

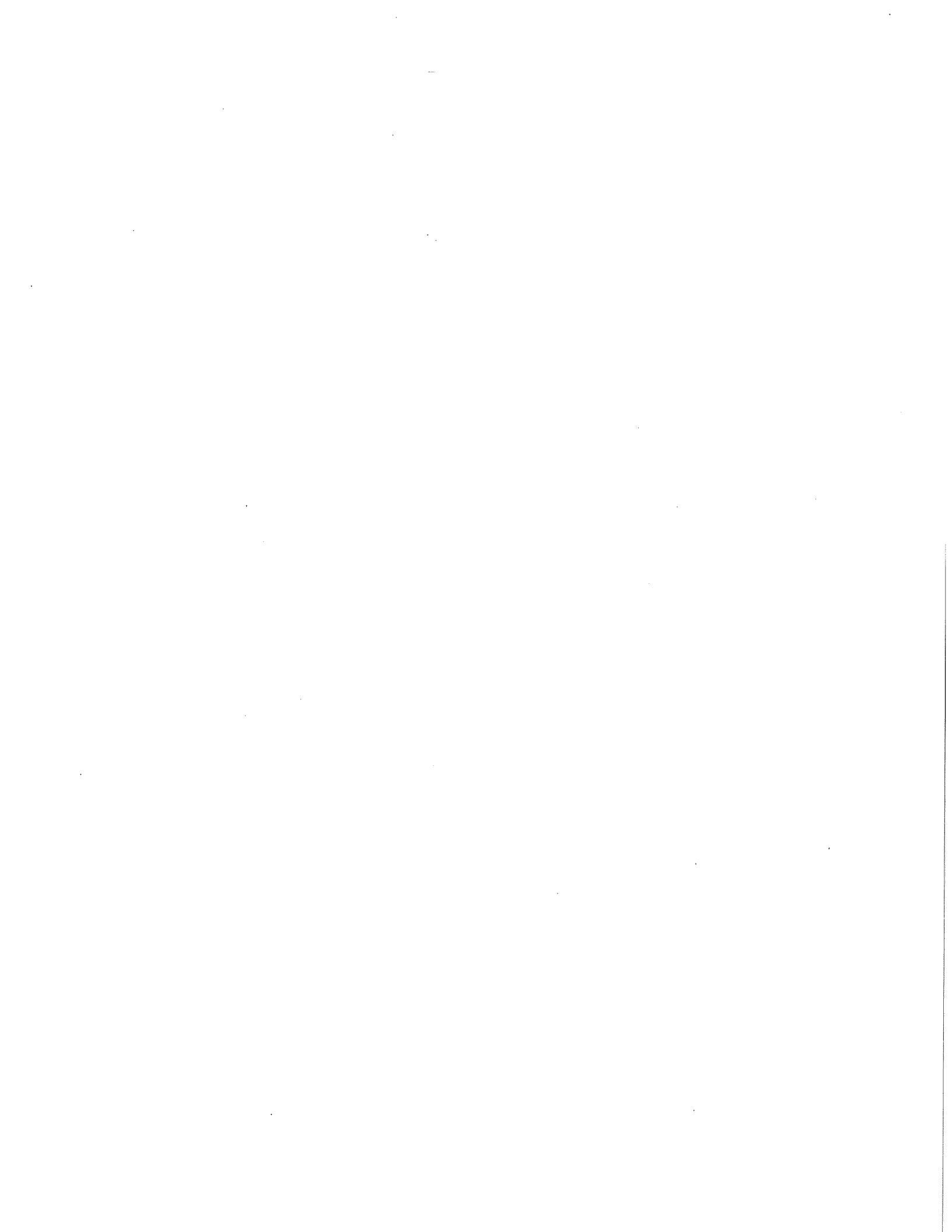


WASHINGTON STATE
DEPARTMENT OF
E C O L O G Y

**1998 Site Investigation
Bertrand Creek & Meadowdale Areas
Whatcom County, Washington**

**Study of Drinking Water
From Residential Wells**

October, 1999
Publication Number: 99-601



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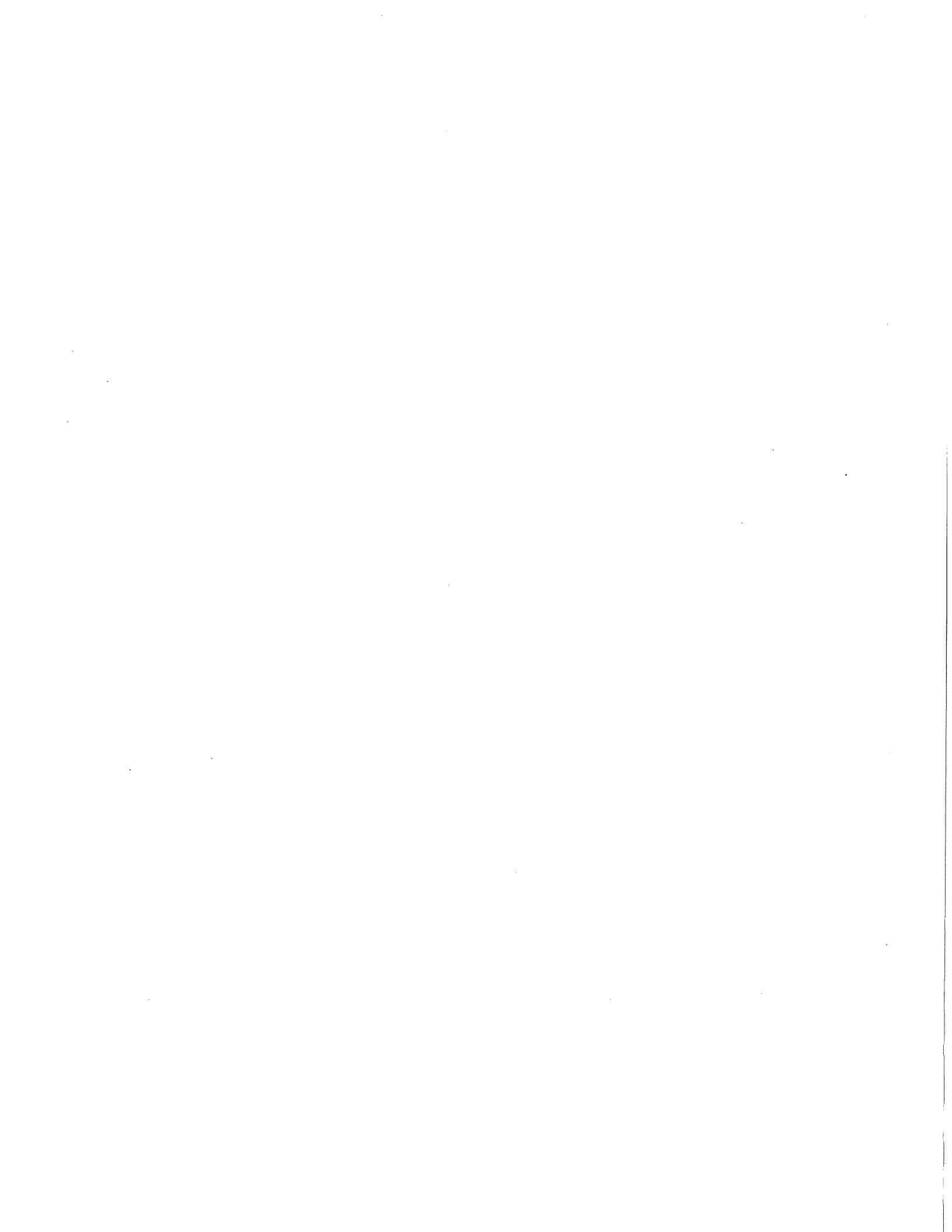
Errors appeared on two maps in Ecology's Publication 99-601 - 1998 Site Investigation, Bertrand Creek & Meadowdale Areas.

The errors appear in Figure 17 and Figure 25. (Please see back of page for copies of the maps.). A red dot in each of the maps should appear as a green dot.

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Sincerely,

Mary K. O'Herron
Project Manager
Bellingham Field Office



Washington State Department of Ecology

**1998 Site Investigation
Bertrand Creek & Meadowdale Areas
Whatcom County, Washington**

**Study of Drinking Water
From Residential Wells**

Principal Author: Mary O'Herron
Project Manager
Bellingham Field Office

October, 1999
Publication Number: 99-601

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Acronyms / Symbols

>	greater than
<	less than
ATSDR	Agency for Toxic Substances and Disease Registry
CAP	cleanup action plan
DBCP	1,2-dibromo-3-chloropropane
1,2-DCP	1,2- dichloropropane
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GPS	Global Positioning System
MCL	Maximum Contaminant Level (Drinking Water Standard)
MSL	mean sea level
MTCA	Model Toxics Control Act (RCW 70.105D)
ppb	parts per billion (ug/L)
ppm	parts per million (mg/L)
PQL	practical quantitation limit
RI	remedial investigation
SAIC	Science Applications International Corporation
TNC	transient non-community well
USGS	United States Geological Survey

Acronyms / Symbols (Cont'd)

VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
WAC	Washington Administrative Code
WCHHS	Whatcom County Health and Human Services
WDOA	Washington State Department of Agriculture
WDOH	Washington State Department of Health

Abstract

In 1998, the Washington State Department of Ecology conducted an investigation of drinking water from domestic wells in the Bertrand Creek and Meadowdale areas, near the City of Lynden in Whatcom County, Washington. Ethylene dibromide (EDB) had been detected in local wells during earlier surveys. It had been used as a fungicide (nematocide) for strawberry, raspberry and seed potato crops in the area until 1983. The investigation sought, by way of collecting and analyzing drinking water samples from individual households, to further define the nature, extent and potential for migration of fumigant-related contaminants. 123 sites were assessed for a variety of contaminants including EDB; 1,2-dibromo-3-chloropropane (DBCP); volatile organic compounds (VOCs) – including 1,2-dichloropropane (1,2-DCP); hardness; nitrate-nitrite; chloride; calcium; magnesium; sodium; potassium and total coliform bacteria. A subset of the residences' water samples were analyzed for acid herbicides and nitrogen-containing pesticides.

Results indicate that the area of concern may not have expanded or migrated significantly from what had been determined in the past and that concentrations of EDB observed appear to be lower than historical values. However, newly detected areas of concern may be the result of formerly unreported or undiscovered EDB application. The study also served to identify several additional domestic drinking water contaminants at levels which exceed the Drinking Water Standard, including 1,2-dichloropropane (1,2-DCP), nitrates and coliform bacteria.



Executive Summary

This report presents the results of the Washington State Department of Ecology's (Ecology) Site Investigation of chemical contamination in domestic drinking water wells in the Bertrand Creek and Meadowdale areas of Whatcom County. The Site Investigation was performed in general accordance with Washington Administrative Code (WAC) 173-340-350, Washington State Model Toxics Control Act (MTCA) RCW 70.105D requirements.

The Site Investigation sought, by way of collecting and analyzing drinking water samples from individual households, to further define the nature, extent and potential for migration of fumigant-related contaminants. The Site Investigation results are used as part of an assessment of current or potential future risks posed by fumigant-related contaminants to human health and the environment. This information has been used in an "options report" to evaluate potential remedial activity alternatives for the area.

Background

Ethylene dibromide (EDB) was a soil fumigant used as a nematocide to kill root worms in strawberry, raspberry, seed potato and other crops between the 1940s and 1983. It was also used in grain storage and as a component of leaded gasoline. In 1983, EPA banned EDB from agricultural use due to its nature as a probable human carcinogen.

In Washington, 1,2-dichloropropane (1,2-DCP) was used primarily as a soil fumigant for nematodes on berries and potatoes. Presently, the greatest use of 1,2-DCP is in chemical manufacturing; it is found in trace amounts in fumigants.

In 1984, investigations by several state agencies determined that four areas in the state had problems with EDB-contaminated drinking water. Whatcom County had two of these sites – one near Bertrand Creek and another in an area near Lynden known as Meadowdale.

Both the Meadowdale and Bertrand Creek areas had been found to have groundwater and/or drinking water contaminated with EDB. An Ecology report released on June 11, 1986 initially described Study Area A (Meadowdale) and B (Bertrand Creek). In 1992, the exact perimeter of each site was defined in a settlement agreement stemming from the 1988 lawsuit, *State of Washington v. Great Lakes Chemical*, in which Ecology sought recovery of costs associated with remedial activities at several EDB sites.

In the Meadowdale area northeast of Lynden, a Meadowdale Water Association well was found to be contaminated with EDB. The problem was resolved by connecting the water association to the City of Lynden system. In addition, a few homes in the Meadowdale study area that were not served by the Meadowdale Water Association were provided with bottled water when contamination was found.

In the Bertrand Creek area, a water line was not extended to serve the residents. Neither pre-existing water associations nor municipal systems were deemed feasible for extension of water services to the affected homes. Instead, bottled water for drinking and cooking was made available to households where EDB was known or suspected to be in the drinking water from domestic wells.

In December 1997 EDB-contaminated groundwater began to re-emerge as an issue, prompting a more current evaluation of area drinking water by Ecology and other agencies.

A number of agencies involved in investigations or studies of drinking water/groundwater conditions in northern Whatcom County began coordinating sampling efforts and the sharing of data. These agencies included the U.S. Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), the State Departments of Ecology (Ecology) and Health (WDOH), and Whatcom County Health and Human Services (WCHHS).

Ecology's investigation would help to determine the current drinking water status for wells serving (primarily) individual homes within the Bertrand Creek area and whether there was remaining contamination beyond the Meadowdale Water Association service area. Phase 1 of the study was designed to look at homes in and adjacent to areas where bottled water had historically been delivered. Phase 2 was designed to expand upon the information collected during Phase 1, new data from other agencies, and historic data regarding groundwater or drinking water conditions in both the Meadowdale and Bertrand Creek areas.

In June 1998, under contract with Ecology, SAIC (Science Applications International Corporation) began collecting drinking water samples in the Bertrand Creek area.

Site Investigation

All of the samples of domestic tap water were analyzed for EDB/DBCP, volatile organic compounds (VOCs) – including 1,2-DCP, hardness, nitrate-nitrite, chloride, calcium, magnesium, sodium, potassium and total coliform bacteria. A small subset of the residences' water samples were analyzed for herbicides and additional pesticides -- homes near to historical detections of these chemicals. All of the water sources were also tested in the field for pH, conductivity, turbidity, dissolved oxygen, and temperature.

Phase 1 – Bertrand Creek Study Area

Ecology's Phase 1 sampling took place during June and July 1998 and focused on the historic "bottled water delivery area." Ecology's contractor (SAIC) collected samples from 51 residences whose wells serve a total of 58 homes, along with a small grocery store, a church and several businesses.

Phase 2 – Bertrand Creek Study Area

Ecology's Phase 2 sampling took place during September and October 1998. Sampling focused beyond the historic "bottled water delivery area" in Bertrand Creek. Tap water was collected from homes where residents or owners were willing to participate in the study. SAIC collected samples from 63 residences in the Bertrand Creek area whose wells serve a total of 68 homes along with several small businesses.

Phase 2 – Meadowdale Study Area

During Phase 2, SAIC collected samples from eight households in the Meadowdale area where homes are not served by municipal water or community wells and where the USGS was not already collecting samples.

Sampling Summary

EDB – Ethylene Dibromide

The maximum amount of EDB allowed in drinking water (i.e., the Maximum Contaminant Level or MCL) is 0.05 ppb (parts per billion).

EDB was detected at levels greater than the 0.05 ppb MCL at 8 of the 123 locations sampled. EDB was detected at another 6 locations at levels below the MCL, but above the lowest level at which the chemical can be reliably measured using this analytical method (i.e., the Practical Quantitation Limit, or PQL, of 0.02 ppb).

EDB was found at levels greater than the PQL of 0.02 ppb in nine locations along Birch Bay-Lynden Road, east of the Bob Hall Road intersection. This was the same general area where it had been detected in the past. Six of those samples showed concentrations greater than the drinking water standard (MCL) of 0.05 ppb. Many additional homes to the east, north and west of these residences had no EDB detected in their wells. This suggests that the area of concern may not have expanded or migrated significantly from what had been determined in the past.

EDB was also found at levels greater than 0.05 ppb in two locations along Willeys Lake Road, nearly a mile south of the area where it had been found in the past. With the intervening groundwater flow interrupted or affected by one or both tributaries of Bertrand Creek, it is unlikely that the EDB detected here had migrated south from the Birch Bay-Lynden Road area. Instead, this suggests that the newly detected area of concern may be the result of formerly unreported or undiscovered EDB application and -- because historical sampling had occurred both to the west and east along Willeys Lake Road without detecting EDB -- provides support for earlier speculation that soil fumigant contamination was very localized.

No elevated EDB levels were detected in the Meadowdale area at the locations sampled.

1,2-DCP

The maximum amount of 1,2-DCP allowed in drinking water (i.e., the Maximum Contaminant Level or MCL) is 5.0 ppb (parts per billion).

1,2-DCP was detected at levels greater than the 5.0 ppb MCL at 6 of the 123 locations sampled. 1,2-DCP was detected at another 28 locations at levels below the MCL, but above the practical quantitation limit (PQL) of 0.25 ppb.

1,2-DCP was detected at levels greater than the PQL of 0.25 ppb in 19 locations along Birch Bay-Lynden Road and the southernmost part of Bob Hall Road. Four of those samples showed concentrations greater than the drinking water standard of 5.0 ppb. Because it was detected at such a large number of locations during the Phase 1 testing, additional testing was conducted during Phase 2 to determine more fully the extent of 1,2-DCP contamination. It was then found at levels above the PQL of 0.25 ppb at an additional 13 sites in the Bertrand Creek area, including 2 sites where concentration of 1,2-DCP was found to be greater than the MCL of 5.0 ppb..

1,2-DCP was also detected at levels greater than the PQL of 0.25 ppb in two locations in the Meadowdale area. Neither of those samples showed concentrations greater than the drinking water standard of 5.0 ppb.

Additional tests

In addition to the soil fumigants, a number of other contaminants were detected that affect drinking water quality. One hundred and eighteen of the 123 sampling locations tested had nitrate present, 48 above the MCL. Seventy-eight of the 123 sampling locations had coliform bacteria present, nine with E.coli detected. In addition, a long menu of other chemicals were detected in samples from one or more of the locations, though none at levels greater than the drinking water standard.

Recommendations

Several data, education and monitoring needs have emerged. The following specific needs have been identified for consideration and discussion by citizens and government agencies involved with groundwater issues in northern Whatcom County.

- Conduct an objective analysis of water supply, treatment and filtration options to help select the option(s) best suited for the north Whatcom County EDB and 1,2-DCP contamination problems.

- Work with local governments to select the preferred remedial action(s) by September 1999.
- Complete final remedial action project design, depending on alternative(s) selected following completion of the consultant's options report.
- For households where the levels of EDB and/or 1,2-DCP exceed the MCL, take appropriate interim action (such as the use of carbon shower filters) to minimize dermal and inhalation exposure pathways until remedial action plan can be completed and implemented.
- Evaluate the bottled water delivery program in view of both new and historic data to assure that, until a remedial action plan can be implemented, all households that should be included in the water program are offered the opportunity to participate.
- Collect and analyze additional samples of domestic drinking water from homes south of the southern boundary of the original Bertrand Creek site. Homes near households where EDB was detected at levels greater than the PQL, and homes downgradient from these locations, should have their drinking water sampled and analyzed.
- Conduct follow-up sampling at un-tested homes in the Bertrand Creek area near households where 1,2-DCP was detected at levels greater than 50 percent of the drinking water standard and/or EDB was detected at levels greater than the PQL.
- Conduct follow-up sampling at un-tested homes in the Meadowdale area near households where 1,2-DCP was detected at levels greater than 50 percent of the drinking water standard and/or EDB was detected at levels greater than the PQL.
- Collect additional samples of domestic drinking water from un-tested homes outside of the Meadowdale and Bertrand Creek areas near locations where 1,2-DCP was detected at levels greater than 50 percent of the drinking water standard and/or EDB was detected at levels greater than the PQL.
- Plans for additional sampling should be shaped by findings from studies conducted by all agencies working in the area.
- Implement a monitoring program in areas where EDB and/or 1,2-DCP have been detected. Follow-up sampling should continue on a regular basis at all locations where EDB or 1,2-DCP has been detected.
- In the event that new source areas may be discovered, expand sampling and monitoring programs to include additional households.
- Implement or strengthen existing education and outreach programs regarding domestic well maintenance and health issues. Most existing regulations do not apply to domestic

wells that serve only one household. Homeowners should be made aware of the hazards commonly associated with rural domestic wells and provided with information about pollution prevention and detection activities that they can do themselves.

- Conduct research into the relationship between groundwater and tap water analytical results. In the meantime, caution should be exercised in using drinking water analytical results to draw conclusions about groundwater contamination numbers (or vice versa).
- Collect samples from water association wells and transient non-community (TNC) water system wells in the areas of concern, and take necessary actions based on findings. (Note: WCHHS and WDOH collected samples from all six of the local TNC wells by June, 1999.)

1.0 Introduction

This report presents the results of the Washington State Department of Ecology's (Ecology's) Site Investigation of chemical contamination in domestic drinking water wells serving primarily individual households in the Bertrand Creek and Meadowdale areas of Whatcom County. The Site Investigation was performed in general accordance with Washington Administrative Code (WAC) 173-340-350, Washington State Model Toxics Control Act (MTCA) RCW 70.105D requirements.

1.1 Background

Ethylene dibromide (EDB) was a soil fumigant used as a nematocide to kill root worms in strawberry, raspberry, seed potato and other crops over a period of several decades. It was also used in grain storage and as a component of leaded gasoline. In 1983, it was banned from agricultural use by the U.S. Environmental Protection Agency (EPA) due to its nature as a probable human carcinogen.

In 1984, investigations by several state agencies determined that four areas in the state had problems with EDB-contaminated drinking water. Two of the sites were located in Whatcom County. The other two were in Skagit and Thurston counties.

The collective historical designation for the Whatcom County areas has been the "Whatcom EDB Site" in the state Toxics Cleanup Site Inventory. That site is actually comprised of two "study areas" designated in 1984 – the Meadowdale Study Area and the Bertrand Creek Study Area. Both the Meadowdale and the Bertrand Creek study areas had been found to have groundwater contaminated with EDB.

Both sites are near the City of Lynden. The Meadowdale study area is northeast of the city and the Bertrand Creek study area is west of the city. (See Figure 1.) An Ecology report released on June 11, 1986² first described them as Study Area A (the Meadowdale study area) and Study Area B (the Bertrand Creek study area). In 1992, the exact perimeter of each area was defined in a settlement agreement stemming from a 1988 lawsuit Ecology filed against a manufacturer of EDB (Great Lakes Chemical).

In the Meadowdale Study Area, a Meadowdale Water Association well had been found to be contaminated with EDB. The water association, which served about 75 homes and a number of dairies, was connected to the City of Lynden water system in 1988 with funding by Ecology. In addition, a few homes in the Meadowdale study area with EDB-contaminated well water (but not served by the Meadowdale Water Association) were provided with bottled water.

² Black and Veatch, 1986

In the Bertrand Creek Study Area, no pre-existing water system could be modified to cost-effectively serve a limited number of households which had EDB-contaminated drinking water. Instead, Ecology began a program to deliver bottled water for drinking and cooking to households where EDB was known or suspected in domestic well water.

The issue of EDB-contaminated groundwater began to re-emerge in December 1997. At that time, with the appointment of a new Ecology site manager in the agency's Bellingham Field Office and inquiries from property purchasers in the area, the need to both update the bottled water program and to review the site files became apparent. With subsequent interest in the issue of groundwater contamination generated by a local U.S. Geological Survey (USGS) study and citizen questions about the incidence of childhood leukemia in portions of northern Whatcom County, it was determined that a more current evaluation of the drinking water should be conducted.

In February 1998, County Executive Pete Kremen directed Whatcom Health and Human Services to take the lead in north county groundwater issues. Additionally, in February 1998, EPA received a citizen's petition requesting that it conduct a preliminary assessment of areas where improper storage/dumping/burial of pesticides and/or pesticide containers allegedly took place.

A number of agencies – Ecology, EPA, U.S. Geological Survey (USGS), Washington State Department of Health (WDOH), and Whatcom County Health and Human Services (WCHHS) – were interested in sampling drinking water or groundwater in the northern county. The agencies agreed to meet regularly, to coordinate their activities and to share sampling data.

As a part of this coordination effort, it was determined that Ecology would focus its sampling in the Meadowdale and Bertrand Creek areas while USGS and WDOH would focus most of their sampling outside of those areas. EPA focused its investigation on those locations identified in the citizens petition, on other potential contaminants source areas it identified during its investigation and on an area-wide groundwater grid sampling effort ... all primarily in the Bertrand Creek area.

Ecology undertook an investigation to determine the quality of drinking water within the Bertrand Creek area and – with some limited follow-up sampling – whether contamination problems existed in the Meadowdale study area beyond the Meadowdale Water Association service area.

Phase 1 of the study was designed to look at homes in and immediately adjacent to the area where bottled water had historically been delivered.

Phase 2 was designed to expand upon the information collected during Ecology's Phase 1, on data provided by other agencies, and on historic groundwater and drinking water data.

In the spring of 1998 Ecology contracted with SAIC (Science Applications International Corporation) to collect the drinking water samples. Sampling began on June 15, 1998.

1.2 Purpose

The Site Investigation sought, by way of collecting and analyzing drinking water samples from individual households, to further define the nature, extent and potential for migration in groundwater of the fumigant-related contaminants EDB and 1,2-DCP. The Site Investigation results are used to assess current or potential health and environmental risks posed by those fumigant-related contaminants and to evaluate remedial action alternatives.

The Site Investigation, and the subsequent assessment of water source and treatment alternatives, will be used to develop an action plan describing the design, construction, operation, maintenance and monitoring of remedial activities. Most operation, maintenance and monitoring activities would need to continue until the site was determined to be "clean" and was removed from the state's Hazardous Sites List. A site may be removed from the state's Hazardous Sites List after cleanup or remediation is complete and Ecology determines that cleanup standards have been met.³

1.3 Objectives and Scope of Work

The objectives of this Site Investigation were to collect and analyze sufficient information to assess the nature and extent of drinking water contaminants in the Bertrand Creek study area and in a representative number of homes in the Meadowdale area, and to enable the selection of a remedial alternative. Steps taken to accomplish this goal are summarized below.

- Collect samples of tap water from households and evaluate whether EDB contamination is present.
- Include analysis for other potential contaminants in addition to EDB to provide a more complete profile of the condition of each household's well water.
- Choose target analytes based on an assessment of historical files and input from other agencies.
- Compare current and historic drinking water data from Bertrand Creek households that are in (or adjacent to) areas historically known to have EDB-contaminated domestic drinking water (the "bottled water delivery area").

³ For the Bertrand Creek-area, remedial actions will be targeted at eliminating or greatly reducing human health risks associated with domestic use of contaminated water. Actual "cleanup" of the groundwater aquifer underlying the Bertrand Creek and Meadowdale sites is neither technically nor financially feasible, though "natural attenuation" is expected to eventually eliminate or greatly reduce EDB and 1,2-DCP contaminant levels.

- Evaluate Phase 1 analytical data, along with information from other agencies' studies and from homeowner analytical results, to determine if specific households beyond the previously defined delivery area should have their drinking water tested during Phase 2.
- Collect samples and assess the chemical quality of household drinking water from a representative number of domestic wells in the Bertrand Creek area (but outside of the current "bottled water delivery area") to determine whether EDB contamination has expanded beyond the originally established contamination boundaries.
- Evaluate the Meadowdale study area to determine if there are residences that are not being served by the Meadowdale Water Association (or other group water sources) but are, instead, relying on individual domestic wells.
- Assess the chemical quality of household drinking water from a representative number of domestic wells in the Meadowdale area to determine whether EDB contamination exists outside of the Meadowdale Water Association service area.
- Assess the chemical quality of household drinking water from selected households for an expanded list of analytes – including pesticides and herbicides – that historically had been detected in those or neighboring wells.
- Coordinate Ecology's sampling of the Bertrand Creek and Meadowdale areas with studies conducted by other agencies throughout Whatcom County to minimize duplication of effort and to avoid potential problems associated with multiple agencies seeking property access.
- Use data collected by other agencies to supplement the study results and to achieve a more thorough picture of groundwater in northern Whatcom County.

Site Investigation field data and analysis activities were conducted from June through December 1998. The following sections of this report present the Site Investigation results.

2.0 Study Area Background

2.1 Location and General Description

The "Whatcom EDB Site" is comprised of two sub-sites – the Bertrand Creek Study Area (also known as Study Area B) and the Meadowdale Study Area (also known as Study Area A). (See Figure 1.)

Bertrand Creek Study Area

The Bertrand Creek study area is located in Whatcom County, Washington. It lies three miles to the west of the City of Lynden and about two miles northeast of Interstate 5. It is semi-rural and contains approximately seven square miles of agricultural properties and light residential development. (See Figure 2.) The 1992 *State of Washington v. Great Lakes Chemical* settlement defines the Bertrand Creek Study Area (Area B) as:

The 'Bertrand Creek' site in Whatcom County refers to Sections 14, 21, 22, 23, 26, 27 and 28, Township 40 N., Range 2E., West Meridian.

It lays at approximately 80 feet above mean sea level (MSL) and is relatively flat. Its highest point is in the northeast (at 100 ft. above MSL) and it then slopes gradually to the south and southeast to the lowest point (at 50 ft. above MSL).

The principal study area surface water features include parts of Bertrand and Dakota creeks and their tributaries which drain to the Nooksack River to the south and southeast. (For additional information regarding creek habitat, see Appendix A.)

Approximately 20 percent of the Bertrand Creek geographic area is served by the Berthusen Water Association which obtains its water from the City of Lynden. An additional 10 percent of the area is served by community wells. The homes in the remaining 70 percent of the area use private, domestic wells.

A City of Lynden park and campground (Berthusen Park) is located within the Bertrand Creek area, near the intersection of West Badger and Berthusen Roads. Water at the campground is provided by the City of Lynden via the Berthusen Water Association. Also within the Bertrand Creek area are two temporary farm worker housing camps. The camp on Birch Bay-Lynden Road is served by a community well; the Loomis Trail Road camp is served by the Berthusen Water Association.

Meadowdale Study Area

The Meadowdale study area is located to the northeast of the City of Lynden in Whatcom County, Washington, about eight miles northeast of Interstate 5. The southwest corner of the area overlaps the Lynden city limits. It is semi-rural and contains approximately four square

miles of agricultural properties and light to moderate residential development. (See Figure 4.) The 1992 *State of Washington v. Great Lakes Chemical* settlement defines the Meadowdale Study Area (Area A) as:

The 'Meadowdale' site in Whatcom County refers to Sections 9, 10, 15 and 16, Township 40 N., Range 3E, West Meridian.

It lays at approximately 120 feet above MSL and is relatively flat. Its highest point is in the northeast (at 135 ft. above MSL) then slopes gradually to the south and southeast to the lowest point (at 50 ft. above MSL).

The principal study area surface water features include parts of Fishtrap and Kamm creeks and their tributaries which drain to the Nooksack River to the south . (For additional information regarding creek habitat, see Appendix A.)

Approximately 20 percent of the Meadowdale geographic area is served by the Meadowdale Water Association which obtains some of its water from the City of Lynden and the rest of its water from a well on the Van Buren Road. An additional 30 percent of the area is served directly by City of Lynden municipal water. The homes in the remaining 50 percent of the area use individual domestic wells.

A private campground (KOA) is located within the Meadowdale area, near the intersection of Line and Kamm Roads. Water at the campground is provided by the City of Lynden. Also within the Meadowdale area is one temporary farm worker camp which is served by its own (TNC) well.

2.2 Historical, Current and Proposed Land Uses

Historically, the area has been agricultural. In the past, the major crop in the area had been strawberries. In 1984⁴, Whatcom County was described as having 550 acres of berry farms that yielded more strawberries than any other county in the state. Bellingham Herald newspaper reports in 1984 described the use of EDB in the area.

Soil on more than 416 acres of Whatcom County farmland was fumigated with the chemical EDB in the last three years ... (according to the state Dept. of Agriculture)... More than 69 acres in Whatcom County were treated with EDB in 1981, at least 32 acres of strawberry fields and 37 acres of potato fields. The precise figure isn't known because records were not available for sales by the bankrupt Farmers Co-op. ... In 1982, 124 acres were treated ... 116 were strawberry and eight

⁴ Bellingham Herald 2/15/84 "Berry fields checked for EDB" by Donald Tapperson and Andy Fernando and Bellingham Herald 3/18,84 "EDB use on Whatcom fields pinpointed" by Donald Tapperson.

raspberry. That rose again last year to 223 acres, of which 200 were strawberry and the remainder raspberry fields.

Bert Brainard, then Director of Environmental Health for the Bellingham-Whatcom County Health Department, was quoted as saying that most fields that were treated commercially were in the area of Birch Bay and Loomis Trail Roads, around Northwest Road, between West Pole and Piper roads, and northeast of Lynden.

Bertrand Creek Study Area

Currently, the Bertrand Creek study area contains approximately seven square miles of mixed light-residential and agricultural properties. (See Figure 2.) It lays to the west of the Lynden Urban Growth Area. (The western edge of the Lynden Urban Growth Areas lays directly to the east, and adjacent to, Section 23 and part of Section 26.)

Most construction and infrastructure development has occurred along the edges of each section with the section-centers mostly devoted to agriculture. Aside from a few small housing developments, all roads (and thus, all housing) tend to follow along the section lines.

The main agricultural crop in the area is raspberries. Whatcom County is one of the largest producers of raspberries in the nation and the Bertrand Creek area is part of a larger, berry-growing zone in the northern county.⁵ Seed potatoes and other field crops (such as cucumbers and strawberries) are also grown in the area. In addition, there is a small nursery, two dairies, and small herds of horses, beef cattle and dairy calves

Several small businesses operate in the Bertrand Creek study area, including a door manufacturer, a meat processor, a beauty salon, a glazier, a spa-cover distributor and a grocery/gas station.

Meadowdale Study Area

The Meadowdale area contains approximately four square miles of mixed agricultural properties and light-to-moderate residential development, with the southwest corner of the area overlapping the Lynden City Limits. (See Figure 4.)

The Meadowdale area lays to the northeast of (and overlaps in parts of Section 15 and 16) the Lynden Urban Growth Area. Further expansion of the city limits into the Meadowdale area is currently being considered⁶, including 194 acres between the eastern right-of-way of Line Road and the current Lynden city limits, from East Badger Road to include about 40

⁵ Brun, 1997.

⁶ Bellingham Herald, 5/12/99 - "The Lynden Planning Commission has recommended that the City Council approve a request from Line Road Properties LLC to annex 194 acres into the city. The property is between the eastern right-of-way of Line Road and the current

acres south of Bradley Road, and property south of Kamm Road, about one-fourth mile east of Line Road.

Most of the construction outside of the Urban Growth Area has occurred along the edges of each section with the section-centers mostly devoted to agriculture. Within the Urban Growth Area, especially within the Lynden city limits, this is an area of moderately dense housing development criss-crossed by many small residential surface streets and serviced by City of Lynden utilities. Outside of the Urban Growth Area, aside from a few small housing developments, roads (and thus, housing) tend to follow along the section lines, leaving the section-centers mostly in agricultural use.

The main agricultural crop in the area is raspberries. Strawberries and other field crops (such as rhubarb and blueberries) are also grown in the area. In addition, there are a number of dairies and a small nursery.

Several small businesses operate in the Meadowdale area, including an upholstery shop, a private campground and a grocery/gas station. There is also a public high school, a private grade school and several churches in the area.

2.3 Site Physical Characteristics

2.3.1 Meteorology

Meteorological data provide a framework for our understanding of study area hydrology and hydrogeology. Seasonal precipitation and evaporation trends control or strongly influence study area surface water, groundwater, flow patterns, surface water/groundwater interaction, and contaminant migration via the groundwater pathway.⁷

Climate and Precipitation

The climate of the survey area is influenced by winds from the Pacific Ocean. During summer, rainfall is extremely light, so crops growing actively during this period need irrigation. Often several weeks pass without precipitation. During the rest of the year, rains are frequent, especially in the late fall and winter.

Lynden City limits, from East Badger Road to include about 40 acres south of Bradley Road, and property south of Kamm Road about one-fourth mile east of Line Road.”

⁷ Meteorological data presented here were acquired from the “Soil Survey of Whatcom County Area, Washington.”

In most winters one or two storms contain strong and sometimes damaging winds, and in some years the accompanying heavy rains cause serious flooding. In winter, the average temperature at Clearbrook (the nearest weather station) is 38 degrees F. and, in summer, the average temperature is 61 degrees F.

The total amount of precipitation is about 46 inches at Clearbrook. Of this, 30 percent usually falls in April through September. The growing season for most crops falls within this period.

The average seasonal snowfall is 19 inches at Clearbrook. On the average, two or fewer days have at least one inch of snow on the ground. The number of such days varies from year to year.

The average relative humidity in mid-afternoon is about 60 percent.

2.3.2 Geology and Soils

Geology

The Bertrand Creek and Meadowdale areas are located in the central portion of the Fraser Lowland, a topographic basin north of the Puget Lowland that extends into British Columbia (Crandell, 1965). As reported by Black & Veatch (1986) and others, the Fraser Lowland is characterized by glacially derived landforms and soils. At least four episodes of glacial advances are recognized in this region. In the Bertrand Creek and Meadowdale areas, only deposits of the youngest of these glacial advances are exposed. The thickness of unconsolidated glacial deposits, resulting from the Fraser and earlier glacial episodes, ranges from 800 to 1,200 feet in the region (Hall and Othburg, 1974).

As summarized by Black & Veatch (1986), ice from the Sumas Stade pushed into the eastern portion of the Fraser Lowland about 11,000 years ago. Meltwater streams associated with that advance built an outwash plain of glacial material southward. The outwash is predominantly sand near Lynden where it meets the modern Nooksack alluvium, and is clay and silt at its far western end. The Bertrand Creek and Meadowdale areas are both located on the Lynden Terrace, which slopes gently toward the south or southwest. The southern margin of the terrace is a Holocene erosional scarp, cut by the Nooksack River into the outwash plain.

Soils

Soil material in the Lynden study area consists predominantly of Lynden-Hale-Tromp soils, as described by the U.S. Department of Agriculture, Soil Conservation Service.⁸ They are

⁸ U.S. Department of Agriculture/Soil Conservation Service, 1992.

generally deep to very deep, well-drained to somewhat poorly drained and occur on outwash terraces and moraines in the area.

Lynden sandy loam is very deep, well drained soil on outwash terraces. It supports native vegetation that is mainly conifers and shrubs. Typically, the surface layer is dark brown sandy loam eight inches thick. The subsoil is dark brown sandy loam ten inches thick. The substratum is variegated sand. The depth to sand ranges from 14 to 24 inches. Permeability is moderately rapid in the upper part of the Lynden loam and very rapid in the substratum. Available water capacity is moderate. Runoff is slow and the hazard of water erosion is slight.

Hale silt loam is very deep, somewhat poorly drained soil on outwash terraces. It supports native vegetation of mainly trees and shrubs. Typically, when mixed to a depth of eight inches, the soil is dark brown silt loam. The subsoil is light olive brown, mottled loam eight inches thick. The substratum, to a depth of 60 inches, is mottled sand. The depth to sand or loamy sand ranges from 15 to 30 inches. Permeability is moderate in the upper part of the Hale soil and very rapid in the substratum. Available water capacity is moderate. Runoff usually is very slow and the soil may be ponded during the winter. There is little or no hazard of erosion.

Tromp loam is very deep, moderately well drained soil also on outwash terraces. It supports native vegetation of mainly conifers and shrubs. Typically, the surface layer is dark brown loam 11 inches thick. The upper nine inches of the subsoil is dark brown and brown loam. The lower six inches is weakly cemented, dark yellowish brown, mottled sandy loam. The upper 20 inches of the substratum is weakly cemented, olive brown, mottled sand. The lower part to a depth of 60 inches is grayish brown and dark grayish brown, mottled sand. The depth to sand ranges from 14 inches to 30 inches. Permeability is moderate in the upper part of the Tromp soil and very rapid in the substratum. Available water capacity is high. Runoff is very slow, and there is little or no hazard of erosion.

2.3.3 GROUNDWATER

Wells within the Bertrand Creek and Meadowdale areas draw from a shallow unconfined aquifer. Water levels are generally within 6 to 33 feet of the ground surface. Ground water recharge comes primarily from precipitation that percolates through the permeable glacial and alluvial deposits. Approximately 49 inches of precipitation falls in the study area annually (Black & Veatch, 1986). The regional ground water flow direction is generally from the uplands in the north toward the Nooksack River in the south.

Agricultural practices and other land uses in the area have been shown to have an impact upon water quality. There is little or no natural geologic protection of the shallow aquifer

from infiltration of surface waters, therefore runoff from fields and stockyards can easily enter the shallow ground water system (Black & Veatch, 1986)

A 1988 report (Creahan) describes a study in which more than 100 wells in each site were measured in March 1987 and again in September 1987. Results showed that in the:

Meadowdale area: Most water table elevations were lower in September, as expected, following the drier summer months. Although flow direction is generally southward, there were local variations in direction. The only seasonal difference in the hydraulic gradient was observed in the northeast where the gradient was slightly steeper in March than in September.

Bertrand Creek area: There are minor seasonal changes in water table elevations and negligible seasonal change in ground water flow direction. The flow direction is generally southward, but there is more variability in flow direction in the Bertrand Creek area than in the Meadowdale area. The upstream-pointed water table surface contour lines along Bertrand Creek show clearly that ground water is flowing toward, and discharging to, the creek.

The average flow velocities calculated in Meadowdale ranged from 0.5 m/day (meters per day), in the northwest and southeast, to 5 m/day along the Nooksack floodplain. In the Bertrand Creek area, the average velocities were estimated to range from 0.5 m/day in the north to 2.5 m/day along the southern edge of the Lynden Terrace (Creahan, 1998).

These estimates should not be construed to provide meaningful information concerning the distance traveled by EDB, or other contaminants, through the aquifer. They may, however, assist in providing a first-order estimate as to a suggested radius of any investigation designed to delineate the extent of contamination downgradient from known area or point-sources of contamination. Any additional investigative work concerning the migration of contaminants should include aquifer tests in each of the sites in order to define the transmissivity, or hydraulic conductivity, and storage coefficient of the aquifer.

(For a more thorough assessment of the area hydrogeology, see Appendix B.)

3.0 Initial Evaluation

Sections 3.1 and 3.2 summarize events and the investigations which occurred in the area prior to the 1998 Site Investigation. Section 3.1 discusses events and investigations which occurred prior to winter 1997. Section 3.2 discusses events and investigations which occurred after winter 1997, but prior to (or concurrent with) the Site Investigation. Data from these investigations were evaluated to identify areas requiring further information during the Site Investigation. Section 3.3 discusses the area from a regulatory standpoint.

3.1 History Prior to 1997

Ethylene dibromide (EDB) was a chemical that the EPA ordered withdrawn from agricultural use in 1983. Its main use had been as a fumigant for nematodes in soil where strawberries, raspberries and seed potatoes were to be grown. EPA's actions were based on evidence that EDB was a carcinogen in animals and a possible carcinogen in humans.

A number of state agencies – including the Department of Ecology, the Department of Agriculture (WDOA), and the Department of Social & Health Services (DSHS)⁹ – conducted groundwater investigations in those areas of the state where EDB had been used as a component of agricultural pesticides. Contaminated groundwater serving domestic wells was verified in three counties – Thurston (one site), Skagit (one site), and Whatcom (two sites). The two areas in Whatcom County were referred to as the Meadowdale Study Area (Study Area A) and the Bertrand Creek Study Area (Study Area B).

In June 1986 the state of Florida sued a manufacturer of EDB (Great Lakes Chemical) for contaminating water in 19 counties. Great Lakes Chemical settled for \$1.5 million but denied all allegations that EDB contamination was caused by its negligence.

In July 1986 Washington's Attorney General sought "injunctive relief to require defendant – Great Lakes Chemical Company – to investigate the extent of EDB contamination that has occurred from the use of its EDB products and to repair or remediate the damages caused." In 1987, Great Lakes Chemical offered the State of Washington a \$40,000 settlement, which was declined.

In 1988, the State of Washington filed suit against Great Lakes Chemical Company, seeking \$3.3 million to (among other items) remedy water problems of residents near Bertrand Creek, to recover costs incurred by Washington taxpayers for remediation activities at the four sites, and for damages to groundwater.

⁹ In 1990, the legislature created the Department of Health and directed to its authority several human and environmental health programs – including drinking water -- that previously had been under Department of Social and Health Services.

In December 1989, Great Lakes filed a motion for summary judgement based on federal preemption of states claims. The motion was denied. In 1990 the company offered to settle for \$150,000. Ecology responded with a settlement request of \$1.3 million. Great Lakes counter-offered a \$237,400 settlement. In 1991, the suit, *State of Washington v. Great Lakes Chemical*, proceeded to trial.

In January 1992, Ecology and Great Lakes reached a final settlement agreement of \$575,000. The agreement spelled out the legal boundaries of the four sites – Meadowdale (Site A) and Bertrand Creek (Site B) in Whatcom County (See Figures 1, 2 and 4) and one site each in Skagit and Thurston counties. The company was not released from liability for any future site discoveries.

By the time of the 1992 settlement, alternative drinking water sources were established by Ecology (in partnership with local governments) for all four sites. In Thurston County, a new well and delivery system was constructed to expand the service area of the Pattison Lake Water Association. In Skagit County, Ecology paid for a new water supply system for the Birdsview area.

In Whatcom County, the Meadowdale Water Association was hooked up to the City of Lynden's municipal water system and a new well was installed in the eastern portion of the Association's service area, away from known EDB contamination. The Bertrand Creek area was considered to be too sparsely populated and too far from the city to make a municipal water line economically feasible and, at the time, there were no pre-existing water association systems in the area deemed feasible for modification to supply the affected homes. Instead, residents in a subsection of the Bertrand Creek area where EDB-contaminated drinking water was known or suspected were offered the option of having bottled water delivered to their homes (with the expense to be covered under the state's toxic cleanup fund).

The exact location of the bottled water delivery area first appears in the site files in a 1989 Ecology memo. The memo proposes the addresses from 8100 to 8400 Bob Hall Road and 900 to 1300 Birch Bay-Lynden Road (encompassing the area of known contamination) as being eligible for the bottled water program.

The Meadowdale area continued to be sampled intermittently following hook-up of the Meadowdale Water Association to the City of Lynden water system. A series of sampling events took place in the Bertrand Creek area between 1984 and 1994. Almost all of them investigated whether EDB had contaminated groundwater or tap water. Some studies included sampling for additional chemicals. At some homes, domestic water sources were sampled many times, some only once, and some were never sampled at all. Some of the studies focused specifically on the Bertrand Creek area and some only sampled a few homes in this area as part of larger projects. For this reason, the historical data regarding the presence of chemicals in the groundwater is something of a patchwork, concentrating mostly on homes along Birch Bay-Lynden and Bob Hall roads, but also including information from other locations throughout and beyond the Bertrand Creek area.

Data appears to be most reliable for EDB-contamination. Some data collected between 1986 and 1990 indicates that there does not appear to be a significant fluctuation in concentration from season to season. However, there is some reason to believe that concentrations of EDB may vary somewhat in the wake of major rain events.

In addition to EDB, studies conducted between 1984 and 1994 indicate the presence in tap water or groundwater of a number of additional contaminants including: 1,2-DCP (dichloropropane), nitrates, dinoseb, TCE (trichloroethylene), methylene chloride (a possible lab contaminant), DBCP (1,2-dibromo-3-chloropropane), benzene, xylene, simazine, carbofuran, and 1,2,3-TCP (1,2,3-trichloropropane). Not all chemicals were found in all samples, and concentrations varied from greater than the drinking water standard (> the MCL) to barely detectable.

After EDB, the most commonly encountered chemical was 1,2-DCP (another nematocide). This chemical was used as a constituent of the soil fumigant Telone. It is currently a low-level contaminant (<1 percent) of the soil fumigant Telone II.

The history of Whatcom County EDB groundwater contamination and remedial action activities is long and complex. See Appendix C for a chronology of key events and/or milestones.

3.2 History: 1997 through May 1999

Starting in late 1997, interest in the quality of groundwater in this area had again come into focus.

At that time, responsibilities for the Whatcom County EDB site and other Whatcom County toxic cleanup sites were transferred to a new site manager in the Ecology Bellingham Field Office. The agency also began to receive inquiries from property purchasers in the area. These events prompted a review of the bottled water program and historical site files.

In 1997, the USGS was denied right-of-way access for groundwater sampling by Whatcom County government, at the urging of local raspberry growers.¹⁰ Around this same time, WDOH and WCHHS began to look into a possible increase in the incidence of childhood leukemia in northern Whatcom County.

In 1998, a citizens' petition requested EPA to conduct a preliminary assessment of allegations of improper handling of pesticides and/or pesticide containers that had been responded to by Ecology in the early 1990s. The Agency for Toxic Substances and Disease registry (ATSDR) also began investigations of human health and exposure issues in response

¹⁰ USGS had begun sampling in parts of Whatcom County in 1990 as part of a cooperative study with Whatcom County. The National Water Quality Assessment (NAWQA) came later. (See chronology.)

to both a citizens' petition and to Ecology's request for assistance. The same group of petitioner's asked ATSDR at the same time to look into health effects

In the spring of 1998, Ecology made the determination that a more current evaluation of the drinking water should be conducted.

As a number of different agencies – Ecology, EPA, USGS, WDOH, and WCHHS – were planning to undertake activities involving the Bertrand Creek area and/or northern Whatcom County, the project managers and agency personnel agreed to coordinate activities and to share their data.

As part of this coordinated effort, Ecology focused its sampling activities within the Bertrand Creek and Meadowdale areas. WCHHS and WDOH focused most of their sampling efforts outside of those areas. EPA planned to work in and around the Bertrand Creek area. The USGS planned to work in areas throughout northern Whatcom County.

As it became available, data from these agencies, historical analytical data, results from samples taken by local residents and chemicals identified in petitions to ATSDR and EPA were all factors which shaped the nature of Ecology's investigations.

The results of these pre-Site Investigation assessments are summarized as follows:

- Preliminary USGS data (1997) showed the presence of 1,2-DCP in groundwater east of the Loomis Trail/Weidkamp Road intersection and along Birch Bay–Lynden Road.
- A draft (1998) Sumas-Blaine Aquifer report shows moderately high to high nitrate and chloride levels in the area. (See Figure 7.)
- A number of homeowners in the area had sampled their own wells. One, on Loomis Trail Road, found 1,2-DCP and 1,2,3-TCP. One, on Weidkamp Road, found EDB, 1,2,3-TCP and 1,2-DCP.
- WDOH had sampled drinking water at several homes in the area (1993/94). One home on Loomis Trail Rd., east of the Loomis Trail/Weidkamp intersection, had a number of contaminants present. These included EDB, 1,2-DCP, dinoseb, DBCP, benzene, xylene, simazine, 1,2,3-TCP and carbofuran.
- The citizens' petition received by EPA identified three contaminants of concern – EDB, 1,2-DCP and 1,3-Dichloropropene (1,3-DCP).
- The citizens' petition received by ATSDR identified several contaminants of concern -- EDB, 1,2-DCP, 1,3-DCP, atrazine, simazine and carbofuran.
- Preliminary field analytical results of groundwater samples collected in relation to the 1998 EPA investigation tentatively confirmed the historical EDB data along Birch Bay-

Lynden Road and also showed high concentrations of 1,2-DCP near the Bob Hall/Birch Bay- Lynden intersection and along Loomis Trail Road.

3.3 Potentially Hazardous Substance Sources

The issue of contaminant source was addressed during earlier investigations and as part of the 1988 lawsuit brought by Ecology against Great Lakes Chemical (settled in 1992).

Additional questions about contaminant sources arose during a 1992 investigation by Ecology regarding allegations of improper handling or disposal of agricultural pesticides and herbicides. Unresolved at that time, the investigation of these allegations was re-opened in 1998 by the EPA, prompted by a citizens' petition. The 1998-99 EPA study (Bertrand Creek Properties, Site Investigation Report, Lynden, Washington) took place concurrently with the Ecology Phase 1 and Phase 2 investigations.

Neither the earlier Ecology investigations nor the 1998 EPA investigation identified any specific point-source for the EDB and 1,2-DCP groundwater contamination. The source of these chemicals in groundwater (and thus, in drinking water) appears to have been through agricultural application. Specifically, the 1999 EPA Site Investigation report concluded that:

No evidence of illegal dumping or burial of pesticides or pesticide containers was found at the areas investigated during this field effort.

The groundwater contamination at this site could have been caused by agricultural application of pesticides on fields.

As for other chemical contaminants discovered in the course of these investigations, the potential sources are varied. Few additional contaminants were seen at more than one or two sampling locations. Some appear to be linked to either current or historic pesticide application. Others appear to be potentially linked to activities and sources such as plumbing repair (PVC pipe adhesive), farm fuel tanks, vehicle repair/maintenance, and wood preservatives in new construction. (See Appendix D for a list of chemical uses.)

Coliform bacteria, seen in many of the samples, have been characterized by WCHHS as a common problem in rural residential wells. Nitrate, also seen in many of the wells, appears to be associated with agricultural activities. Recent studies¹¹ have concluded that raspberries and dairy were the most frequently identified land uses upgradient of wells that exceeded the drinking water standard of 10 mg/L nitrate.

¹¹ Erickson, 1998.

4.0 Investigation Activities

4.1 General

The objective of this Site Investigation was to collect, develop and analyze sufficient information to enable selection of a remedial alternative. The Site Investigation assessed the nature and extent of drinking water contaminants throughout the Bertrand Creek site and in representative samples from the Meadowdale area. The following Site Investigation activities were performed to supplement data generated during the previous investigations summarized in Section 3.0:

- Review current and historical data to identify contaminants of concern and locations where these contaminants have been detected in the past.
- Solicit volunteers to participate in the sampling program and obtain permission to collect drinking water samples. Emphasis was placed on obtaining volunteers from households where historic or current data indicated the presence of EDB and/or 1,2-DCP. In Phase 1, emphasis was placed on obtaining as many volunteers as possible. In Phase 2, emphasis was placed on obtaining a fairly even distribution of samples from throughout the Bertrand Creek and Meadowdale areas.
- Collect samples of water from all possible domestic drinking water wells in the Bertrand Creek area where EDB contamination had historically been detected or suspected. Analyze the samples for contaminants of concern.
- Collect samples of water from a representative number of domestic drinking water wells in the Bertrand Creek area, but outside of the vicinity where EDB had historically been detected. Analyze the samples for contaminants of concern.
- Collect samples of water from a select number of domestic drinking water wells in the Meadowdale area. Analyze the samples for contaminants of concern.
- Collect samples of water from a select number of domestic drinking water wells in the Bertrand Creek area where specific herbicides and pesticides had been detected in the past. Analyze samples from these wells, and those of neighboring households, for these additional contaminants.
- Coordinate sampling activities with those of EPA, USGS, WDOH and WCHHS.
- Summarize Ecology's sampling data and the results of analyses conducted by other agencies.

SAIC, as a consultant contracted by Ecology, performed Site Investigation field activities in general accordance with our Site Investigation Work Plan (April 1998). Appendix E discusses field investigation procedures in detail.

Activities are summarized below.

4.2 Phase 1 – Bertrand Creek Study Area

In order to fully assess the current status of an area where EDB had been detected in the past, Ecology made a deliberate effort to obtain drinking water samples from all homes in and adjacent to the historic “bottled water delivery area.” A list of known addresses was obtained from site records and updated during a site visit. Following this, two Ecology teams went door-to-door in the area during the first week of June 1998.

Fact sheets and permission forms for the sampling event were provided in both English and Spanish. (See Appendix F for copies.)

Residents were provided with a fact sheet describing the planned sampling event, were asked if they would participate, and were asked to sign a permission form. If the resident was not at home at the time of the visit, a plastic bag (containing the fact sheet, permission form, and a stamped enveloped addressed to Ecology’s site manager) was taped to the door. If no reply was obtained by either of these methods, a letter was sent directly to the resident and (if applicable) to the landlord, inviting them to participate. The sampling began on June 15th, but additional volunteers were accepted through June 26th.

Only one location per well (with one exception) was included in the list of volunteers. Homes where the water was known to first pass through any type of water treatment system were eliminated from the pool of volunteer sites, as were all households that obtained their water from a community well.

Because the SAIC staff were able to modify their schedule to suit the needs of certain residents (i.e., one home could only be sampled from an indoor tap) and because of the intensive solicitation effort, participation in the Phase 1 sampling event was 92 percent (58 households out of 63 households contacted participated).

Ecology’s Phase 1 sampling took place during June and July 1998. Ecology’s contractor collected domestic drinking water samples from 51 residences whose wells serve a total of 58 homes, a small grocery store, a church, and several businesses in the Bertrand Creek area.

During Phase 1, sampling focused on the area historically referred to as the “bottled water delivery area.” It included that part of the Bertrand Creek study area where EDB contamination had historically been known or suspected. In addition, domestic water

samples were collected from residences up to ¼ mile to the north, east and west of the delivery area. (No homes with domestic wells were available to the immediate south.) Tap water was collected from all homes where the resident and/or owner was willing to participate in the study. (Five households declined to participate and did not have their water sampled by Ecology.) (See Figure 10.)

All of the samples of domestic tap water were analyzed for EDB/DBCP, volatile organics (VOCs) – including 1,2-DCP, hardness, nitrate-nitrite, chloride, calcium, magnesium, sodium, potassium and total coliform bacteria. A small subset of the residences also had their tap water analyzed for additional pesticides and herbicides -- homes near to where historical detections of these chemicals had occurred. All of the water sources were also tested in the field for pH, conductivity, turbidity, dissolved oxygen, and temperature.

Results were provided to the residents (in a series of three letters) as they became available.

At the request of Ecology, WCHHS notified residents of households where coliform samples had tested positive for E. coli.. These residents were contacted by phone within days of the sampling event.

(See Appendix F for example of letters, attachments and translations.)

4.3 Phase 2 – Bertrand Creek Study Area

As a result of the publicity that followed the Phase 1 sampling event, a number of other residents in the Bertrand Creek area contacted Ecology and asked to participate in the second round of sampling. In addition to these volunteers, Ecology again prepared a preliminary list of addresses and then had agency personnel go door-to-door to solicit volunteers for the sampling event. In areas where existing data indicated that contaminated groundwater might be present (near the intersection of Loomis Trail and Weidkamp roads) all residents were asked to participate. Throughout the remainder of the Bertrand Creek area, rather than asking all residents to participate, Ecology attempted to obtain a representative distribution of sampling sites while limiting their total number to approximately 65. Homes where the USGS had arranged to sample were not included in Ecology's list of sampling sites. Further, in order to minimize duplication of effort and potential problems with multiple agencies seeking access, EPA deviated from its plan to seek volunteers for residential well sampling along Loomis Trail Road. Instead, it was agreed upon by Ecology and EPA that Ecology would pursue residential well sampling along Loomis Trail Road.

Only one home per well was included in the list of volunteers. Homes where the water was known to first pass through any type of water treatment system were eliminated from the pool of volunteer sites, as were all households that obtained their water from a community well or municipal water source. (The exception to this was one home where the residents' drinking water came from the City of Lynden. As no other homes using domestic wells were

in the area, samples were collected at this location from a garden tap supplied by an on-site well. This, technically, did not represent a drinking water sample but nonetheless provided valuable information about the water quality in that part of the Bertrand Creek area.)

Because the SAIC staff were able to modify their schedule to suit the needs of certain residents and because of the intensive solicitation effort, participation in the Phase 2 sampling event succeeded in providing a representative cross-section of domestic drinking water results for the area.

Ecology's Phase 2 sampling took place during September and October 1998. Ecology's contractors collected samples from 63 Bertrand Creek study area residences whose wells serve a total of 68 homes and several small businesses.

During Phase 2, sampling focused on collecting samples of water from a representative number of domestic drinking water wells in the Bertrand Creek area that were outside of the vicinity where EDB had historically been detected. Tap water was collected from 63 homes where the resident and/or owner was willing to participate in the study.¹² (See Figure 11.)

All of the samples of domestic tap water were analyzed for EDB/DBCP, VOCs – including 1,2-DCP, hardness, nitrate-nitrite, chloride, calcium, magnesium, sodium, potassium and total coliform bacteria. A small subset of the residences also had their tap water analyzed for additional pesticides and herbicides -- homes near to where historical detections of these chemicals had occurred. All of the water sources were also tested in the field for pH, conductivity, turbidity, dissolved oxygen, and temperature.

Results were provided to the residents (in a series of three letters) as they became available.

At the request of Ecology, WCHHS notified residents of households where coliform samples had tested positive for *E. coli*.. These residents were contacted by phone within days of the sampling event.

(See Appendix F for example of letters, attachments and translations.)

4.4 Phase 2 – Meadowdale Study Area

As a result of the publicity that followed the Phase 1 sampling event, a number of residents in the Meadowdale area contacted Ecology and asked to participate in the second round of

¹² A number of households declined to participate and their tap water was not sampled by Ecology. Other households were not sampled for a number of reasons, such as the presence of a water treatment unit, another home using the same well was sampled or another nearby well was sampled. Two households that had volunteered did not have their water sampled when it was found their wells had either gone dry or the pump had been turned off.

sampling. In addition to these volunteers, Ecology again prepared a preliminary list of addresses. Instead of going door-to-door, Ecology provided half of the funding for a mass-mailing by WCHHS. This mailing (see Appendix F for a copy of the letter) solicited volunteers for sampling to be conducted by Ecology, USGS, and WDOH throughout northern Whatcom County. A number of residents in the Meadowdale area responded. The USGS chose some based on their proximity to raspberry fields. Rather than asking all residents to participate, Ecology chose eight of the remaining volunteer sites to obtain a relatively representative distribution of sampling sites.

Only one home per well was included in the list of volunteers. Homes where the water was known to first pass through any type of water treatment system were eliminated from the pool of volunteer sites, as were all homes that obtained their water from a community well or municipal water source. During September and October 1998, Ecology's contractors collected samples from eight Meadowdale-area wells serving eight homes.

During Phase 2, sampling in the Meadowdale area focused on collecting samples of water from a select number of domestic drinking water wells. It included that part of the Meadowdale area where the USGS had not already chosen to sample and where neither the City of Lynden nor the Meadowdale Water Association provided households with municipal water. Tap water was collected from eight of the homes where the resident and/or owner was willing to participate in the study. (See Figure 12.) (Other households were not sampled for a number of reasons such as the presence of a water treatment unit or because another nearby well was sampled.)

All of the samples of domestic tap water were analyzed for EDB/DBCP, VOCs – including 1,2-DCP, hardness, nitrate-nitrite, chloride, calcium, magnesium, sodium, potassium and total coliform bacteria. All of the water sources were also tested in the field for pH, conductivity, turbidity, dissolved oxygen, and temperature. None of the households from the Meadowdale area had their tap water analyzed specifically for pesticides (other than those included in other analyses) or for herbicides.

Results were provided to the residents (in a series of three letters) as they became available.

At the request of Ecology, WCHHS notified residents of households where coliform samples had tested positive for *E. coli.* These residents were contacted by phone within days of the sampling event.

(See Appendix F for examples of letters, attachments and translations.)

4.5 Methods and Quality Assurance

4.5.1 Sampling Activities¹³

During Phase 1 and Phase 2 sampling, a total of 127 water samples were collected, which included four duplicate samples from 123 domestic wells. Phase 1 and Phase 2 water sampling was conducted from June 15 to July 1, 1998 and September 21 to October 8, 1998, respectively. SAIC field personnel consisted of Romy Freier-Coppinger, Glenn Haupt, and Lynn Brimmer. The first section of the "Methods and Quality Assurance" report describes the field methods used to perform the sampling. The second section describes the daily activities that occurred during and Phase 1 and Phase 2 sampling. This includes a discussion of the areas and number of wells sampled on a daily basis.

Field Methods

Global Positioning System

A portable Global Positioning System (GPS) receiver was supplied by Ecology to locate the horizontal position of each wellhead. Prior to use, field personnel followed a daily set up procedure supplied by Ecology to ensure proper operation of the GPS unit. The GPS unit was placed at the wellhead and a unique eight-digit filename was created based on the street address of the well to be sampled. Data was collected for approximately eight minutes or longer if the unit was having difficulty receiving satellite data. In some instances, the GPS unit location was adjusted because of overhead interference (trees, sides and roofs of buildings, etc.). In these cases, the distance and offset direction (bearing) of the GPS unit relative to the wellhead was recorded. Additionally, if the water sample was collected at a location other than the wellhead (i.e., outside water tap or faucet) the distance and offset direction (bearing) from the sample location to the wellhead was recorded. This information was recorded on the groundwater sample data sheet and was supplied to Ecology along with the collected GPS data on a daily basis.

Tap-water Quality Instrumentation

A Horiba U-10 water quality instrument was used to take field measurements of pH, electrical conductivity, temperature, and turbidity. This instrument was calibrated daily according to the manufacturer directions with calibration solution supplied by the manufacturer. A YSI Model 50 B was used to measure dissolved oxygen in the field. This instrument was calibrated to 100 percent air saturation, according to the manufacturer directions, on a daily basis.

¹³ SAIC, 1999.

Well Locations and Sampling Procedures

Well locations for water sampling were identified by Ecology. Ecology and SAIC field personnel discussed the locations to be sampled prior to the start of fieldwork. More locations were added as work progressed and as more residents replied favorably to having their water sampled. A well sampling permission form was filled out by the property owner and supplied to the field personnel. This form provided information on the location of the well, outside water taps and knowledge of water softeners, filters, and other treatment systems. Water sample locations were sketched on the back of the sampling permission form. Additionally, many water sample locations were marked with red flagging. In all cases, field personnel would first attempt access to the wellhead to collect a water sample at this location. Samples collected at the wellhead were recorded in the field book. If access to the wellhead was not possible, water samples were collected at the red-flagged outside tap or kitchen tap as identified on the water sample permission form. Additionally, water samples were collected upstream of water softeners, filters, and other treatment systems. Samples that could not be collected as stated above were noted in the fieldbook with a reason for the deviation.

Deviations in the above sampling procedures occurred at four sample locations. Samples collected at 1127 Birch Bay-Lynden (lab sample 278515) and 505 Birch Bay Lynden roads (lab sample 418521) were sampled through an existing garden hose because there was no access to the tap head or wellhead. The volatile sample 398504 collected at 1121 Willeys Lake Road had excessive amounts of air due to tap head problems. A filter system could not be bypassed based on the plumbing design at the wellhead located at 603 Birch Bay-Lynden; therefore, laboratory sample 398531 collected at this location was filtered.

Water was purged from the well for at least several minutes to as long as one-half hour at a rate of five to 15 gallons per minute, depending upon the distance of the sample collection point to the distance of the wellhead. Samples collected at the wellhead were generally purged for a shorter period of time than those samples collected away from the wellhead. Purged water was permitted to drain onto the ground. Tap water field measurements of pH, electrical conductivity, temperature, turbidity, and dissolved oxygen were recorded at regular intervals during the water purging process.

Final tap water field measurements for each well were provided in the electronic database deliverable. Water sample collection was initiated when field measurements were stabilized to 10 percent of the previous reading and the appropriate volume of water had been purged from the well. Prior to sampling, the purge rate was greatly reduced. Volatile organic compound (VOC) samples were collected at a rate of 0.1 gpm to minimize aeration of the sample and to collect a headspace-free sample. Additionally, water samples were collected for nitrate, chloride, hardness, calcium, sodium, potassium, magnesium, EDB, DBCP, and total coliform analyses. Preservatives were added to sample bottles as directed by the laboratory.

Sample Identification and Documentation Procedures

Prior to sample collection, bottles were labeled with the sample time, date, type of preservative (if required), sampler's initials, analysis required, project name, and the unique six-digit laboratory number. Sample tags containing this information were placed on each sample bottle. Sample information was also recorded in the field book and on the chain-of-custody (C-O-C) form at the time of sample collection. Additionally, the eight-digit field station identification number, which corresponds to the street address number and street name, was recorded on the C-O-C to cross-reference the laboratory number. Samples collected for coliform analyses were delivered to a different laboratory using their own five-digit laboratory sample bottle number. These samples, however, had the same eight-digit field station identification numbers for cross-references purposes.

Sample Handling and Delivery

Samples were partially packed in the field for delivery to the laboratory. Samples were immediately placed in coolers, and kept cool with a combination of double zip-lock bagged ice and "blue ice" packs. Glass sample bottles were covered with bubble wrap and arranged in the cooler between plastic (poly) bottles to protect against breakage. SAIC field personnel daily relinquished samples and C-O-C documentation to Ecology. Shipment of samples to the laboratory was performed by Ecology. Samples collected for coliform analysis were retained and kept cool overnight by SAIC personnel, then delivered directly to a local laboratory at the start of the next day.

Phase 1 Sampling

Phase 1 water sampling was performed the weeks of June 15 to June 18, 1998, and June 29 to July 1, 1998, in Study Area B (Bertrand Creek). No sampling occurred the week of June 22 so that the laboratory would not get overloaded with samples. A total of 51 wells were sampled during Phase 1 activities.

June 15, 1998, SAIC mobilized equipment to the site and met with Ecology to discuss sample locations and pick up additional sample equipment and sample bottles. Five water samples were collected along Birch Bay-Lynden Road. After collecting sample 1191BBL0 and 1199BBL0, which are on adjacent properties, it was learned that both sample locations are supplied by one well. It was decided by Ecology that both samples would be submitted for analytical testing. These sample locations share one GPS filename 1191BBL0, which is the horizontal location of the well head. SAIC relinquished samples to Ecology for delivery to Manchester laboratory.

June 16, 1998, SAIC delivered previous day coliform samples to Udder Health (the local laboratory used for coliform analysis), and collected seven water samples along Birch Bay-

Lynden Road and one water sample on Bob Hall Road. Samples were relinquished to Ecology for delivery to Manchester laboratory.

June 17, 1998, SAIC delivered previous day coliform samples to Udder Health and then collected 11 water samples from ten wells (included field duplicate sample) along Birch-Bay Lynden and Bob Hall roads. Contractors also collected field duplicate sample at location 8126BBL0. Samples were relinquished to Ecology for delivery to Manchester laboratory.

June 18, 1998, SAIC delivered previous day coliform samples to Udder Health, then collected ten water samples along Birch Bay Lynden Road and Bob Hall Road. Samples were relinquished to Ecology for delivery to Manchester laboratory and coliform samples were delivered to Udder Health by SAIC.

June 29, 1998, SAIC picked up sampling equipment and sample bottles, then collected eight water samples from wells on Birch Bay-Lynden, Bob Hall, and Loomis Trail roads. SAIC relinquished samples to Ecology for delivery to Manchester laboratory.

June 30, 1998, SAIC delivered previous day coliform samples to Udder Health, then collected nine water samples on Bob Hall, Birch Bay-Lynden, and Loomis Trail roads. Five of the nine samples were split samples collected at the Enfield wells by Dave Bader (Enfield's consultant). Enfield split samples correspond to following Ecology Field Station Identification/Laboratory Sample Number: 1064BBL0/278509, 8220BH00/278511, 8225BH00/278512, 8239BH00/278513, 8256BH00/278514. SAIC relinquished samples to Ecology for delivery to Manchester laboratory.

July 1, 1998, SAIC delivered previous day coliform samples to Udder Health, then collected a total of three water samples, which includes a field duplicate sample at field station identification 1212LT00. The field duplicate was identified with the same laboratory number 278518 and sample time as the environmental sample collected at this location. Sample bottles for the duplicate sample were labeled as a duplicate on the bottle label. SAIC delivered coliform samples to Udder Health and relinquished remaining samples to Ecology for delivery to Manchester laboratory.

All samples relinquished to Ecology by SAIC were turned over directly to the project's site manager. Samples were kept cold and delivered to the Manchester Laboratory in a timely fashion. Samples collected on June 15, 16, and 29 were shipped to the laboratory via UPS on the day following collection. Samples collected on June 17, 18, 30 and July 1 were delivered to the laboratory by Ecology staff on June 19 and on July 2.

Phase 2 Sampling

Phase 2 water sampling was conducted September 21, 1998, to September 24, 1998; and from October 5, 1998, to October 8, 1998, in remaining Bertrand Creek area wells and in the Meadowdale area. Samples were not collected the week of October 12 to assist the Manchester Laboratory in managing its analysis workload. A total of 71 wells were sampled during Phase 2 activities.

September 21, 1998, SAIC contractors met with the Ecology site manager in Bellingham and picked up sampling equipment, sample bottles, and an updated list of wells to be sampled. Six samples were collected along Willeys Lake Road and relinquished to Ecology for delivery to the Manchester laboratory.

September 22, 1998, SAIC delivered previous day coliform samples to Udder Health. The contractor then collected ten water samples along Willeys Lake Road, Parkwood Way, North Enterprise, and Enterprise Road. Samples were relinquished to Ecology for delivery to Manchester laboratory.

September 23, 1998, SAIC delivered previous day coliform samples to Udder Health, then collected ten water samples along Willeys Lake Road, Parklynn Way, and North Enterprise Road. Samples were relinquished to Ecology for delivery to Manchester laboratory.

September 24, 1998, SAIC delivered previous day coliform samples to Udder Health, then collected ten water samples along Willeys Lake, Birch Bay-Lynden, and Rathbone roads, including a field duplicate at field station location 7999RB00. The environmental sample collected at 0920 at field station 7999RB00 was identified as laboratory number 398526. The associated field duplicate was labeled with a sample time of 0925 but was identified with the same laboratory number as the environmental sample. Coliform samples were delivered to Udder Health; remaining samples were relinquished to Ecology for delivery to Manchester laboratory.

October 5, 1998, SAIC staff met at the Ecology office to pick up sampling supplies and sample bottles. Seven samples were collected along Loomis Trail and Weidkamp roads. Samples were relinquished to Ecology for delivery to Manchester laboratory.

October 6, 1998, SAIC delivered previous day coliform samples to Udder Health, then collected nine water samples in the Meadowdale area along Kamm, Clay, East Badger, Pangborn and Northwood roads, and two water samples in the Bertrand Creek area along Loomis Trail and Willeys Lake roads. Samples were relinquished to Ecology for delivery to the Manchester laboratory.

October 7, 1998, SAIC delivered previous day coliform samples to Udder Health. Collected ten water samples from the Bertrand Creek area along Loomis Trail Road, Parklynn Way, Willeys Lake Rd., and Birch Bay-Lynden Road. Samples were relinquished to Ecology for delivery to the Manchester laboratory.

October 8, 1998, SAIC delivered previous day coliform samples to Udder Health. Contractor collected eight water samples (including one field duplicate sample) along Loomis Trail, Weidkamp, and Willeys Lake roads. Sample number 418534 collected at 1330 is the field duplicate sample associated with environmental sample 418533 collected at 1325 from field station 8539WKR00. Samples were relinquished to Ecology for delivery to the Manchester laboratory, except for coliform samples, which SAIC delivered to Udder Health.

All samples relinquished to Ecology by SAIC were turned over directly to the project's site manager. Samples were kept cold and delivered to the Manchester Laboratory in a timely fashion. Samples collected on September 21, 22 and October 5 and 6 were shipped to the laboratory via UPS on the day following collection. Samples collected on September 23, 24 and October 7 and 8 were delivered to the laboratory by Ecology staff on September 25 and on October 9.

(For additional information regarding sampling methodology and field procedures, see the Draft Sampling Plan in Appendix G.)

4.5.2 Laboratory Activities

Unless otherwise specified, all samples were received by the Ecology/EPA Manchester Laboratory or by Udder Health Systems, Inc., in good condition. All analyses were performed within the specified holding times. Instrument calibration was performed and calibration verification standards and blanks were utilized when appropriate. All initial and continuing calibration verification standards were within the relevant method control limits. Where appropriate to the method, procedural blanks and spiked sample analysis were also conducted.

Three significant items were reported by the Manchester Laboratory:

- One-liter sample bottles sent to the laboratory on June 17th were received with excessive headspace and were unusable. The remaining unused VOC vials were used for analysis instead. These provided sufficient sample without compromising the quantitation limits.
- Sample 98418517 (collected at 632 Loomis Trail Rd.) contained a significant amount of an unidentified compound which interfered with the detection of EDB. The peak of this compound was near the retention time of EDB on both columns, but so broad that it would mask a trace amount of EDB. Therefore, reporting limits were raised for that sample.
- VOA analyses, for both Phase 1 and 2, showed low levels of certain target compounds in the laboratory blanks. Methylene chloride and acetone are commonly used in laboratory solvents and are often detected in laboratory blanks. (Note: If concentrations reported in the sample are at least five times greater than those detected in the blank, they are considered to be present in the sample.)

For Laboratory Quality Assurance Summaries and for additional information regarding analytical methods and procedures, see Laboratory Results in Appendix H.

5.0 Contaminant Nature and Extent

This section contains analysis results for drinking water samples collected during the Site Investigation. Contamination concentrations and distribution are summarized. In addition, analytical results are compared to federal and state cleanup standards. Section 7.0 discusses potential contaminant migration pathways.

5.1 Chemical Data Quality

In general, the data are complete and of known and acceptable quality. In cases where data quality control criteria were not met, appropriate qualifier flags have been added to the data summary tables. These qualifiers, and overall data completeness and quality, are in the Quality Assurance Reports included with the laboratory analytical reports in Appendix H.

In addition to the standard quality assurance procedures, the Ecology 1998 Site Investigation results can also be directly compared to sample results collected by other parties. The consultant hired by a local resident/property owner collected split samples from six of Ecology's sampling locations. The WDOH and USGS collected samples from several locations where Ecology had also sampled. In all but one location, the results were very similar. (See Table 10 for the results.)

Four derivations from the normal sampling procedure were noted by SAIC. Samples from two locations were collected through an existing garden hose because there was no access to the tap head or wellhead. One sample had excessive amounts of air due to tap head problems. In addition, a filter system could not be bypassed based on the plumbing design at the wellhead located at another site; therefore, the sample collected at this location was filtered. Appropriate qualifier flags have been added to the data summary tables.

5.2 Drinking Water Samples

5.2.1 General

Site Investigation samples were collected from a household kitchen tap (one location), from a non-household outside tap (one location), from taps at the well-head and – for the vast majority of samples – from outdoor household taps. (Note: The term “outdoor household tap” is used to describe outside water taps which are served by the same domestic well and lines as the household's drinking water, but are not served by any household water-treatment or filtration devices.)

Sample locations are shown in Figures 10, 11 and 12. Samples were collected from 51 locations during Phase 1 and from 71 locations during Phase 2, providing information on the

quality of drinking water taken from a total of 123 wells. Samples were analyzed for EDB/DBCP, VOCs – including 1,2-DCP, hardness, nitrate-nitrite, chloride, calcium, magnesium, sodium, potassium and total coliform bacteria. All of the water sources were also tested in the field for pH, conductivity, turbidity, dissolved oxygen, and temperature.

A sub-set of these sites was also tested for the presence of additional pesticides and herbicides. Samples were collected from locations where the chemicals had been detected in the past and from homes surrounding those early detection sites. Samples were collected from eight locations during Phase 1 and from six locations during Phase 2. Samples were analyzed for acid herbicides and nitrogen-containing pesticides.

Analytical results for these samples are summarized for each group of compounds and presented in Tables 1 through 9.

5.2.2 Analytical Results ¹⁴

Drinking Water Standards for EDB and 1,2-DCP

The Drinking Water Standard or Maximum Contaminant Level (MCL) for EDB is 0.05 parts per billion (0.05 ppb) which is also noted as 0.05 micrograms per liter (0.05 ug/l).

The Drinking Water Standard or Maximum Contaminant Level (MCL) for 1,2-DCP is 5.0 parts per billion (5.0 ppb) which is also noted as 5.0 micrograms per liter (5.0 ug/l).

Phase 1 – Bertrand Creek Area

EDB was found at levels greater than the practical quantitation limit (PQL) of 0.02 ppb (> 0.02 ppb) in nine locations along Birch Bay-Lynden Rd., east of the Bob Hall Road intersection. This was the same general area where it had been detected in the past. Six of those samples showed concentrations greater than the Drinking Water Standard (> the MCL) of 0.05 ppb.

The remaining 42 homes to the east, north and west of these homes had no EDB detected in their drinking water at or above the 0.02 ppb level. (See Figure 13 and Table 1.)

1,2-DCP was detected at levels greater than the PQL of 0.25 ppb (> 0.25 ppb) in 19 locations along Birch Bay-Lynden Road and along the southernmost part of Bob Hall Road. Four of

¹⁴ Laboratory Quality Assurance Summaries and Analytical Results for the 1998 Bertrand Creek/Meadowdale Site Investigation have been assembled as a separate support document .

these samples showed concentrations greater than the Drinking Water Standard (> the MCL) of 5.0 ppb.¹⁵

The remaining 32 homes had no 1,2-DCP detected in their drinking water at or above the 0.25 ppb level. (See Figure 14.)

In addition to the soil fumigants, a number of other contaminants affecting drinking water quality were detected.

- Fifty-one of the 51 wells had nitrate present, 21 above the MCL. (See Figure 15.)
- Thirty-three of the 51 wells had coliform bacteria present, three with *Escherichia coli* (E.coli) detected. (See Figure 16.)
- In addition, a number off other chemicals were detected in several of the samples. (See Tables 1, 2, 3, 8 and 9.)

Phase 2 – Bertrand Creek Area

EDB was found at levels greater than the PQL of 0.02 ppb (> 0.02 ppb) in five locations in the Bertrand Creek area. Three of those samples showed concentrations greater than the Drinking Water Standard (> the MCL) of 0.05 ppb.

The remaining 58 homes had no EDB detected in their drinking water at or above the 0.02 ppb level. (See Figure 17.)

1,2-DCP was detected at levels greater than the PQL of 0.25 ppb (> 0.25 ppb) in 13 locations in the Bertrand Creek area. Two of those samples showed concentrations greater than the Drinking Water Standard (> the MCL) of 5.0 ppb. (See Figure 18.)

The remaining 50 homes had no 1,2-DCP detected in their drinking water at or above the 0.25 ppb level.

In addition to the soil fumigants, a number of other contaminants affecting drinking water quality were detected.

- Fifty-nine of the 63 wells had nitrate present, 21 above the MCL. (See Figure 19.)
- Thirty-eight of the 63 wells had coliform bacteria present, 6 with *Escherichia coli* (E.coli) detected. (See Figure 20.)
- In addition, a number off other chemicals were detected in several of the samples. (See Tables 1, 2, 3, 8 and 9.)

¹⁵ As local 1,2-DCP data had been somewhat limited in the past, this was the first thorough assessment of its presence in this area's drinking water. (This study was more locally intensive than Ecology's 1989 agricultural chemicals pilot study which had indicated a widespread 1,2-DCP problem.) As it was detected at levels > the MCL at the homes to the eastern and western limits of the Phase 1 testing, the results indicated the need for additional testing during Phase 2 to determine the extent of contamination along Birch Bay-Lynden Road.

Phase 2 – Meadowdale Area

None of the homes in the Meadowdale area had EDB detected in their drinking water at or above the 0.02ppb PQL level. (See Figure 21.)

1,2-DCP was detected at levels greater than the PQL of 0.25 ppb (> 0.25 ppb) in two locations in the Meadowdale area. None of those samples showed concentrations greater than the Drinking Water Standard (> the MCL) of 5.0 ppb. (See Figure 22.)

The remaining six homes had no 1,2-DCP detected in their drinking water at or above the 0.25 ppb level.

In addition to the soil fumigants, a number of other contaminants affecting drinking water quality were detected.

- Eight of the eight household water supplies had nitrate present, six above the MCL. (See Figure 23.)
- Seven of the eight households had coliform bacteria present, none with E.coli detected. (See Figure 24.)
- In addition, a number of other chemicals were detected in several of the samples. (See Tables 1, 2, 3, 8 and 9.)

Summary of Analytical Data

EDB/DBCP: Both EDB and DBCP (1,2-dibromo-3-chloropropane) were detected in drinking water samples. Historical analytical information had indicated that both chemicals had been present in local drinking water in the past. Ecology's 1998 analytical results indicated the same. EDB and DBCP analytical results are presented in Tables 1.

DBCP was detected in six samples. The highest concentration was detected at 0.058 ppb along Bob Hall Road. None of the sampling locations showed levels of DBCP > the MCL of 0.2 ppb.

EDB was detected in 14 samples. Most (9) of these samples were collected in the "bottled water delivery area" of the Bertrand Creek area. Three detections were near the Loomis Trail/Weidcamp intersection and another two located in the middle of Willeys Lake Road.

109 samples showed no trace of EDB at or above the 0.02 ppb PQL.

Eight drinking water samples had EDB present at levels > the MCL (greater than the Drinking Water Standard) of 0.05 ppb. The highest concentration was detected at 0.24 ppb in the middle of the bottled water area where EDB had historically been detected. Another six drinking water samples had EDB present at levels less than the MCL (< the MCL) but above 0.02 ppb PQL.

EDB sampling results are illustrated in Figures 21 (Meadowdale) & 25 (Bertrand Creek) and Table 1.

VOCs: A number of different volatile organic compounds (VOCs) were detected in drinking water samples. Historical information had indicated that 1,2-DCP, xylene, benzene, methylene chloride, TCE and 1,2,3-TCP had been detected in some local drinking water samples. Ecology's 1998 analytical results indicated that these – along with a number of additional analytes – were present.¹⁶

1,2-DCP was detected in 34 samples. Most (30) of these sample locations were in or near the Bertrand Creek “bottled water delivery area.” An additional two detections were found east of the Loomis Trail/Weidcamp intersection (Area B), with another two located near the Pangborn/Northwood intersection (Area A). Analytical results are presented in Table 7.

Eighty-nine samples showed no trace of 1,2-DCP present.

The highest concentration of 1,2-DCP was detected at 10.0 ppb along Loomis Trail Road. Six drinking water samples had 1,2-DCP present at levels > the MCL (greater than the Drinking Water Standard) of 5.0 ppb. Another 28 drinking water samples had 1,2-DCP present at levels less than the MCL but above 0.25 ppb PQL.

1,2-DCP sampling results are illustrated in Figures 22 (Meadowdale) & 26 (Bertrand Creek) and Table 7.

Analytical results are summarized in Tables 8 (Phase 1) and 9 (Phase 2) for all other VOA analytes that were detected during the 1998 Site Investigation.

Pesticides: A number of different pesticides were detected in drinking water samples, though none (other than EDB or 1,2-DCP) at or above their respective MCLs. Historical information had indicated that simazine, atrazine and carbofuran had been present in some drinking water samples. Ecology's 1998 analytical results -- collected from a subset of all homes sampled -- indicated that these, along with several other pesticides (bromacil, metalaxyl and prometon) were present at low levels.

Analytical results are summarized in Table 2 for all nitrogen pesticides sampled for during the 1998 Site Investigation. Nitrogen pesticide sampling locations are illustrated in Figure 27.

Herbicides: A number of different herbicides were detected in drinking water samples, though none at or above their respective MCLs.

¹⁶ EDB was detected during the VOA analysis of some samples. However, because the Drinking Water Standard for EDB is significantly lower than the detection limit for the VOA analytical method that was used, a separate (more sensitive) analysis was run specifically for EDB/DBCP. (See previous section.)

Historical information had indicated that dinoseb had been present in some drinking water samples. Ecology's 1998 analytical results -- collected from a subset of all homes sampled -- indicated that dinoseb, along with another herbicide (2,6-dichlorobenzamide), was present at low levels.

Analytical results are summarized in Table 3 for all acid herbicides sampled for during the 1998 Site Investigation. Acid herbicide sampling locations are illustrated in Figure 27.

Total coliform bacteria: Samples were collected at all locations and analyzed for the presence of total coliform bacteria.

Coliform bacteria is not a contaminant regulated under MTCA. Although there was no historical information available regarding coliform contamination at any of these locations, it is a common problem in rural domestic wells. Of the 123 samples collected and analyzed, 78 showed coliform as being present. Nine of those had E.coli detections.

There was no discernable pattern to the distribution of coliform-contaminated wells. Coliform sampling results are illustrated in Table 5 and Figures 24 (Meadowdale) and 28 (Bertrand Creek).

Nitrate: Samples were collected at all locations and analyzed for the presence of nitrate.

Nitrate is not a contaminant regulated under MTCA. It is a common groundwater problem in northern Whatcom County and there is existing information about high nitrate levels in groundwater in this general area. However, there is historical information regarding nitrate contamination at only about a half-dozen of the 1998 sampling locations.

During the Site Investigation, nitrate was detected in 118 samples -- located, for the most part, downgradient of various agricultural activities. The highest concentration was 56.0 ppm along Enterprise Road. A total of 48 drinking water samples had nitrate present at levels > the MCL (greater than the Drinking Water Standard) of 10.0 ppm. Another 70 drinking water samples had nitrate present at levels less than the MCL but above the laboratory detection limit. The remaining five samples showed no trace of nitrate present.

Nitrate sampling results are illustrated in Figures 23 (Meadowdale) and 29 (Bertrand Creek) and Table 6.

5.2.3 Drinking Water Quality Summary

The Site Investigation results for drinking water are summarized as follows¹⁷:

EDB is present in the area where it had historically been found. The concentrations are lower than had been seen in the past, but there continue to be a number of households where the concentration of EDB exceeds the MCL.

EDB is present at concentrations exceeding the MCL in some drinking water samples collected to the south of the historic border of the Bertrand Creek area. These households had not previously been identified as part of the area of known or suspected EDB-contamination historically included in the "bottled water delivery area."

1,2-DCP was detected in a significant number of samples. Ecology's 1989 report had indicated that 1,2-DCP was a contaminant in local groundwater. Information from the 1998 study indicated that it was a more prevalent contaminant than had previously been documented.

Other VOCs were detected throughout the sampling areas. A number were unique to one or two households and may be associated with specific current or historic activities at those locations. Others may be associated with area-wide use or application.

Total coliform contamination appears to be common throughout the study areas.

Nitrate appears to be a significant contaminant throughout much of the Bertrand Creek and Meadowdale areas.

Analysis for pesticides (other than EDB and 1,2-DCP) and acid herbicides was done at 14 of the 123 households sampled. Of those samples, none showed contamination at levels greater than the MCL, although a number of contaminants were found to be present at low levels (much lower than the MCL).

¹⁷ For more information of recent area groundwater sampling and investigation, see EPA's 1999 report, Bertrand Creek Properties, Site Investigation Report, Lynden, Washington, March 1999. Prepared for EPA Region X by Roy F. Weston, Inc.

6.0 Conclusions, Data Uncertainties, and Recommendations

6.1 Conclusions

EDB was found at levels greater than the PQL of 0.02 ppb in nine sampling locations along Birch Bay-Lynden Rd., east of the Bob Hall Road intersection. This was the same general area where it had been detected in the past. Six of those samples showed concentrations greater than the drinking water standard of 0.05 ppb. Many homes to the east, north and west of these homes had no EDB detected in their wells. This suggests that the area of concern may not have expanded or migrated significantly from what had been identified in the past.

EDB was also found at levels greater than 0.05 ppb in two sampling locations along Willeys Lake Road, nearly a mile south of the area where it had historically been found. With the intervening groundwater flow interrupted and/or effected by one or both tributaries of Bertrand Creek, it is unlikely that the EDB detected here migrated south from the Birch Bay-Lynden Road area. Instead, this suggests that the newly detected area of concern may be the result of formerly unreported or undiscovered EDB application and -- because historical sampling had occurred farther along Willeys Lake Road without detecting EDB -- this could be seen as further evidence that soil fumigant contamination can be very localized.

1998 EDB sampling results, when compared to samples collected in the past from identical sampling locations, appeared to show lower concentrations of EDB in drinking water than that seen historically. This may be the first evidence of the chemical's natural attenuation.

1,2-DCP was detected at levels greater than the PQL of 0.25 ppb in 34 sampling locations, most of them along Birch Bay-Lynden Road and along the southernmost part of Bob Hall Road. Six of the samples showed concentrations greater than the drinking water standard of 5.0 ppb. It was also detected at locations near the Loomis Trail/Weidcamp intersection and (in the Meadowdale Area) near the Pangborn/Northwood intersection.

1,2-DCP detected in and adjacent to the areas where EDB had been found suggests that it was applied to many of the same locations, probably as a substitute for the no-longer-available EDB.

Ecology's 1989 agricultural chemicals pilot study had indicated a somewhat widespread 1,2-DCP problem in the county. The 1998 study was more locally intensive and showed several groups of sampling locations where 1,2-DCP was found -- along Birch Bay-Lynden and Bob Hall Roads, near the Loomis Trail/Weidcamp intersection and (in the Meadowdale Area) near the Pangborn/Northwood intersection. Information from this investigation appears to suggest that -- like EDB -- contamination with this soil fumigant can be very localized. 1998 1,2-DCP sampling results are difficult to compared directly to samples collected in the past. Few were collected from identical sampling locations. Thus, it is difficult to determine

if there is a lower concentrations of 1,2-DCP in drinking water than might have been present in the past. For this reason, it is unclear if any natural attenuation is occurring.

In addition to the soil fumigants, a number of other contaminants affecting drinking water quality were detected. One hundred and eighteen of the 123 sampling locations had nitrate present, 48 above the MCL. Most of these sites were downgradient of dairies and raspberries, supporting the statement made in Ecology's 1997 Sumas-Blaine Surficial Aquifer Nitrate Characterization that these sources may significantly influence the presence of nitrate in groundwater.

Seventy-eight of the 123 sampling locations had total coliform bacteria present, nine with E.coli detected. The presence of coliform bacteria in the water may indicate that well seals are inadequate or that water from the surface may be entering the well. In addition, if surface water is entering the well, the level of EDB or other chemical contamination in the drinking water sample might be diluted and thus the sample may not necessarily be representative of groundwater quality.

In addition, a long menu of other chemicals was detected in samples from one or more of the locations, though none at levels greater than the Drinking Water Standard. (See Appendix D and Tables 8 and 9.)

6.2 Data Uncertainties

Current data uncertainties are summarized as follows:

- Our current understanding of ground water flow conditions of the Bertrand Creek and Meadowdale areas is based on water level measurements taken in March and September, 1987. Factors which might affect the accuracy of these measurements and the resulting ground water contour lines include errors in the estimate of the ground elevation at the wellhead, measurements which may not represent static conditions, differences in well construction, such as well depth and interval screened, and the extrapolation of lines across areas where control may be sparse or lacking. The stream elevations used to construct the water table contours may also be a source of inaccuracy. However, the stream elevations used probably increase the accuracy of the maps as a whole in that they provide some degree of control in areas where control would otherwise be lacking.
- Our current understanding of the presence of soil fumigants in drinking water along the southern border of the Bertrand Creek area is based on samples collected during the Phase 2 sampling event. EDB was detected in two of the samples at levels above the drinking water standard. As this was the first time that some of the homes in this area had been tested and because not all of the households were sampled, the geographical extent of the EDB contamination south of the original Bertrand Creek site boundaries was not fully characterized.

- Our current understanding of the presence of soil fumigants in drinking water in Meadowdale-area residential wells is predominantly based on historic (pre-1990) data and on a total of thirteen household wells sampled during 1998 (eight sampled by Ecology, four by USGS, one by WDOH). EDB and/or 1,2-DCP were not detected in any of the samples at levels above the drinking water standard. 1,2-DCP was detected at lower levels in two samples. As this was the first time that many of the homes in this area had been tested, and because not all of the households were sampled, the geographical extent of EDB and/or 1,2-DCP contamination in certain parts of the Meadowdale Study Area (Area A) was not fully characterized.
- Our current understanding of the presence of soil fumigants in drinking water from residential wells is based on historic (pre-1995) data and on a single round (two phases) of 1998 sampling conducted in the dry season (either mid-summer or early fall). These 1998 numbers are indicative, but not definitive, in characterizing the level of soil fumigants in any individual household's water. Slight fluctuations in EDB and or 1,2-DCP concentrations may occur, especially following major rain events. However, earlier studies have not indicated the occurrence of any significant seasonal fluctuations in EDB and or 1,2-DCP concentrations.
- Our current understanding of the presence of soil fumigant contamination of domestic drinking water outside of the Meadowdale and Bertrand Creek areas is based on historical data and data obtained during 1998 studies by the USGS and WDOH/WCHHS. Their studies indicate possible areas of groundwater contaminated with either EDB and/or 1,2-DCP beyond the original site perimeters and Ecology's 1998 study.
- Our current understanding of drinking water contaminants (other than EDB and 1,2-DCP) in wells serving individual households in the area is based, almost entirely, on a single round of 1998 sampling conducted in the dry season (either mid-summer or early fall). These 1998 numbers may reflect short-term or seasonal conditions that would not necessarily be representative of drinking water quality over a period of years. This is especially true for coliform bacteria, nitrate, and any chemicals normally associated with plumbing installation or repair. In all three cases, the presence or absence of such contaminants in this area's rural domestic drinking water may vary significantly from season to season or from year to year.
- Our historical understanding of groundwater quality is based – for the most part – on drinking water samples from residential wells. The 1998-99 EPA report (Bertrand Creek Properties, Site Investigation Report, Lynden, Washington) indicates that EDB- and 1,2-DCP-contaminated drinking water samples collected in Ecology's 1998 study were located in much the same geographical area as was groundwater contaminated with these chemicals. However, results of samples collected by Ecology from household water taps, in comparison to the results of samples collected by EPA in much of the same geographical area using the Geoprobe™ unit, may reveal lower concentrations of EDB and/or 1,2-DCP. Hence, results of water samples collected from the tap are indicative of contaminant concentrations reaching the household but do not necessarily reflect actual contaminant concentrations in groundwater.

- Samples were not collected at any public water system wells. This includes wells serving community water systems (e.g. water association wells) and wells serving transient non-community (TNC) water systems¹⁹. All public water systems are required to conduct routine water quality monitoring and submit results to WDOH. However, smaller water associations and TNC systems are required to monitor for fewer parameters (e.g. nitrate and coliform only). In both cases, a review of the data reveals that sampling and/or reporting requirements are not always closely followed and that there is occasionally delayed testing and/or missing data.
- Little information was available regarding well construction. A search of Ecology well log files confirmed only that many of the wells had been constructed before such documentation had been required. Without additional information regarding well construction -- including factors as well depth information -- interpretation regarding pesticide and nitrate distribution may be somewhat problematic.
- There is some indication that samples collected from outdoor taps that are “frost-free” taps have a significantly greater chance of being coliform or E.coli positive. Thus, a coliform-positive result for the sampling location may not necessarily indicate that the household drinking water is also coliform-positive.

6.3 Recommendations

In order to address the data uncertainties described above, the following actions are recommended:

- Conduct an objective analysis of water supply, treatment and filtration options. That report will help Ecology, local governments and others select the option(s) best suited for the north Whatcom County EDB and 1,2-DCP contamination problems. The preferred solutions will determine how soon remedies can be in place for those affected households. (Note: This work is currently underway and scheduled for completion in the summer of 1999.)
- Work with local governments to select the preferred remedial action(s) by September 1999.
- For households where the levels of EDB and/or 1,2-DCP exceed the MCL, take appropriate interim action (such as the use of carbon shower filters) to minimize dermal and inhalation exposure pathways until remedial action plan can be completed and implemented.

¹⁹ Serving either transient labor camps or campgrounds.

- Evaluate the bottled water delivery program in view of both new and historic data to assure that all households that should be included are offered the opportunity to participate.
- Complete final remedial action project design, depending on alternative(s) selected following completion of the consultant's options report.
- Collect and analyze additional samples of domestic drinking water from homes south of the southern boundary of the original Bertrand Creek site. Homes near households where EDB was detected at levels greater than the PQL, and homes downgradient from these locations, should have their drinking water sampled and analyzed.
- Conduct follow-up sampling at un-tested homes in the Bertrand Creek area near households where 1,2-DCP was detected at levels greater than 50 percent of the drinking water standard and/or EDB was detected at levels greater than the PQL.
- Conduct follow-up sampling at un-tested homes in the Meadowdale area near households where 1,2-DCP was detected at levels greater than 50 percent of the drinking water standard and/or EDB was detected at levels greater than the PQL.
- Collect additional samples of domestic drinking water from un-tested homes outside of the Meadowdale and Bertrand Creek areas near locations where 1,2-DCP was detected at levels greater than 50 percent of the drinking water standard and/or EDB was detected at levels greater than the PQL.
- Plans for additional sampling should be shaped by findings from studies conducted by all agencies working in the area.
- Implement a monitoring program in areas where EDB and/or 1,2-DCP have been detected. Follow-up sampling should continue on a regular basis at all locations where EDB or 1,2-DCP has been detected.
- In the event that new source areas may be discovered, expand sampling and monitoring programs to include additional households.
- Implement or strengthen existing education and outreach programs regarding domestic well maintenance and health issues. Most existing regulations do not apply to domestic wells that serve only one household. Homeowners should be made aware of the hazards commonly associated with rural domestic wells and provided with information about pollution prevention and detection activities that they can do themselves.
- Conduct research into the relationship between groundwater and tap water analytical results. (Factors to be considered might include well construction, screening depth, substrate material, etc.) In the meantime, caution should be exercised in using drinking

water analytical results to draw conclusions about groundwater contamination numbers (or vice versa).

- Collect samples from water association wells and transient non-community (TNC) water system wells in the areas of concern, and take necessary actions based on findings. (Note: WCHHS and WDOH collected samples from all six of the local TNC wells by June, 1999.)

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Figures

**1998 Site Investigation
Bertrand Creek & Meadowdale Areas
Whatcom County, Washington**



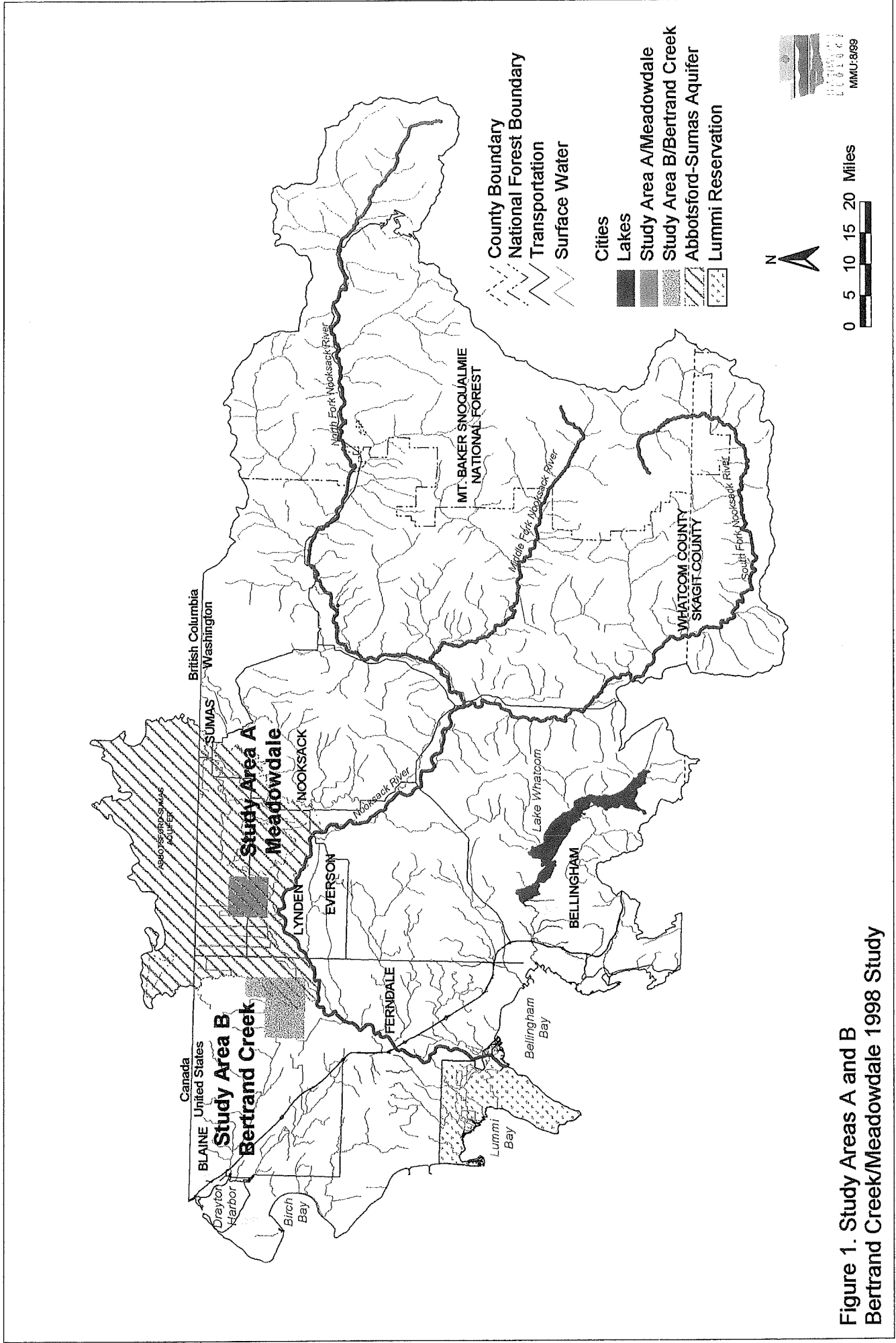


Figure 1. Study Areas A and B
Bertrand Creek/Meadowdale 1998 Study

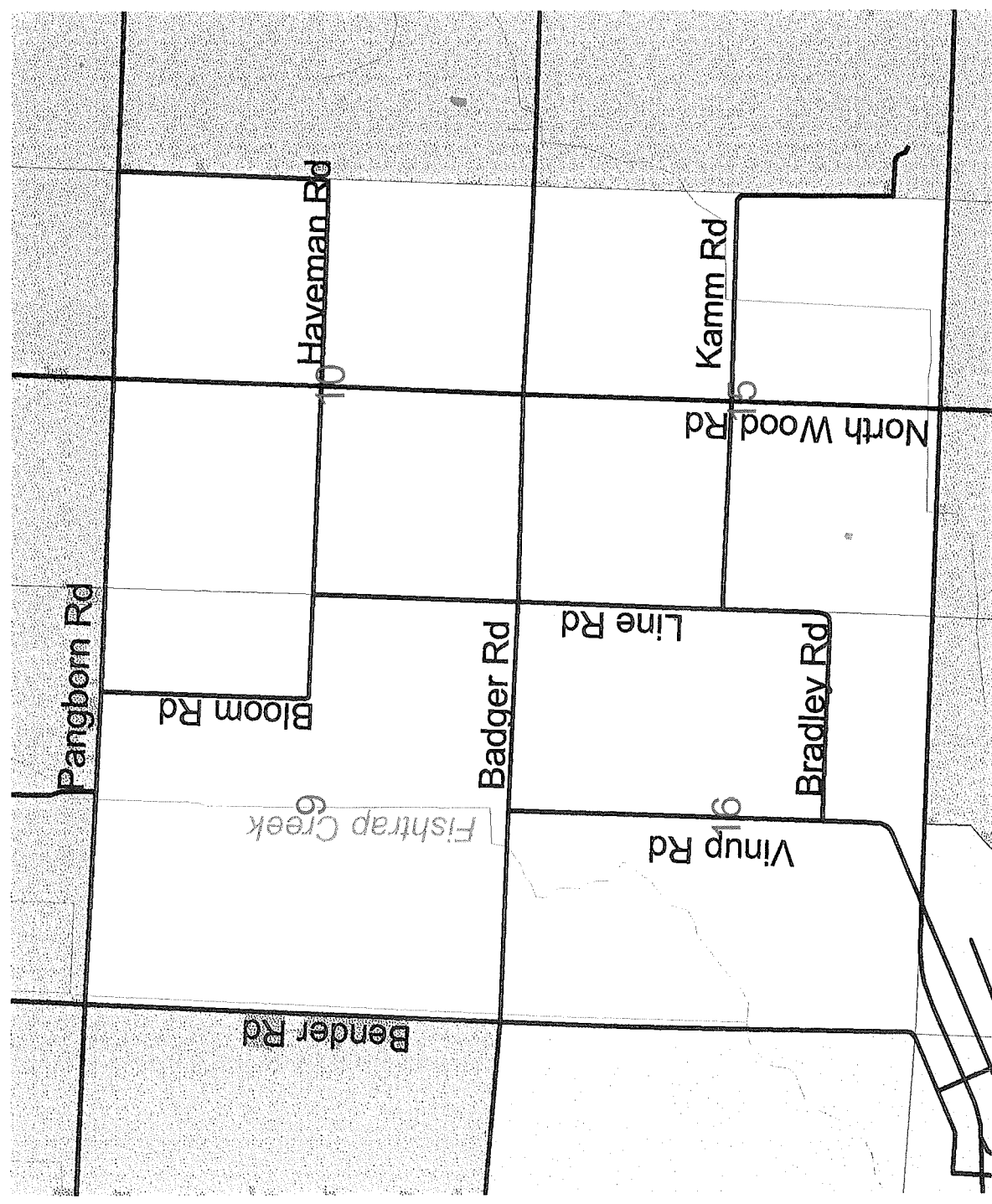
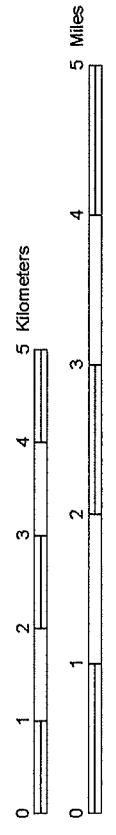
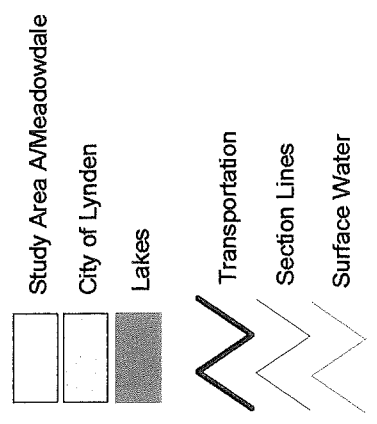
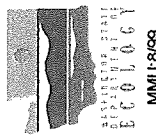
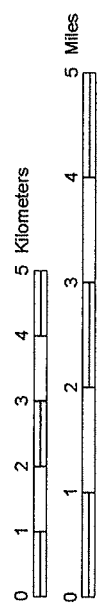



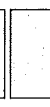




Figure 4. Meadowdale Study Area (Area A)
Bertrand Creek/Meadowdale 1998 Study





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-  Study Area B/Bertrand Creek
-  City of Lynden
-  Lakes
-  Transportation
-  Section Lines
-  Surface Water

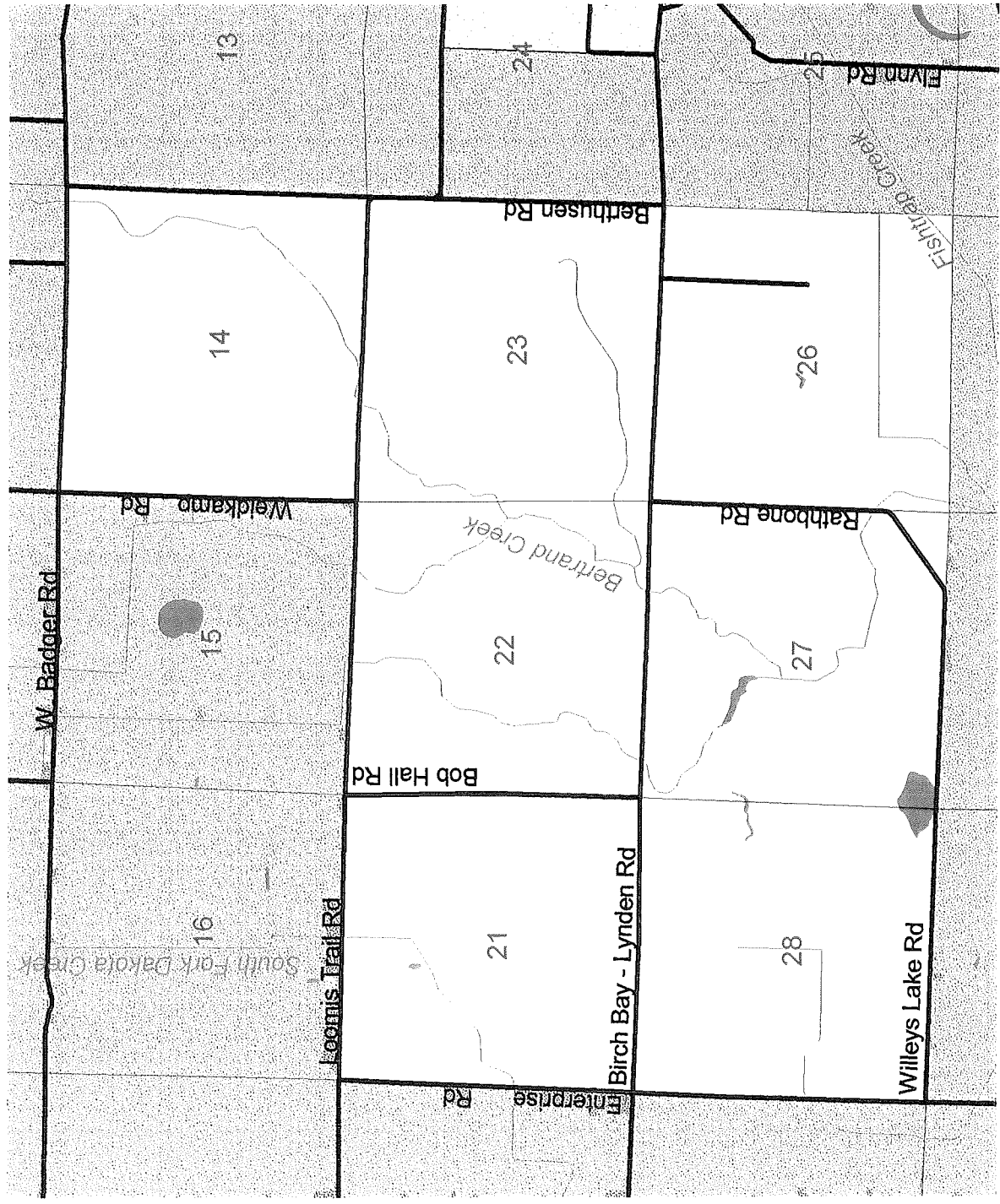


Figure 2. Bertrand Creek Study Area (Area B)
Bertrand Creek/Meadowdale 1998 Study



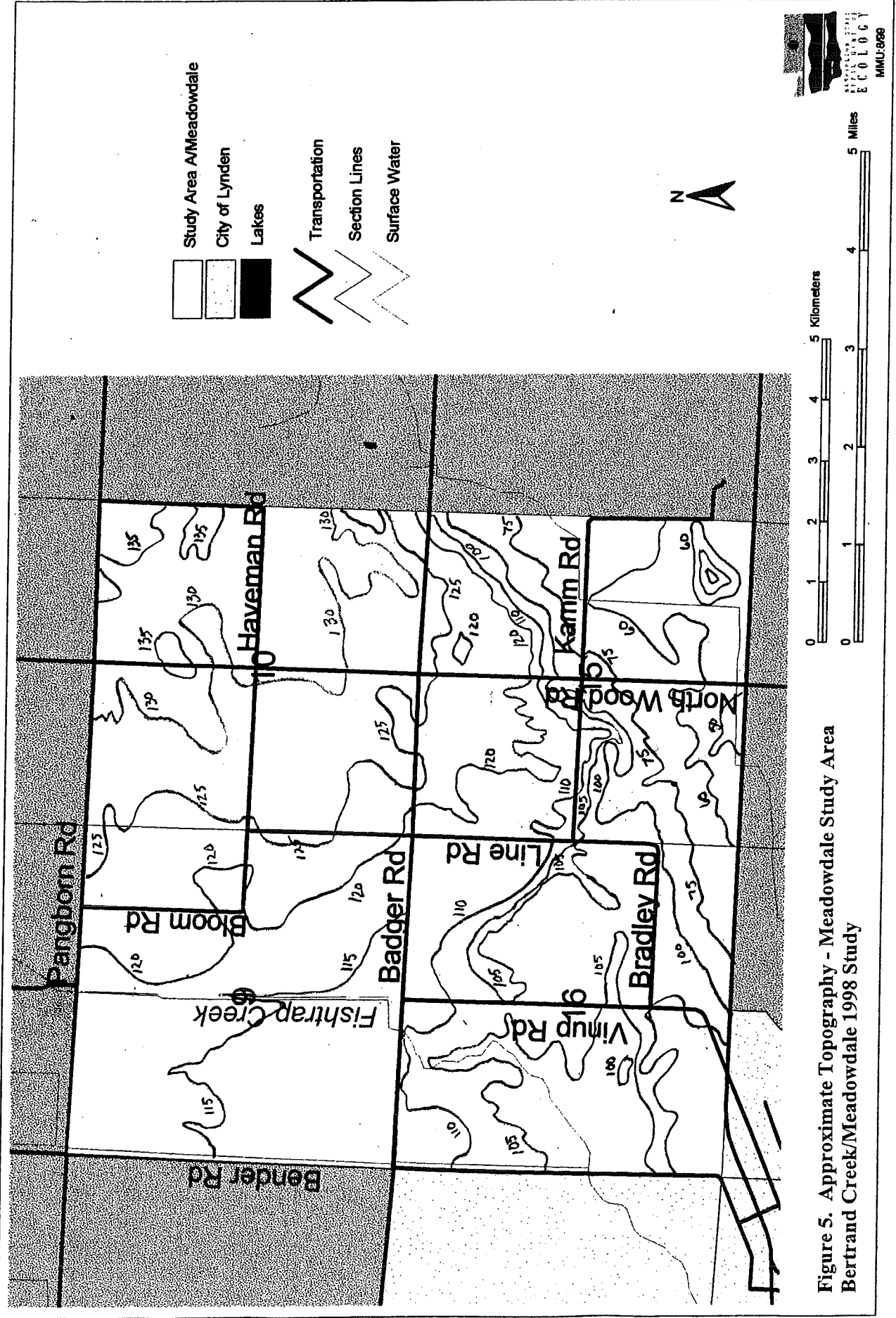


Figure 5. Approximate Topography - Meadowdale Study Area
Bertrand Creek/Meadowdale 1998 Study



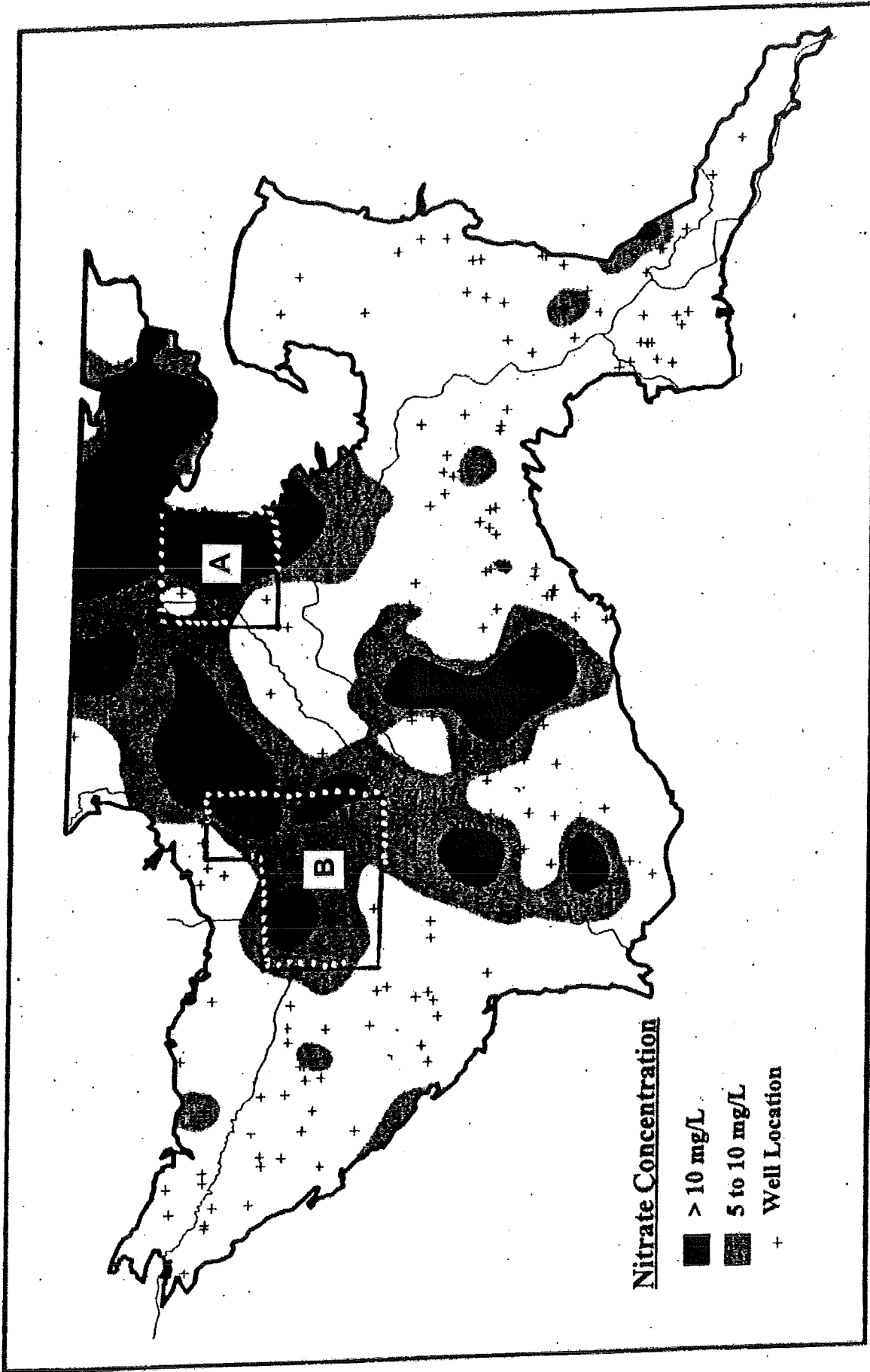


Figure 7. Areas with elevated Nitrate+Nitrite-N, Sumas-Blaine Surficial Aquifer (Study Areas A and B superimposed on original Whatcom County map taken from "Sumas-Blaine Surficial Aquifer Nitrate Characterization".)



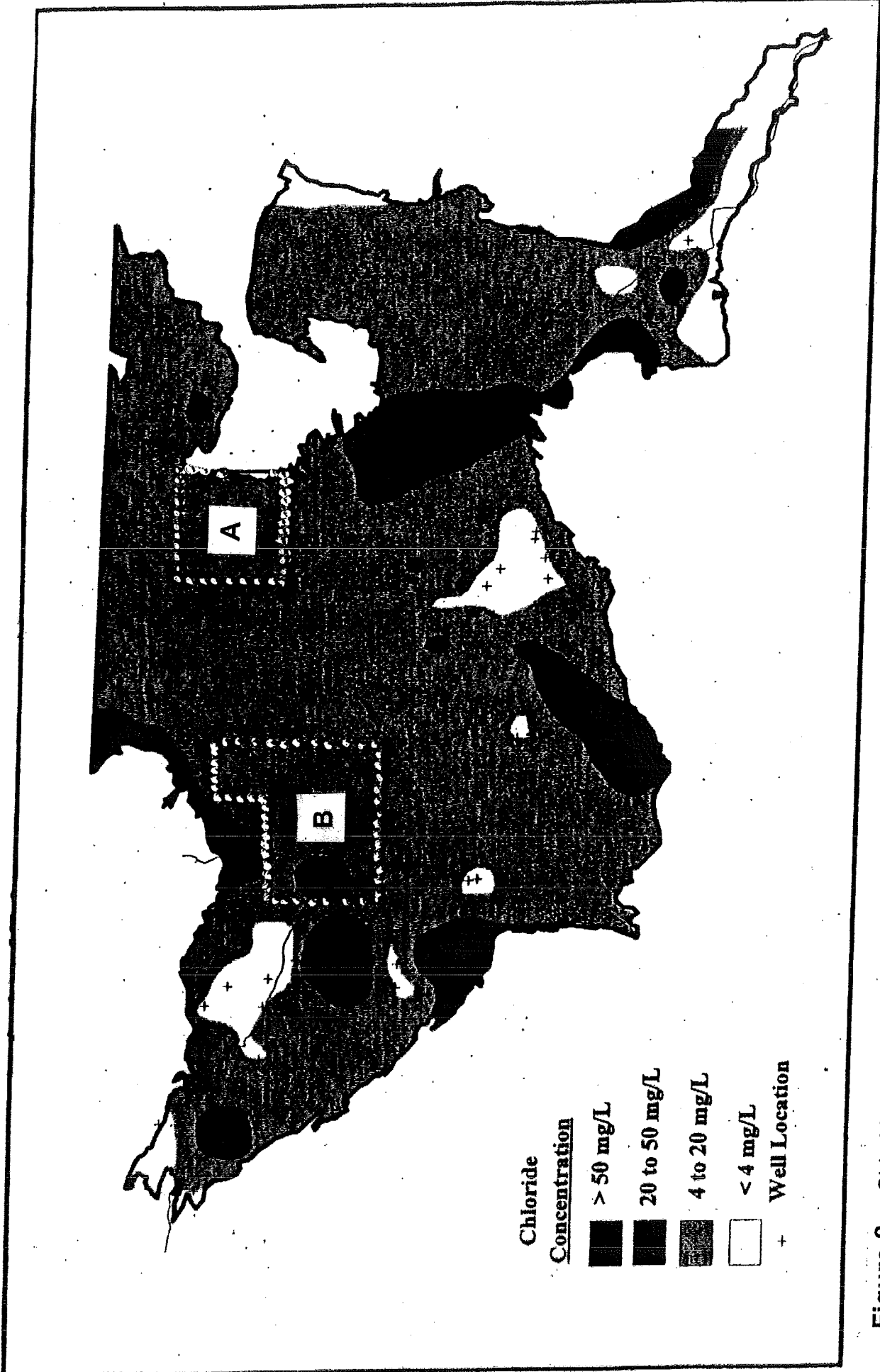
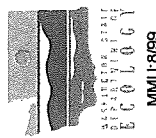
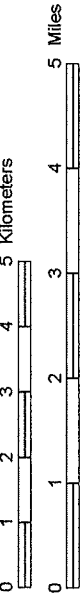
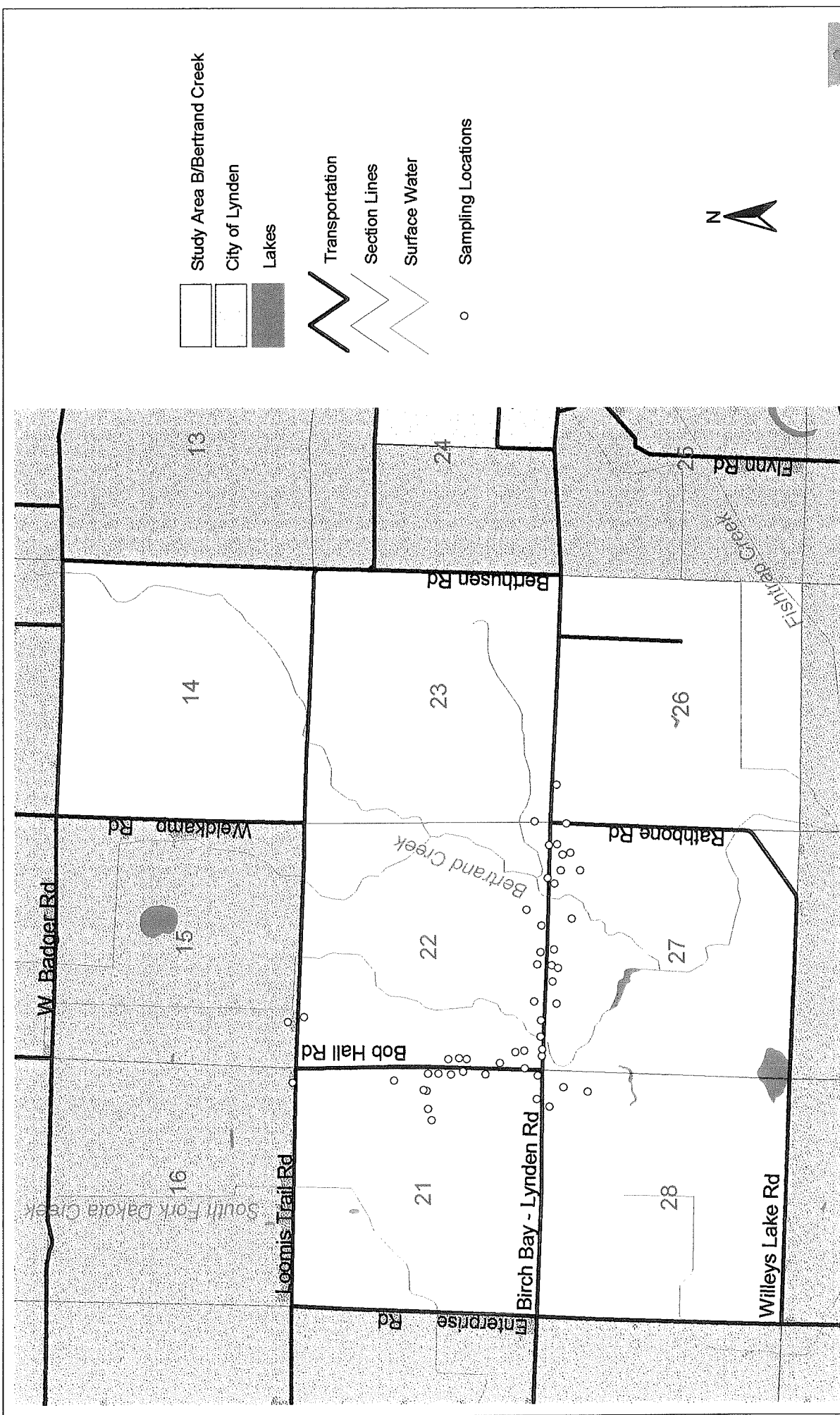


Figure 8. Chloride Concentrations, Sumas-Blaine Surficial Aquifer (Study Areas A and B superimposed on original Whatcom County map taken from "Sumas-Blaine Surficial Aquifer Nitrate Characterization".)





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0 1 2 3 4 5 Kilometers

0 1 2 3 4 5 Miles

Figure 10. Phase 1, 1998 Sampling Locations in Study Area B Bertrand Creek/Meadowdale 1998 Study



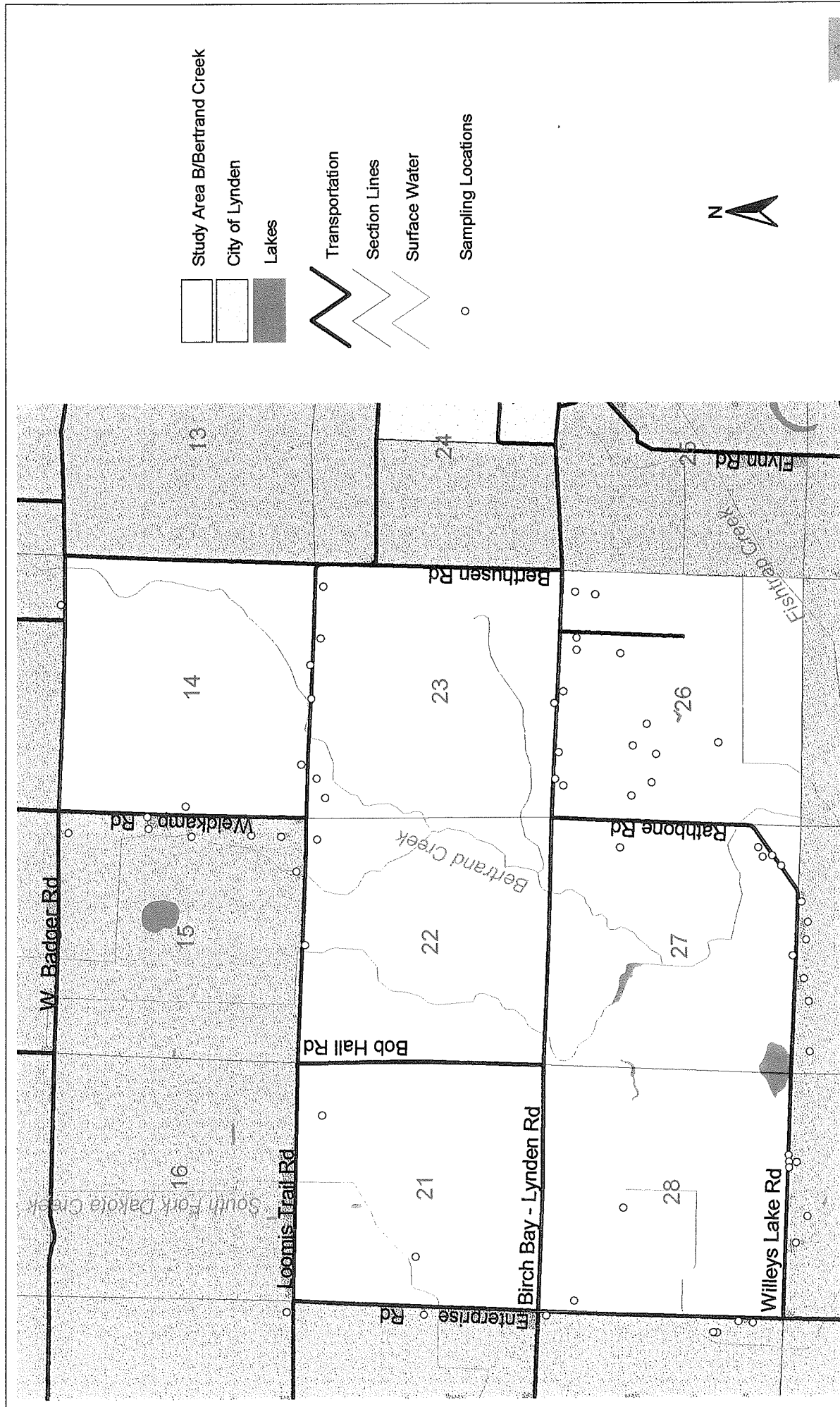


Figure 11. Phase 2, 1998 Sampling Locations in Study Area B
Bertrand Creek/Meadowdale 1998 Study

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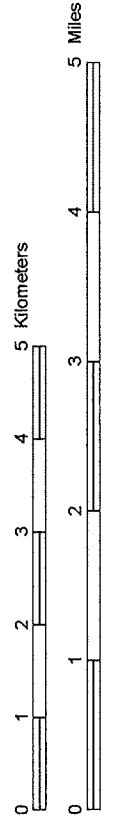
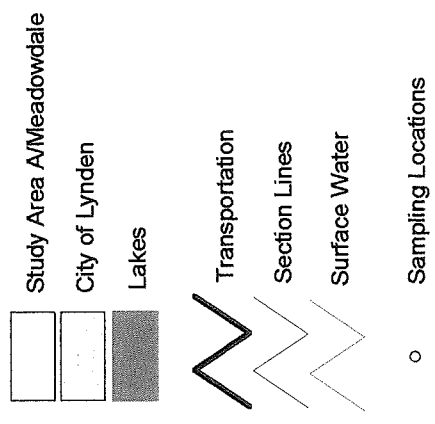
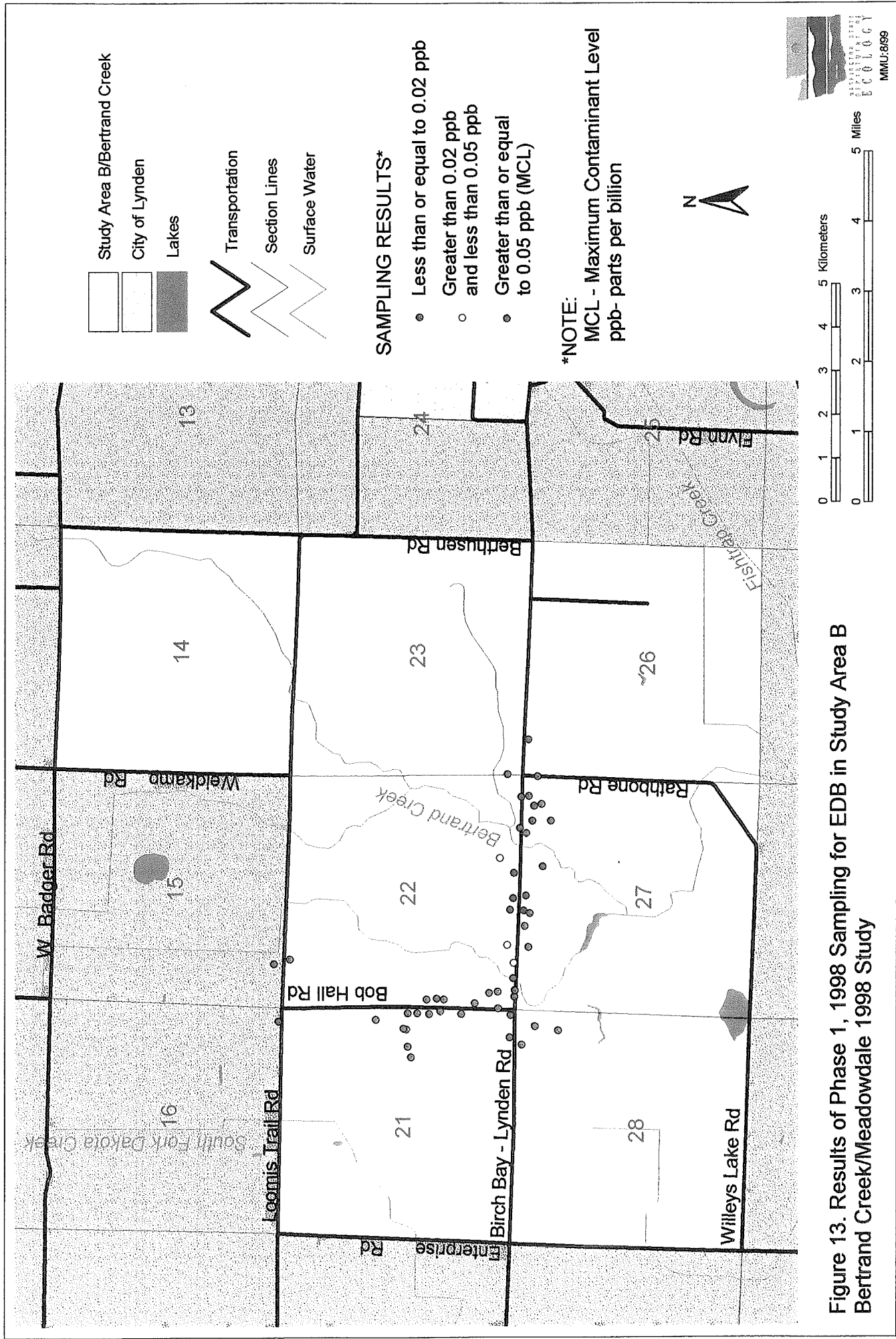


Figure 12. Phase 2, 1998 Sampling Locations in Study Area A
 Bertrand Creek/Meadowdale 1998 Study



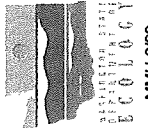
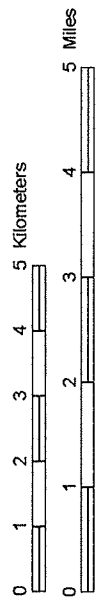
Study Area B/Bertrand Creek
 City of Lynden
 Lakes

Transportation
 Section Lines
 Surface Water

SAMPLING RESULTS*

- Less than or equal to 0.02 ppb
- Greater than 0.02 ppb and less than 0.05 ppb
- Greater than or equal to 0.05 ppb (MCL)

*NOTE:
 MCL - Maximum Contaminant Level
 ppb- parts per billion



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Figure 13. Results of Phase 1, 1998 Sampling for EDB in Study Area B Bertrand Creek/Meadowdale 1998 Study

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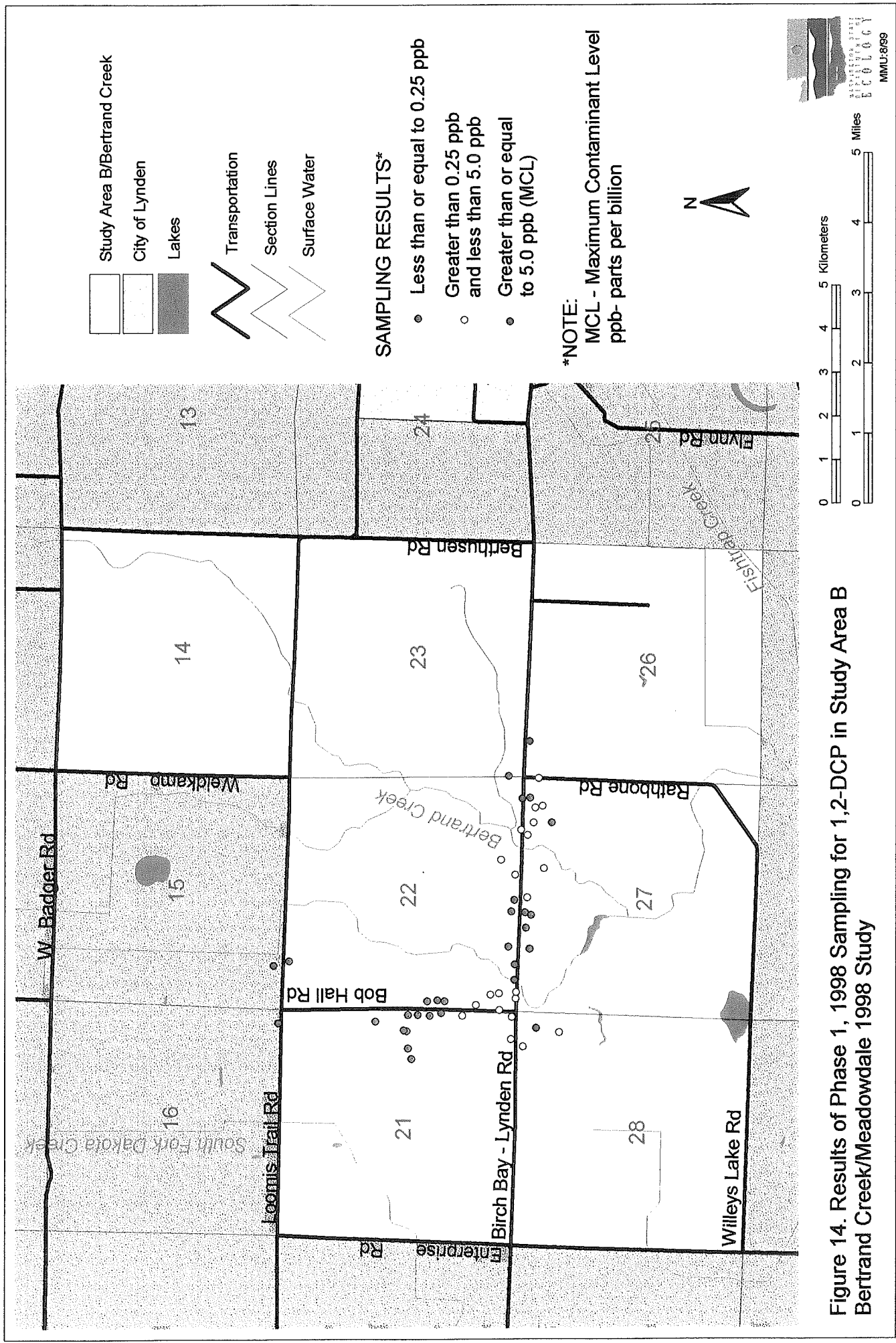
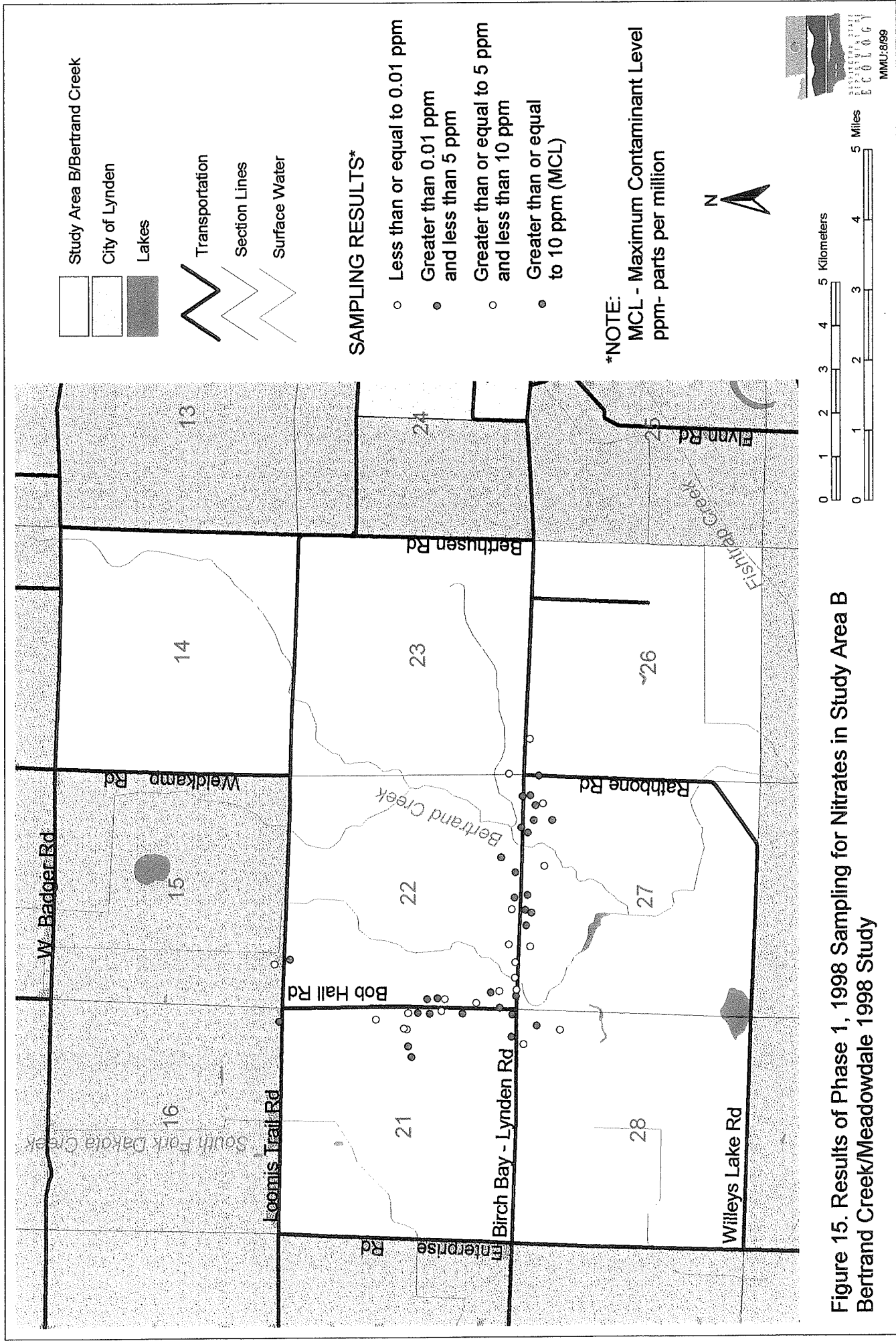


Figure 14. Results of Phase 1, 1998 Sampling for 1,2-DCP in Study Area B Bertrand Creek/Meadowdale 1998 Study

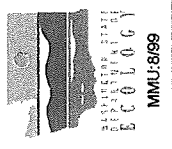
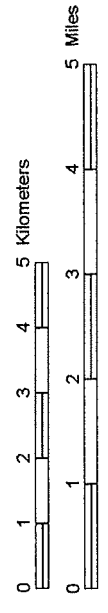


- Study Area B/Bertrand Creek
- City of Lynden
- Lakes
- Transportation
- Section Lines
- Surface Water

SAMPLING RESULTS*




- Less than or equal to 0.01 ppm
- Greater than 0.01 ppm and less than 5 ppm
- Greater than or equal to 5 ppm and less than 10 ppm
- Greater than or equal to 10 ppm (MCL)




*NOTE:
MCL - Maximum Contaminant Level
ppm- parts per million





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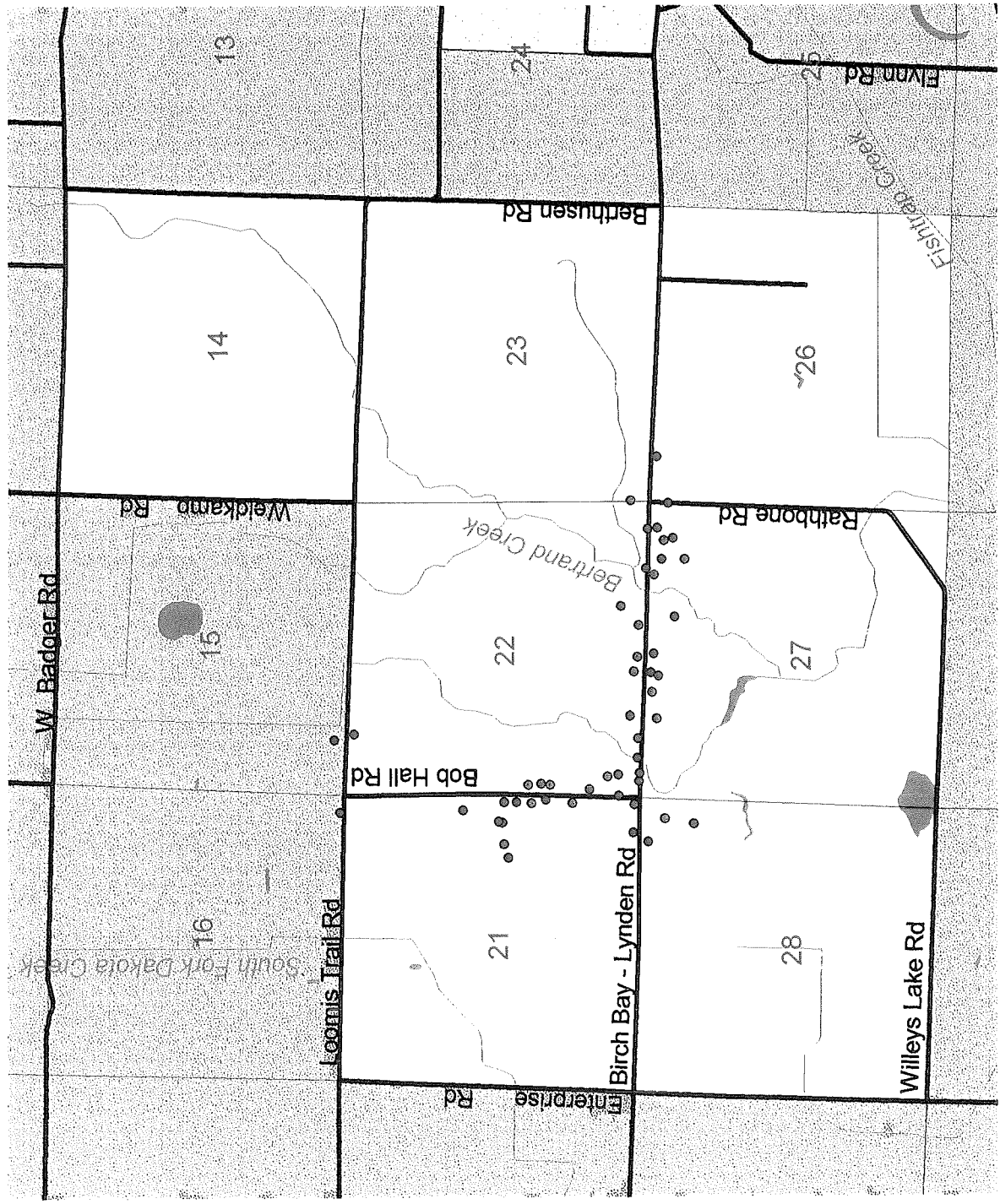
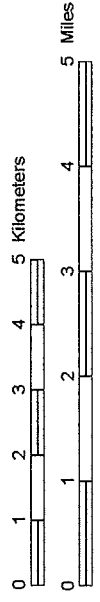
Figure 15. Results of Phase 1, 1998 Sampling for Nitrates in Study Area B Bertrand Creek/Meadowdale 1998 Study

-  Study Area B/Bertrand Creek
-  City of Lynden
-  Lakes

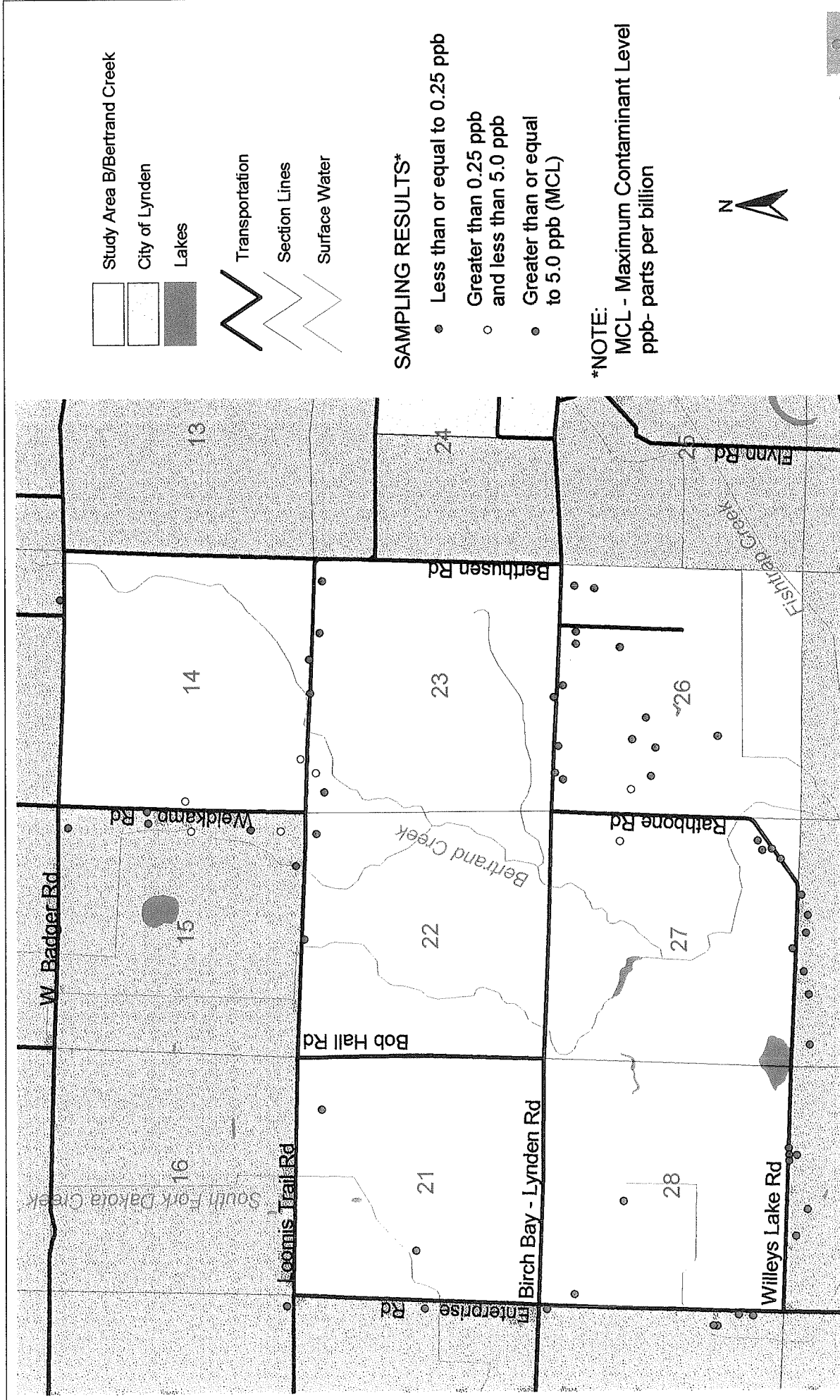
-  Transportation
-  Section Lines
-  Surface Water

SAMPLING RESULTS

-  Absent
-  Present



**Figure 16. Results of Phase 1, 1998 Sampling for Coliform in Study Area B
 Bertrand Creek/Meadowdale 1998 Study**



Study Area B/Bertrand Creek
 City of Lynden
 Lakes

Transportation
 Section Lines
 Surface Water

SAMPLING RESULTS*

- Less than or equal to 0.25 ppb
- Greater than 0.25 ppb and less than 5.0 ppb
- Greater than or equal to 5.0 ppb (MCL)

*NOTE:
 MCL - Maximum Contaminant Level
 ppb- parts per billion

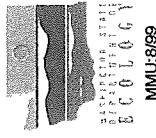
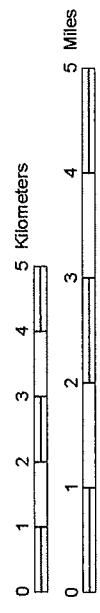


Figure 18. Results of Phase 2, 1998 Sampling for 1,2-DCP in Study Area B Bertrand Creek/Meadowdale 1998 Study

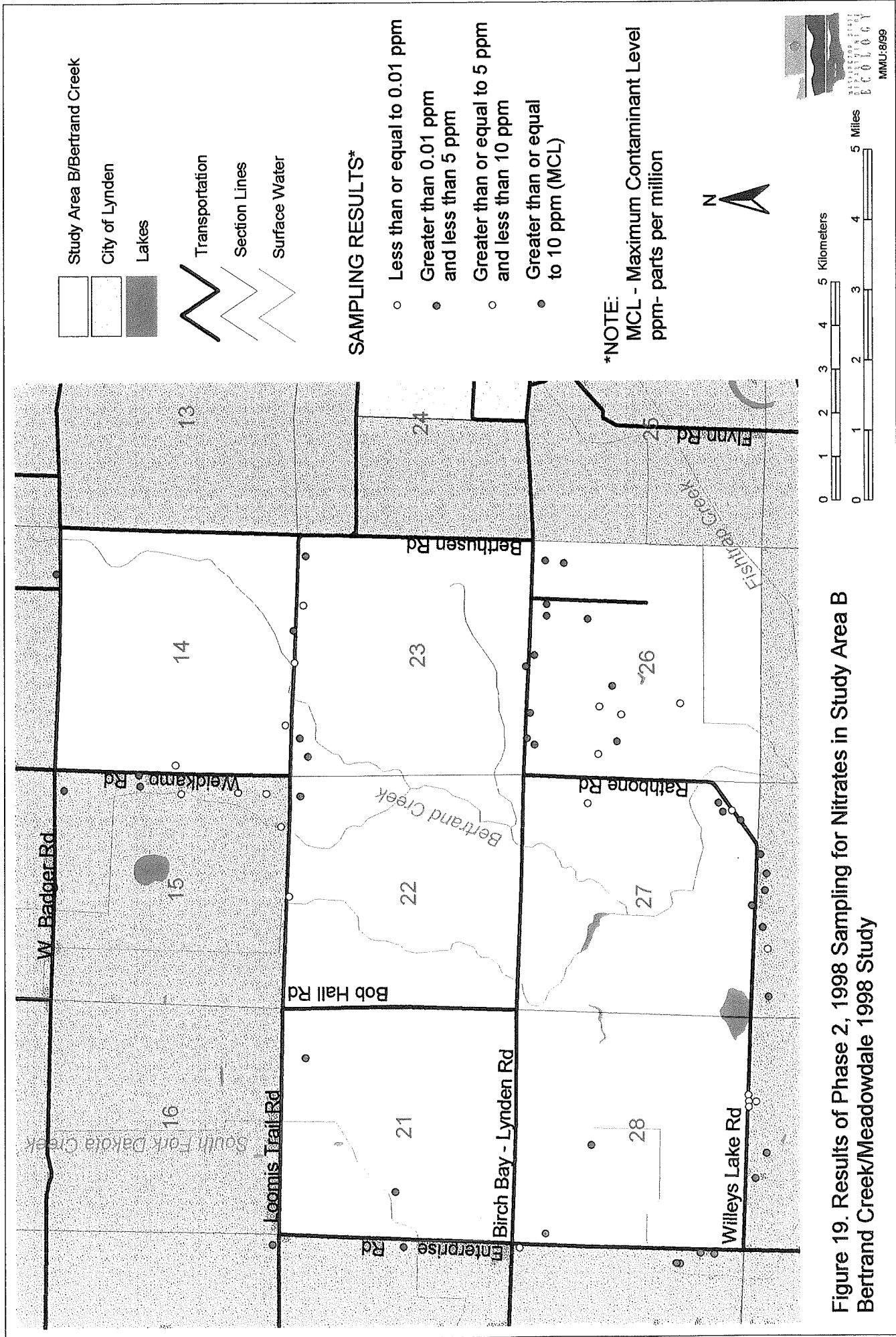


Figure 19. Results of Phase 2, 1998 Sampling for Nitrates in Study Area B
Bertrand Creek/Meadowdale 1998 Study

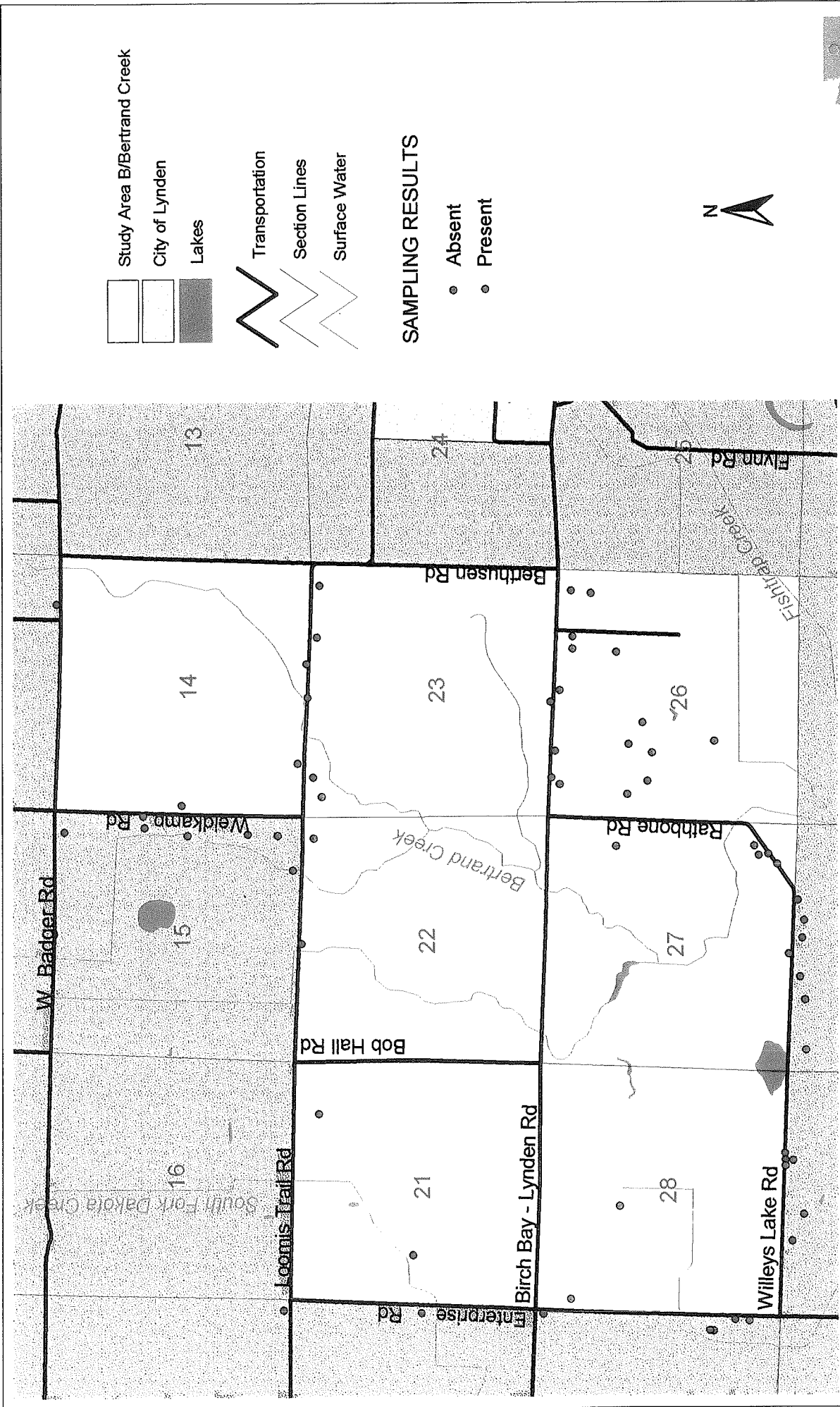
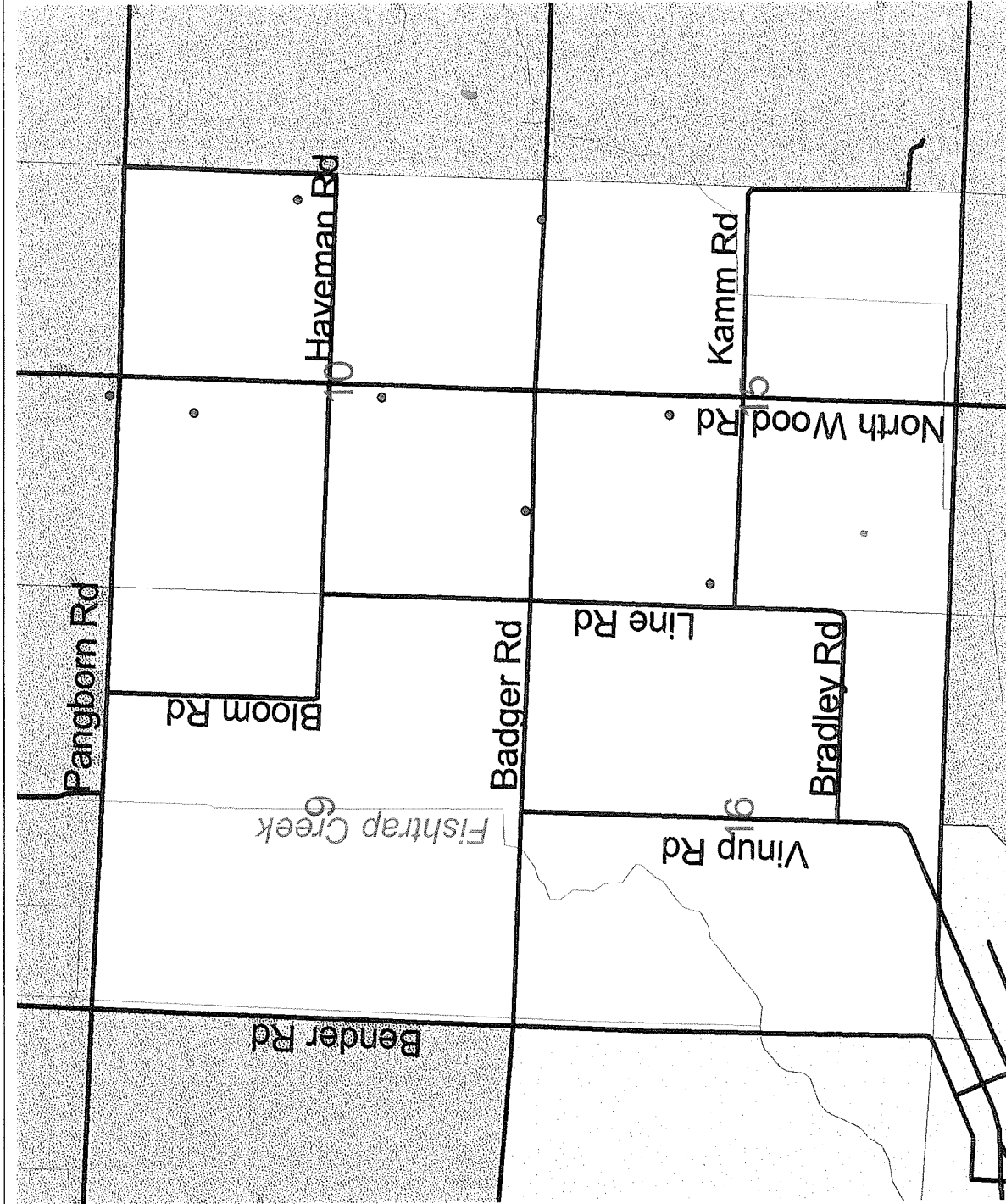


Figure 20. Results of Phase 2, 1998 Sampling for Coliform in Study Area B Bertrand Creek/Meadowdale 1998 Study



Study Area A/Meadowdale
 City of Lynden
 Lakes
 Transportation
 Section Lines
 Surface Water

SAMPLING RESULTS*

- Less than or equal to 0.02 ppb
- Greater than 0.02 ppb and less than 0.05 ppb
- Greater than or equal to 0.05 ppb (MCL)

*NOTE:
 MCL - Maximum Contaminant Level
 ppb- parts per billion

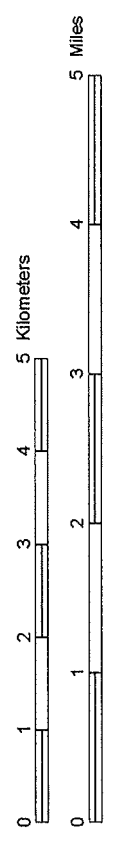
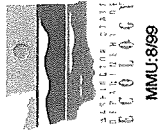


Figure 21. Results of 1998 Sampling for EDB in Study Area A Bertrand Creek/Meadowdale 1998 Study



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Study Area A/Meadowdale
 City of Lynden
 Lakes
 Transportation
 Section Lines
 Surface Water

SAMPLING RESULTS*

- Less than or equal to 0.25 ppb
- Greater than 0.25 ppb and less than 5.0 ppb
- Greater than or equal to 5.0 ppb (MCL)

*NOTE:
 MCL - Maximum Contaminant Level
 ppb- parts per billion

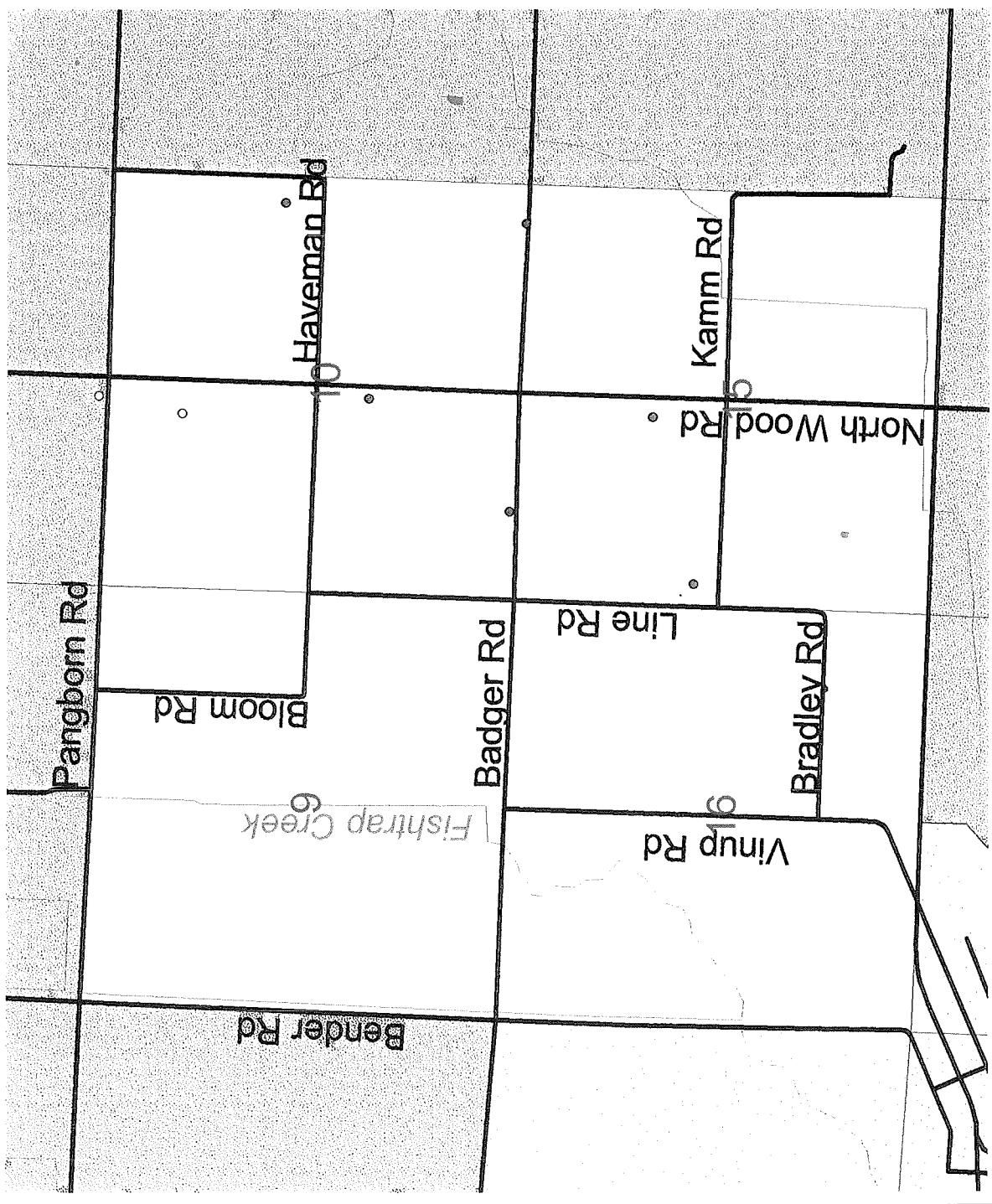
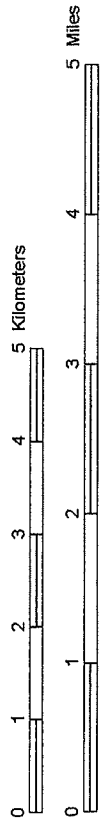
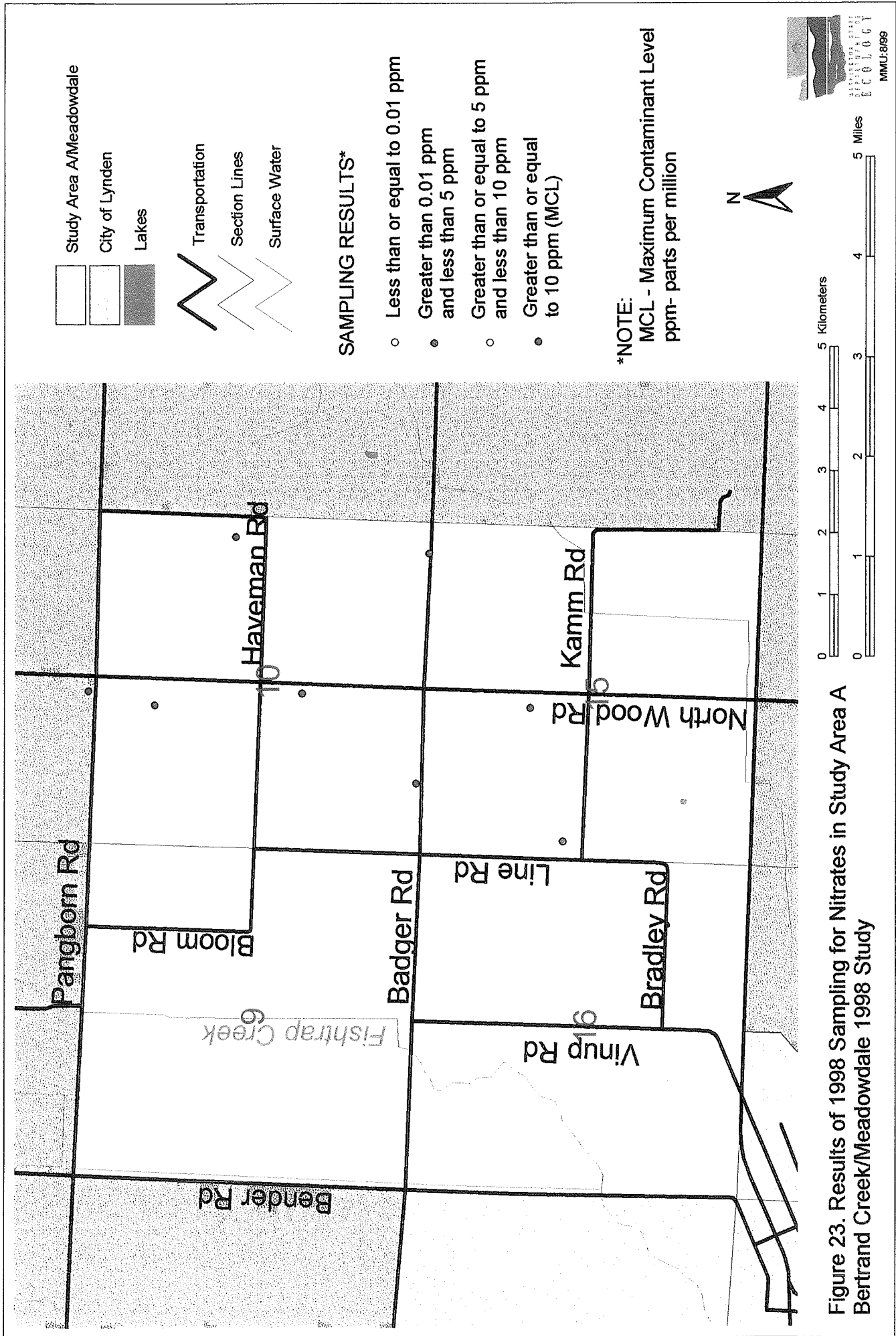


Figure 22. Results of 1998 Sampling for 1,2-DCP in Study Area A Bertrand Creek/Meadowdale 1998 Study



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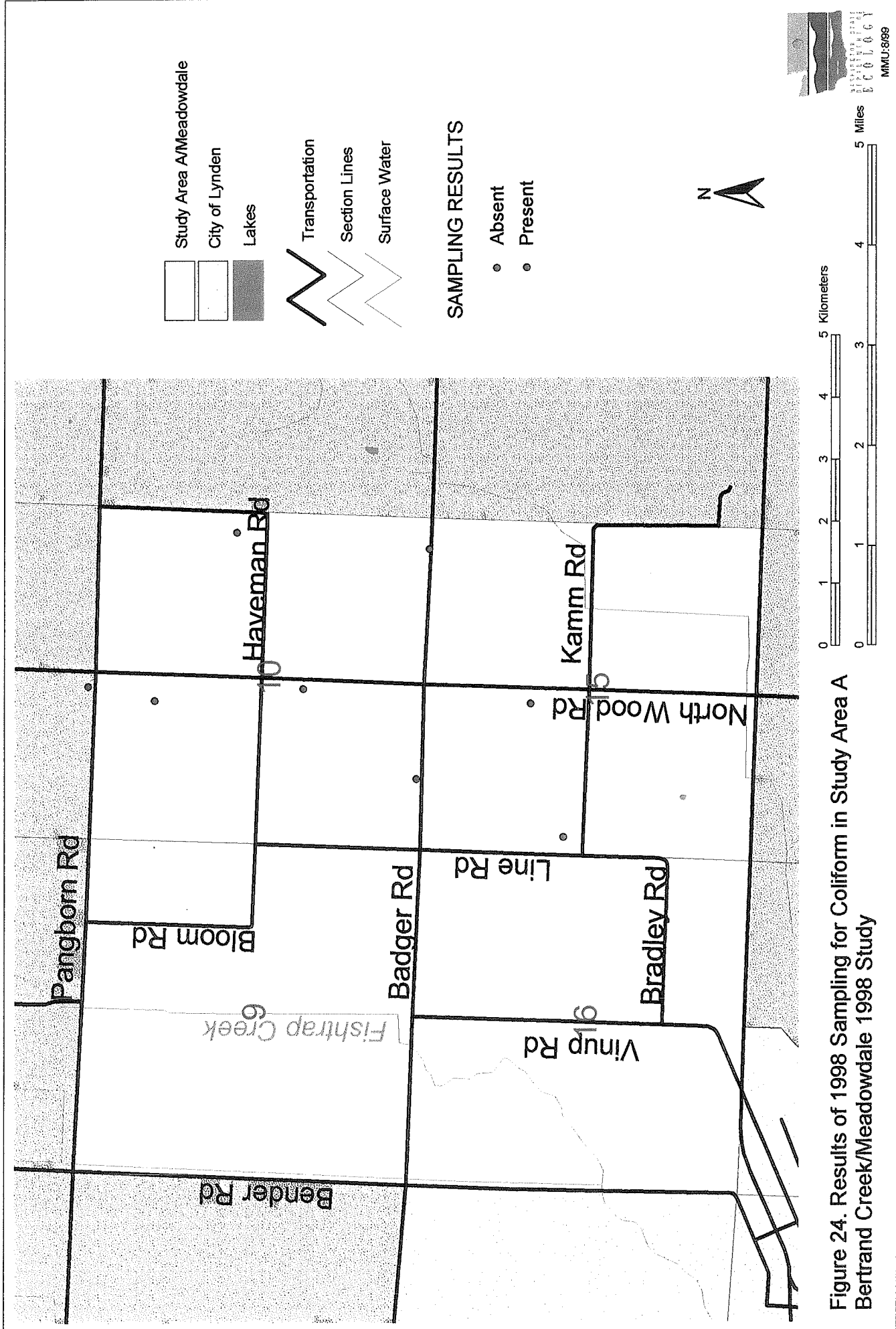


Figure 24. Results of 1998 Sampling for Coliform in Study Area A Bertrand Creek/Meadowdale 1998 Study

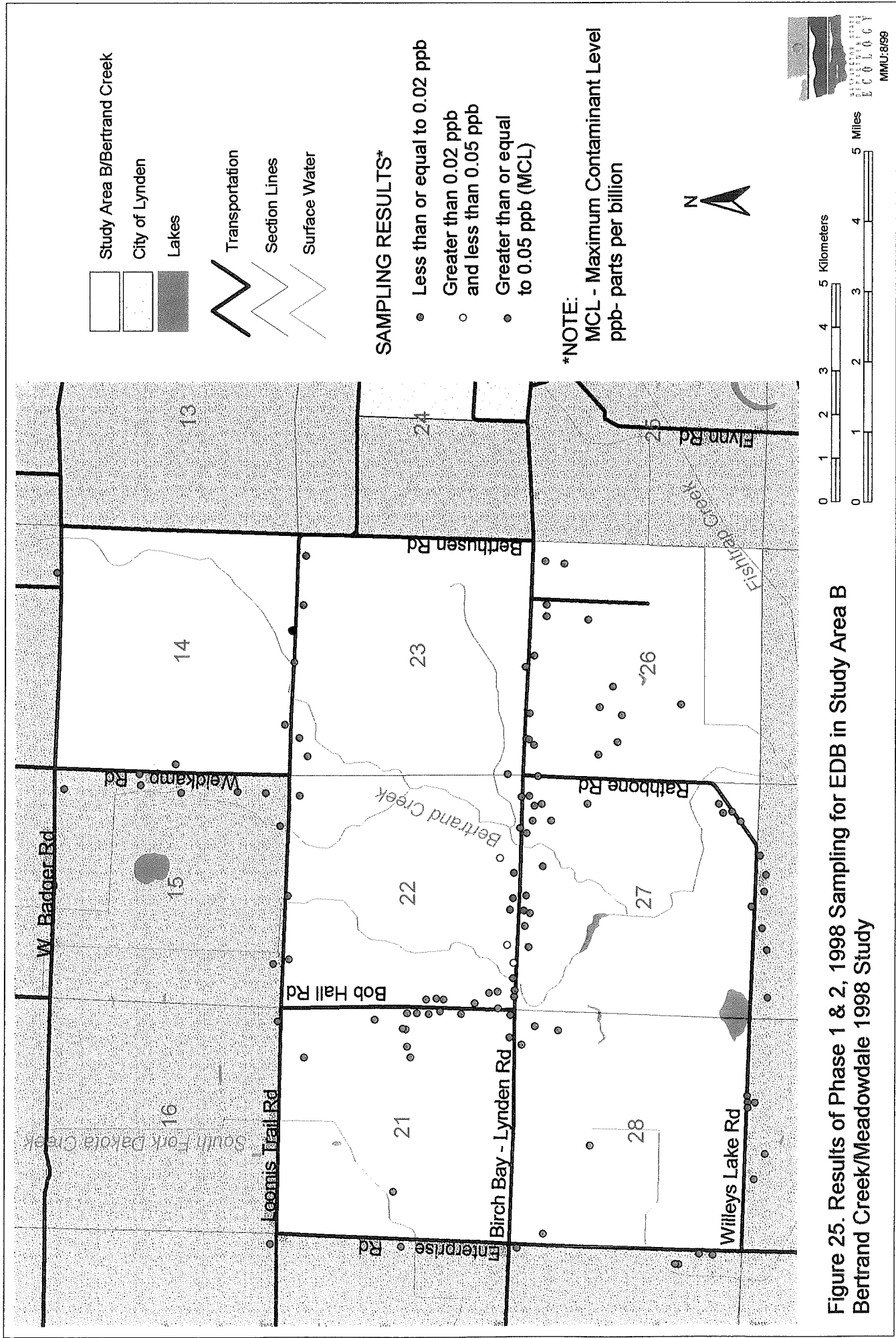


Figure 25. Results of Phase 1 & 2, 1998 Sampling for EDB in Study Area B
Bertrand Creek/Meadowdale 1998 Study



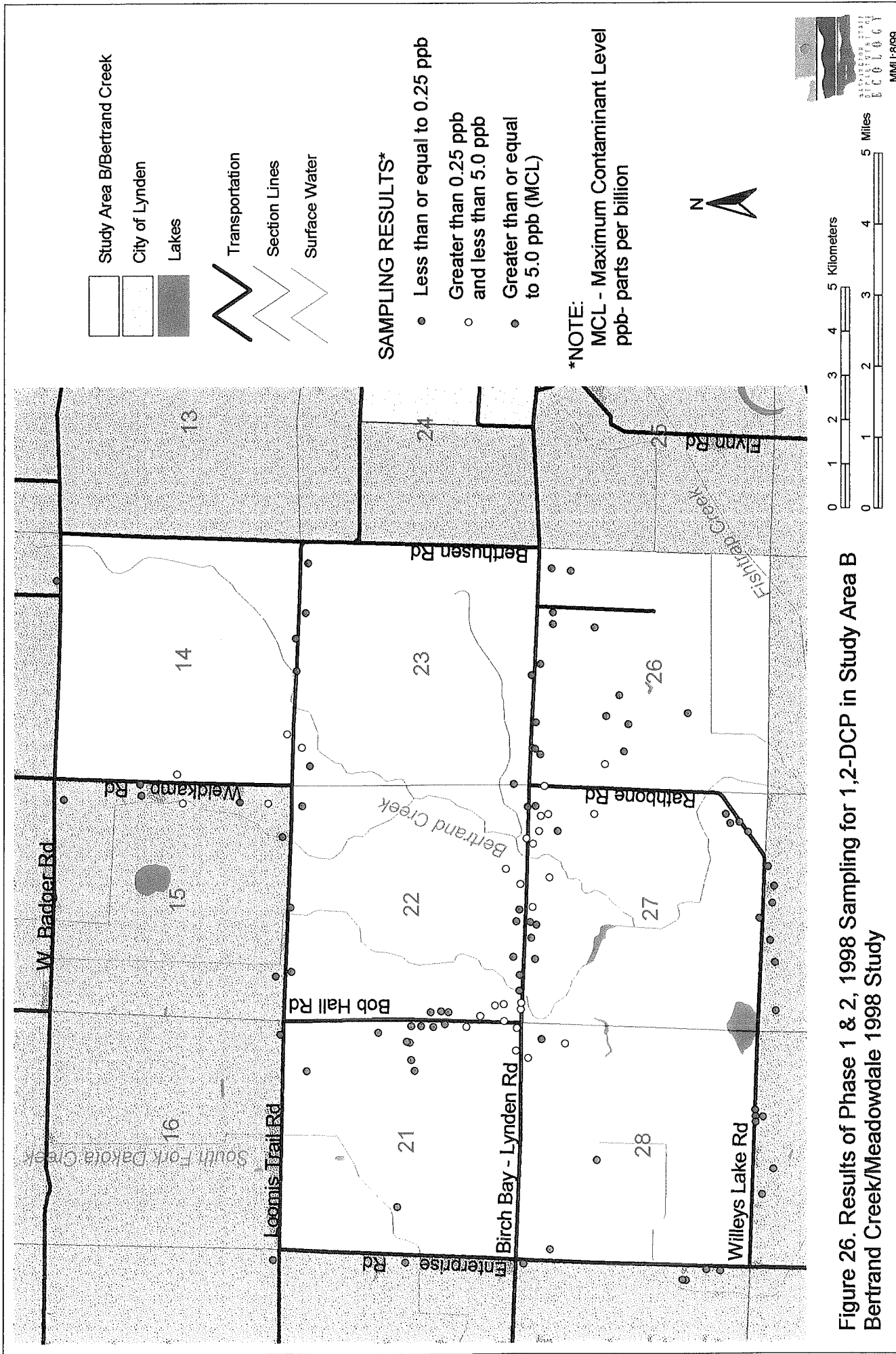


Figure 26. Results of Phase 1 & 2, 1998 Sampling for 1,2-DCP in Study Area B Bertrand Creek/Meadowdale 1998 Study

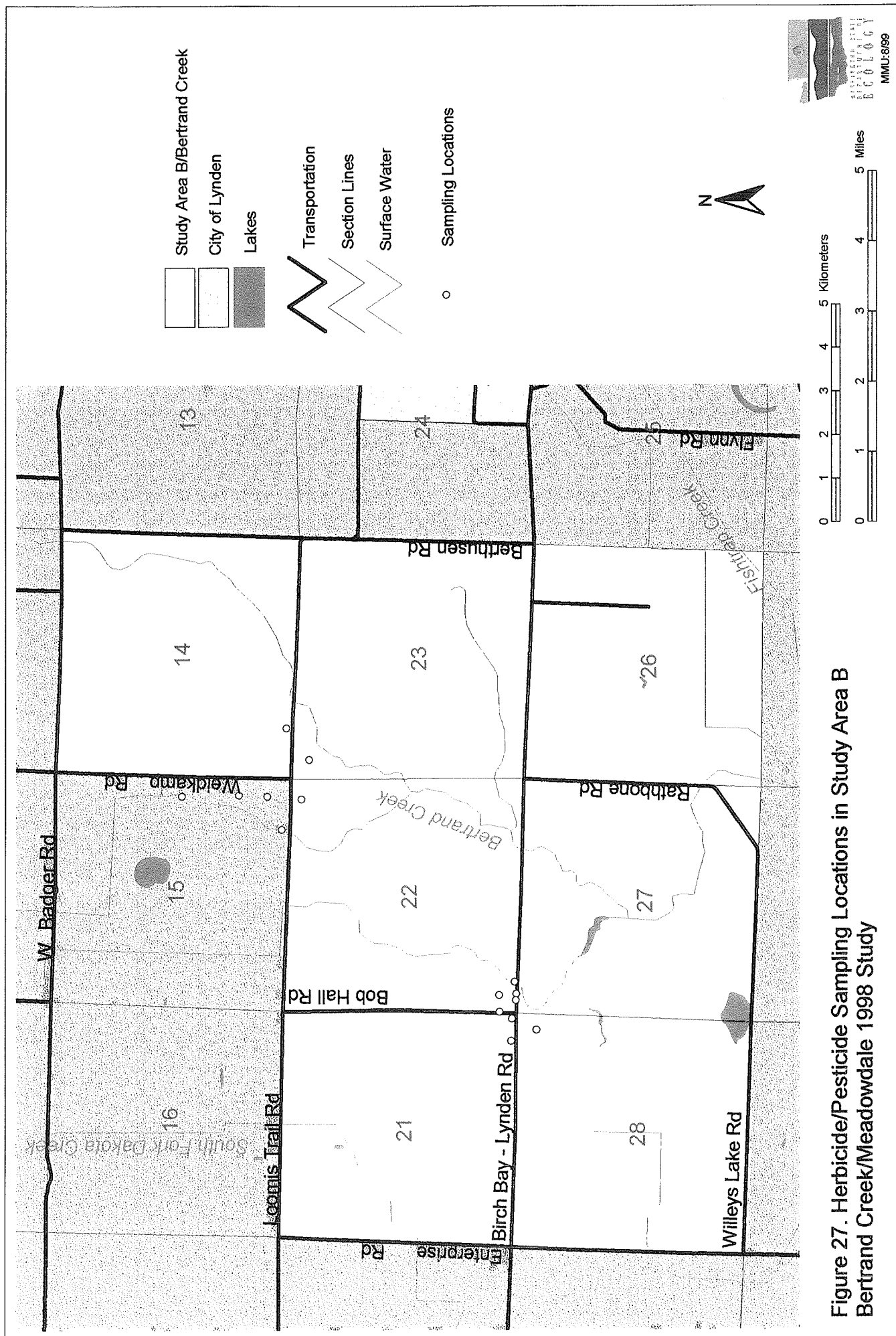
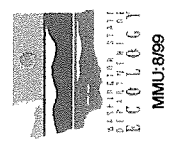


Figure 27. Herbicide/Pesticide Sampling Locations in Study Area B
 Bertrand Creek/Meadowdale 1998 Study



MMU:8169

Study Area B/Bertrand Creek
 City of Lynden
 Lakes

Transportation
 Section Lines
 Surface Water

SAMPLING RESULTS

- Absent
- Present

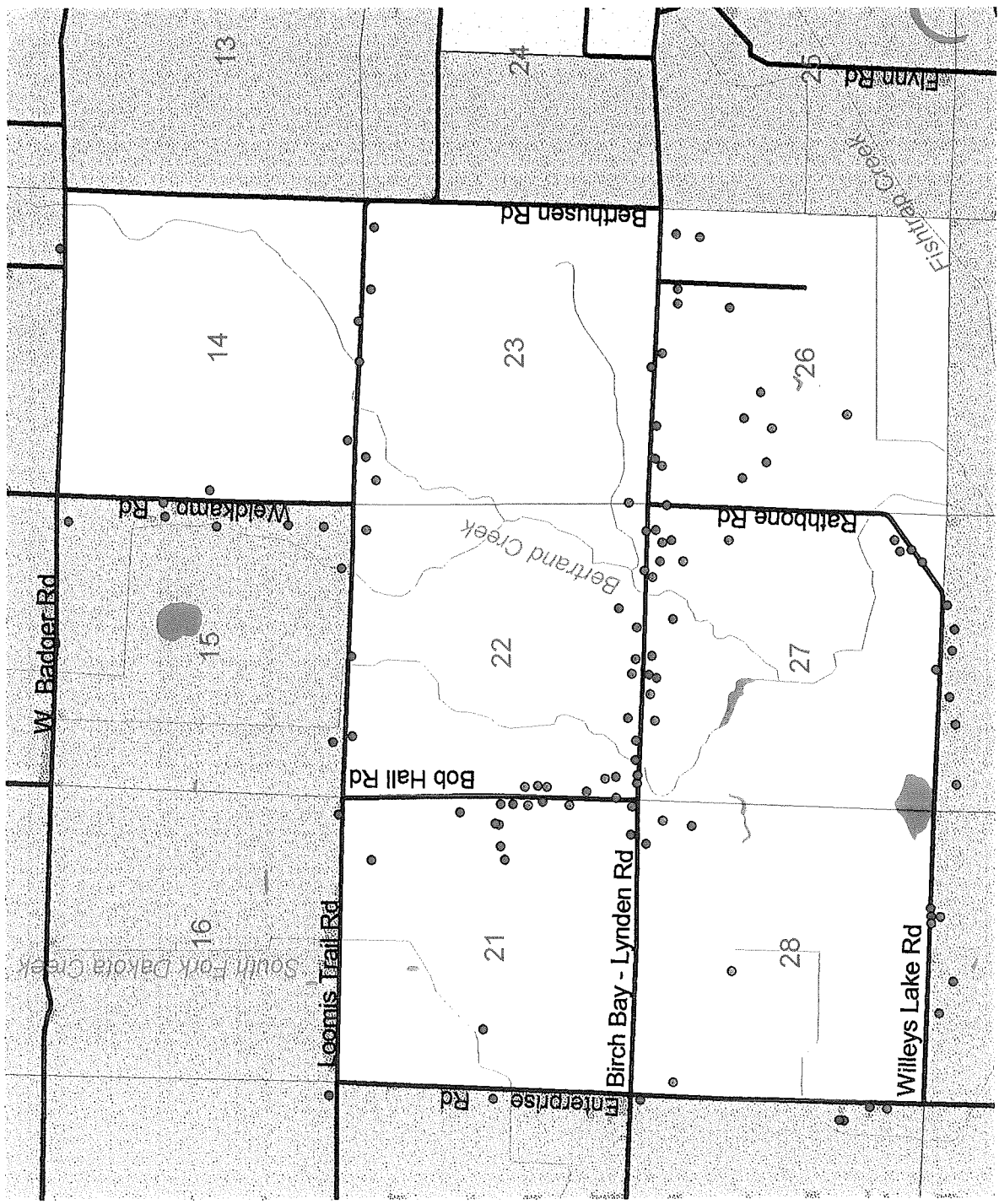
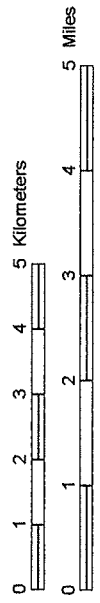


Figure 28. Results of Phase 1 & 2, 1998 Sampling for Coliform in Study Area B Bertrand Creek/Meadowdale 1998 Study

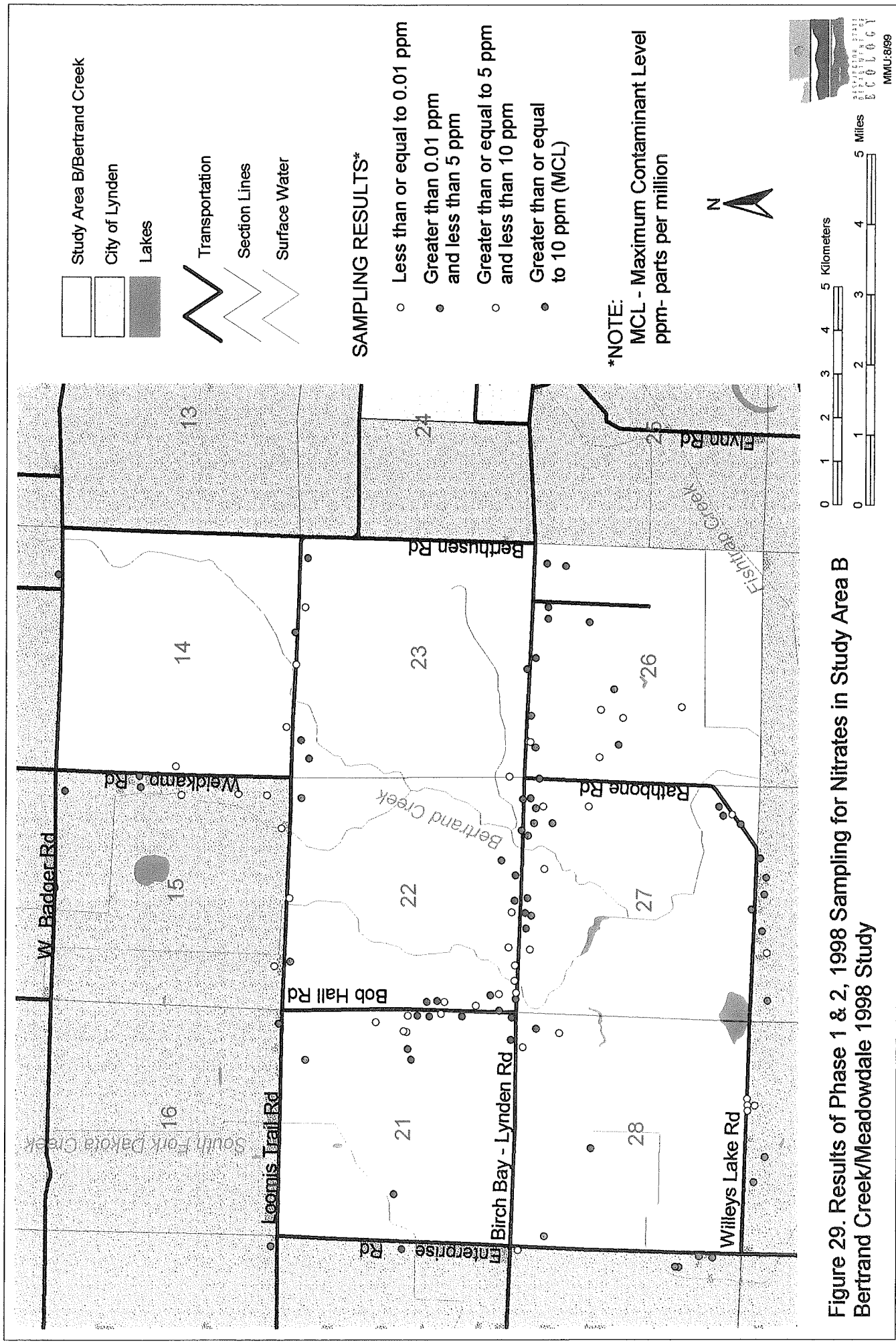


Figure 29. Results of Phase 1 & 2, 1998 Sampling for Nitrates in Study Area B Bertrand Creek/Meadowdale 1998 Study

