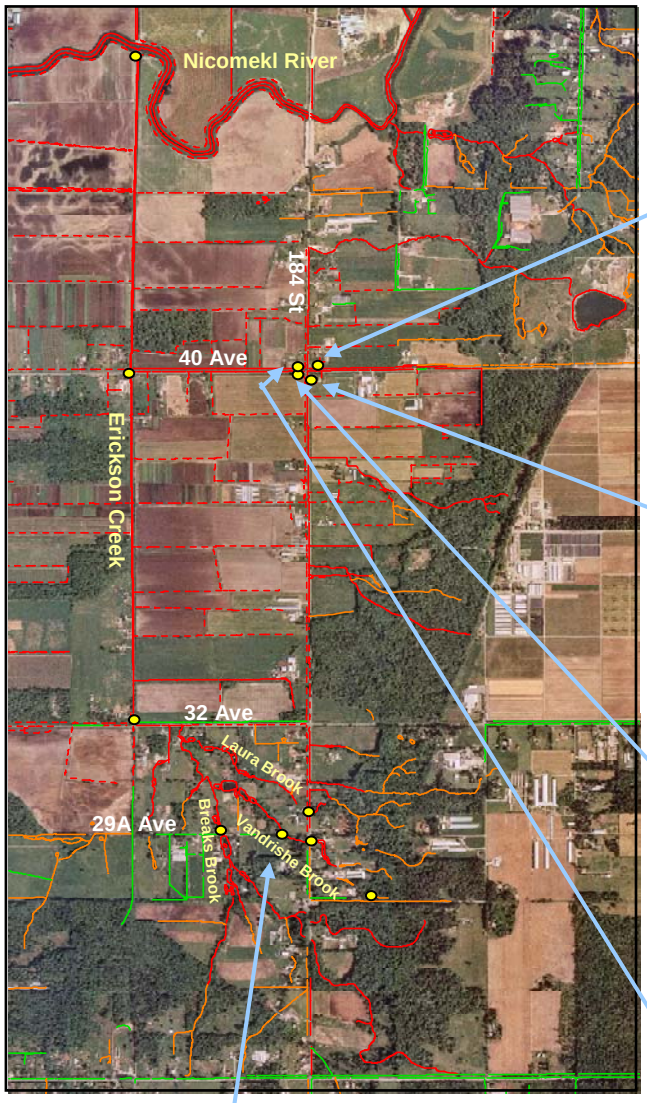
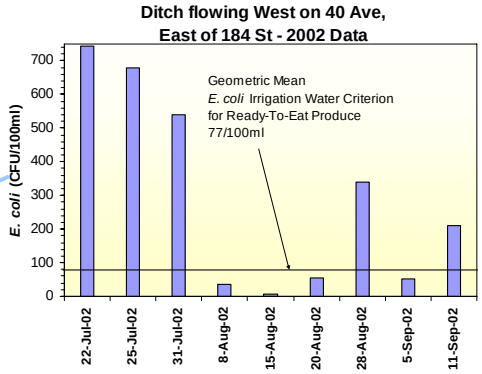
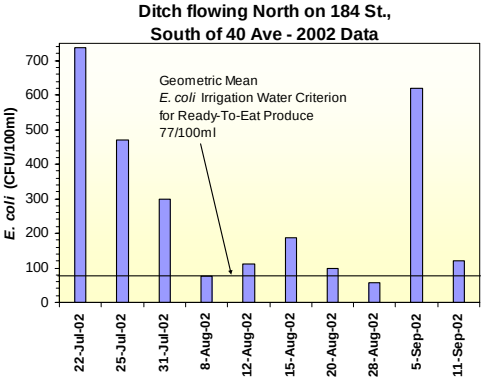
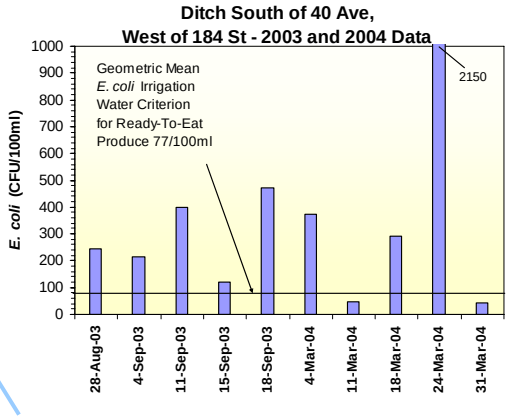


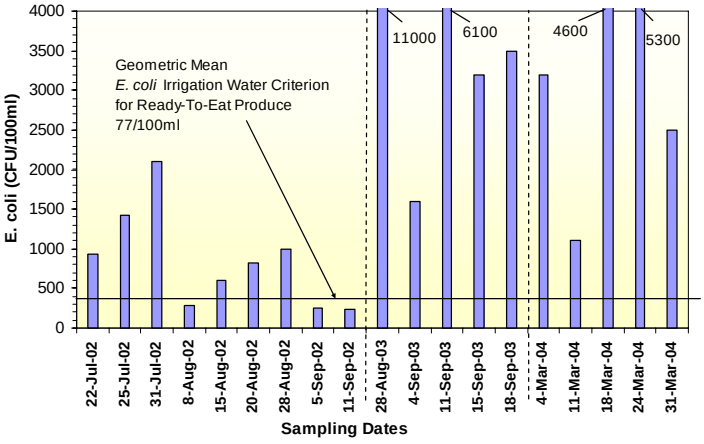
Figure 22. Geometric Means for Erickson Creek sites in 2003 and 2004











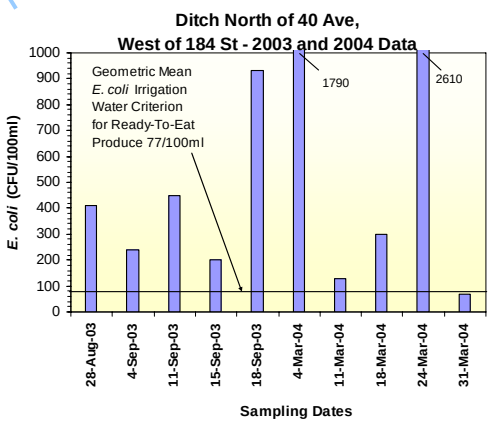


Figure 24. *E. coli* data collected on Erickson Creek Tributaries in 2002, 2003, and 2004

In 2002, a number of sites on Cloverdale watercourses were sampled from July 2 to September 11. Running geometric means were calculated for this period of sampling. At some sites there were differences observed between the running geometric means through this sampling period.

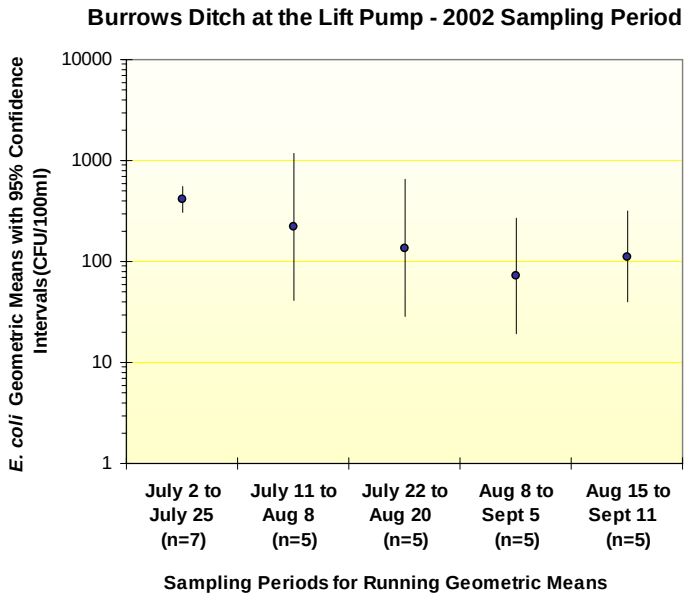


Figure 25. Running Geometric Means for Burrows Ditch at the Lift Pump in 2002

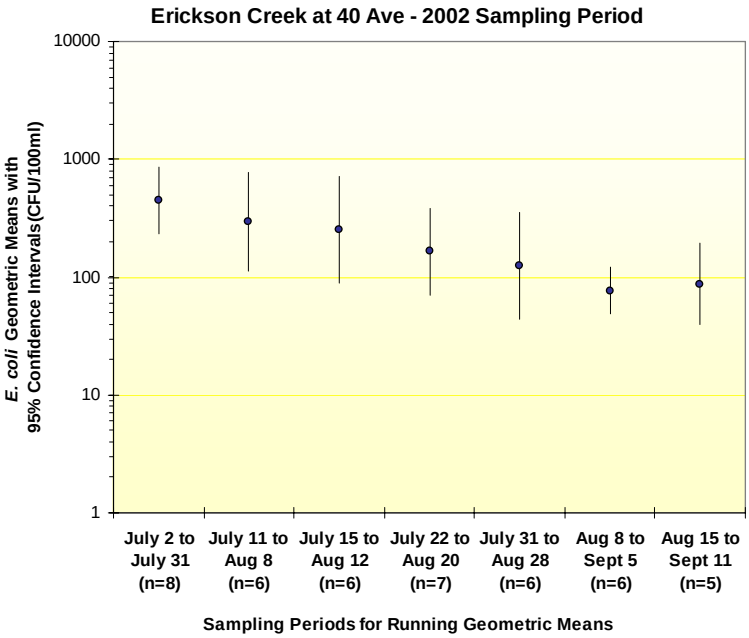


Figure 26. Running Geometric Means for Erickson Creek at 40th Avenue in 2002

Figure 25 shows the running geometric means for Burrows Ditch at the Lift Pump in 2002. From this figure it appears that the geometric mean calculated for this site from July 2 to July 25 was higher than the geometric means calculated for August 8 to September 5 and August 15 to September 11.

Figure 26 shows the running geometric means for Erickson Creek at 40th Avenue in 2002. From this figure it appears that the geometric mean calculated for this site for July 2 to July 31 is higher than the geometric means calculated for August 8 to September 5 and August 15 to September 11. Overall the data suggests there was a declining trend from the July 2-July 31 geometric mean to the July 31-August 28 geometric mean for this site. During this same time period there appeared to be a general decrease in the variability of the data.

These trends at Burrows Ditch, at the Lift Pump and at Erickson Creek at 40th Avenue, may be the result of a drying out of the area over summer and generally lower levels of precipitation that could reduce the impact of the pollutant sources affecting these sites. This may be occurring in conjunction with seasonal land use activities that increase fecal contamination earlier in the season.

4.4 Rainfall Data

In Appendix B the *E. coli* values measured at each of the sites are presented along with data on the amount of rain that occurred 24 hours, 48 hours, 72 hours and 96 hours prior to the sample being taken. Figure 27 shows the precipitation that occurred during the sampling periods in 2002, 2003 and 2004.

During the dry season (sampled from July to September 2002 and from late August to early September 2003) there were indications for some sites that precipitation may affect *E. coli* values. However, there were limited precipitation data during the 2002 sampling period to consider. In 2002, the rainfall event on July 8 seemed to correspond with an elevated *E. coli* level at Erickson Creek at 40th Avenue, Old Logging Ditch at 32nd Avenue, Old Logging Ditch at the Pump Station, the Nicomekl River at 176th Street and the "Ditch" on the south side of 56th Avenue, east of the Langley By-Pass. However, at other sites, there was no spike in *E. coli* levels observed.

In the data from the summer of 2003 and the spring of 2004 values at Erickson Creek at 40th Avenue seem to support the idea that *E. coli* are affected by precipitation levels, particularly within a 24 hour period of sampling. Data for Erickson Creek at the Pump Station and at 32nd Avenue in 2002 and 2003 during the dry season revealed no clear relationship between precipitation and *E. coli* levels. However there are some indications from the small 2004 data set that during the wet season there is a relationship between precipitation levels and *E. coli* counts.

At Burrows Ditch at 40th Avenue, there may be a weak relationship between precipitation and *E. coli* counts in the dry summer period. However, there was no clear relationship between precipitation and *E. coli* counts in the small data set from the spring of 2004.

In the data from the spring of 2004, there were indications that *E. coli* levels may be affected by precipitation in the wet season at Burrows Ditch at the Lift Pump and at 32nd Avenue. However, this is a small data set for 2004. There were no clear indications of a relationship between *E. coli* values and precipitation in the dry period of 2002 and 2003 for these sites.

The data suggest that with a number of sites in the Cloverdale area there are other controlling factors beyond precipitation. There may be confounding factors in the summer such as the impoundment of watercourses, the pumping of Nicomekl River water into the irrigation ditches, shifting sources of pollution both temporally and spatially, survival rates of *E. coli* in warm stagnant ditches and changes in soil moisture over the course of the season.

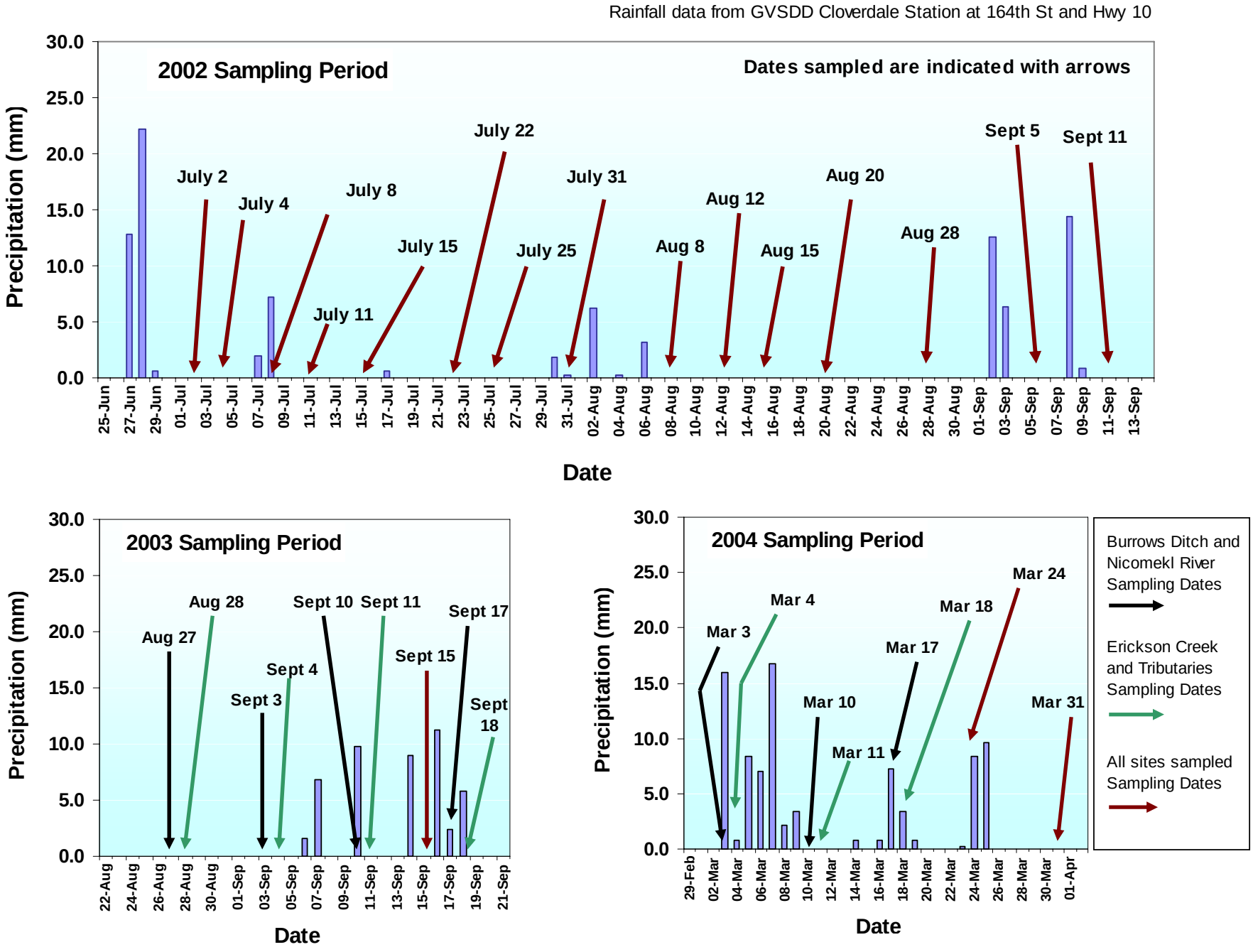


Figure 27. Rainfall Data for 2002, 2003 and 2004 Sampling Periods

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

There have been two reported disease outbreaks traced back to Ready-to-Eat produce grown in one localized area of Cloverdale. There was a disease outbreak in 2001 that was a result of contamination of spinach with *Shigella* and a disease outbreak in 2004 as a result of contamination of cilantro with *Cyclospora*. These recent disease outbreaks have brought the issue of irrigation water quality and produce wash water quality to the forefront.

The monitoring undertaken during this sampling program indicates that the Nicomekl River mainstem, the upstream tributaries, and the three main Cloverdale watercourses used for irrigating Ready-to-Eat produce have been impacted to varying degrees by non-point source pollution. All of these irrigation waters have the potential to carry pathogens that may result in future disease outbreaks due to contaminated Ready-to-Eat produce.

Sampling results showed greatest fecal contamination throughout the Erickson Creek drainage and upstream of the Lift Pump in the Burrows Ditch drainage. Sampling results for sites along Old Logging Ditch did not exceed the irrigation water criterion for Ready-to-Eat produce during this sampling period (July to September 2002, August to September 2003, and March 2004).

Since there are limited data to quantify the relationship between irrigation water quality, the potential for produce contamination and the risk for subsequent illness in consumers, the water quality data in this report was considered relative to a number of criteria/opinion levels. These "benchmarks" together cover a broad range of *E.coli* levels.

5.2 Recommendations

Recommendations have been provided in this report, although it should be noted that these are Ministry of Environment recommendations. Collaboratively, the partner organizations represented in the Cloverdale Irrigation Water Quality Committee are ultimately the bodies that will determine whether all the listed actions and/or policy related to irrigation water quality and food safety in this produce growing area are warranted. Non-point source pollution is challenging, although not impossible, to address. It requires a collaborative and systematic approach.

1. **Sanitary Survey** – It is recommended that the MoE undertake an assessment of all sources of fecal pollution entering watercourses used for irrigation of Ready-to-Eat produce, starting with the highest priority areas. This would include an audit of agricultural and non-agricultural (eg. human septic system) sources. In addition to non-point source issues, the GVRD's Cloverdale sewage pump station contributes overflow into these watercourses and it is recommended that this input also be assessed.

   It is suggested that effort be focused initially on controlling sources of fecal contamination in the drainage area of two of the three main Cloverdale watercourses used for irrigating Ready-to-Eat produce. In particular, it is recommended that priority be given to identifying potential pollution sources throughout the Erickson Creek drainage and upstream of the Lift Pump in the Burrows Ditch drainage.

   Potential sources are to be assessed, documented and followed up on as necessary to improve water quality. In response to the monitoring results of this study, the MoE has undertaken an agricultural audit to help identify and remediate agricultural pollution sources in these priority areas. Other tools such as Environmental Farm Planning, through the Ministry of Agriculture and Lands, could be used as well to help address pollution sources.

2. **Risk Reduction** – Continued communication by the Health agencies with the general public is supported, to provide them with information on how to reduce risks from potential pathogens on produce. It is also recommended that the Health and the Agriculture agencies continue to provide information to individual agricultural producers on Good Agricultural Practices (GAPs) and Best Management Practices (BMPs), to reduce impacts of potential contamination to crops and irrigation water. These GAPs and BMPs include activities such as crop washing in potable water, using safe irrigation-to-harvest intervals and proper manure management practices. The Fraser Health Authority could possibly provide information on proper septic system maintenance (in appropriate languages) to residents who own properties in the area that contain septic fields. Monitoring the application of GAPs and BMPs could also provide valuable information. Ultimately, in addition to information providing, it is recommended that GAPs and BMPs be enforced by appropriate governing bodies.

3. **Area Based Planning** – Since this area is dominated by non-point source pollutants, there is no single solution that can be implemented to improve water quality in these watercourses. There is need for a multi-faceted approach to address the topic of irrigation water quality that would best be achieved through an "area-based planning" process. Such a process – potentially led by MoE – could address cumulative impacts more effectively than a purely regulatory approach.

4. **Working with Stakeholders to Protect Water Quality** – All stakeholders, including the produce industry, and the health, agriculture and environmental agencies have a role to play in assuring an appropriate level of water quality for irrigation uses over the short and long-term. Clarification of roles and responsibilities may improve the groups' effectiveness in addressing this issue.

5. **Monitoring Progress** - Water quality effectiveness monitoring is recommended to be conducted periodically following the implementation of pollution reduction initiatives to assess whether improvement is occurring.

6. **Special Funding** – This irrigation water quality issue has potential health implications for the general public and economic implications for the agricultural community. This is an issue that falls within the mandate of a number of Federal and Provincial Agencies. The complex nature of dealing with non-point source pollution means that additional resources may be necessary. It is recommended that the multi-agency committee working on this issue consider options to obtain funding for projects that will most effectively achieve safer RTE produce over the long-term.

7. **Epidemiological Research** – More work is recommended to clarify the relationship between irrigation water contamination, produce contamination, and disease incidence in human consumers. Development of a science-based criterion is highly advised, and may only be achieved through a pooling of stakeholder resources. It is suggested that Bacterial Source Tracking procedures be improved, so that contributions from various sources can be identified and quantified. This would greatly assist in determining remedial action priorities.

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