LUMMI NATION
WELLHEAD PROTECTION PROGRAM
2011 UPDATE

Prepared For:
Lummi Indian Business Council
(LIBC)

Funded By:
U.S. Environmental Protection Agency
(Grant Number BG-97042602-3)
and the
Lummi Indian Business Council

Prepared By:
Water Resources Division
Lummi Natural Resources Department

Contributors:

Jeremy Freimund, P.H.	Water Resources Manager
Jean Snyder	Water Resources Specialist II
Victor Johnson	Water Resources/GIS Technician III

December 2011

This project has been funded wholly or in part by the United States Environmental Protection Agency under Assistance Agreement BG-97042602-3 to the Lummi Nation. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

TABLE OF CONTENTS

EXECUTIVE SUMMARY
1. INTRODUCTION 1
2. LUMMI RESERVATION WELLHEADS 5
2.1. Topography and Climate 5
2.2. Ground Water Resources 9
2.2.1. Geology 9
2.2.2. Reservation Aquifers 11
2.3. Wellhead Inventory 11
2.4. Wellhead Characteristics 16
3. LUMMI WELLHEAD PROTECTION AREAS 19
3.1. Wellhead Protection Area Delineation Criteria 19
3.2. Wellhead Protection Area Delineation Methods 21
3.3. Lummi Wellhead Protection Areas Delineated in 1997 22
3.4. Lummi Wellhead Protection Areas Delineated in 2011 25
3.5. Lummi Wellhead Protection Areas 28
4. INVENTORY OF POTENTIAL CONTAMINANTS 31
4.1. Rating System for Potential Contaminant Sources 32
4.2. Potential Ground Water Contaminants 32
4.3. Potential Contaminant Sources Area 1 34
4.4. Potential Contaminants in Area 2 42
5. WATER SUPPLY CONTINGENCY PLAN 49
5.1. Current Reservation Water Supply 49
5.1.1. Existing Water System 49
5.1.2. Alternative Water Supply 53
5.1.3. Estimated Replacement Costs 54
5.2. Future Reservation Water Supply 56
6. WELLHEAD PROTECTION MEASURES 59
6.1. Surface Water Monitoring Program 59
6.2. Ground Water Monitoring Program 60
6.3. Comprehensive Water Resources Management Program 61
6.4. Water Resources Protection Code and Regulations 61
6.5. Spill Prevention and Response Plan 62
6.6. Lummi Ground Water Negotiations and Settlements 63
6.7. Water Conservation 64
6.8. Well Decommissioning 64
6.9. General Land Use Plan 66
6.10. Technical Review Committee 66
6.11. Integrated Solid Waste Management Plan 66
6.12. Lummi Tribal Sewer and Water District Code 67
7. WELLHEAD PROTECTION PROGRAM ACTION PLAN 69
8. COMMUNITY EDUCATION AND OUTREACH 71
9. CONCLUSION AND SUMMARY 73
10. REFERENCES 77

List of Figures

Figure 2.1. Regional Location of the Lummi Indian Reservation 6
Figure 2.2. Topography of the Lummi Reservation and Adjacent Areas 7
Figure 2.3. Well Numbering System Used by the USGS in Washington 13
Figure 2.4. Wellheads of the Lummi Reservation and Adjacent Upland Areas 15
Figure 3.1. 1997 Lummi Nation Wellhead Protection Areas 24
Figure 3.2. 2011 Lummi Nation Wellhead Protection Areas 26
Figure 3.3. Comparison of the 1997 and 2011 Lummi Nation Wellhead Protection Areas 27
Figure 3.4. Lummi Reservation Ground Water Characteristics (Cline 1974) 30
Figure 5.1. Lummi Water District Water Lines and Non-Tribal Water Associations 52
Figure 6.1. Wells Decommissioned on the Lummi Reservation between 2006 and 2011 65

List of Tables

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1 35
Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2 43
Table 5.1. Estimated Current Monthly Incremental Water Supply Replacement Costs 56
Table 5.2. Projected Service by the Lummi Water District System[1] 57
Table 7.1. Action Plan to Address Contamination of Reservation Ground Water by Various Pollutants 69

Appendices

Appendix A: Wellhead Inventory

Appendix B: Delineation of Watershed Boundaries from 2005 LiDAR Bare Earth Sample Points

Appendix C: Lummi Tribal Sewer and Water District 2010 Consumer Confidence Report

EXECUTIVE SUMMARY

The overall purpose of the Lummi Nation Wellhead Protection Program is to protect ground water within the Lummi Indian Reservation ("Reservation") from contaminants. The Program is intended to reduce the risk of the Lummi Nation's ground water resources becoming impaired or otherwise unusable as the primary water supply for the Lummi Nation and residents of the Reservation.

As described in the Lummi Nation Water Resources Protection Code (Lummi Code of Laws [LCL] Title 17), the Lummi Nation finds that contamination of ground water resources on the Reservation has a direct, serious, and substantial effect on the political integrity, economic security, health, and welfare of the Lummi Nation, its members, and all persons present on the Reservation. Further, the Lummi Nation finds that those activities posing threats of contamination, if left unregulated, could cause adverse effects. Accordingly, the Lummi Natural Resources Department, in conjunction with the Lummi Planning Department, has developed and will implement this wellhead protection program for the Reservation.

The program is based on the foregoing findings and the following considerations:

- As a finite resource, ground water is one of the most important and critical of the Lummi Nation's resources.
- Over 95 percent of the residential water supply for the Reservation is currently pumped from local ground water wells; contamination of wellheads carries the risk of adversely affecting the health of persons drinking or using water from these supplies.
- The salmon hatchery program, which is culturally and economically significant to the Lummi Nation and its members, is dependent on ground water. No suitable alternative water sources exist on or near the Reservation for the salmon egg incubation program and salmon rearing operation.
- Ample supplies of high quality ground water are essential to serve the purposes of the Reservation as a permanent, economically viable homeland of the Lummi Nation and its members.
- Ground water resources of the Reservation are vulnerable to pollution through saltwater intrusion.
- Ground water resources are vulnerable to contamination by pollutants introduced on or near the ground surface by human activities. Agricultural, residential, community, commercial, and industrial land uses increase the potential for ground water contamination.
- Ground water contamination could lead to the loss of the primary water supply source for the Reservation because water supply wells are difficult to replace, ground water contamination is expensive to treat, and some damages to ground water caused by contamination may be irreversible.

- Alternative water sources to serve the needs of the Reservation are expensive and may not be available in amounts sufficient to replace existing supplies and to provide for anticipated tribal economic and residential growth in the future.

The Lummi Nation Wellhead Protection Program was originally developed in three phases. The Wellhead Protection Program Phase I included a susceptibility assessment and development of contingency and public involvement plans (LWRD 1997). Phase II included implementing the community involvement plan, spill prevention and response planning, and the development of protection measures (LWRD 1998a). Phase III included the development and adoption of the Lummi Nation Water Resources Protection Code (LCL Title 17) and associated regulations.

This update of the 1997 Wellhead Protection Program documents includes the following primary changes to the earlier version:

- Combined the information from Phase I, Phase II, and Phase III into this single updated document.
- Updated the delineated wellhead protection areas.
- Updated the inventory of potential pollutant sources.
- Updated water supply replacement options.
- Added a new section describing on-Reservation wellhead protection programs.
- Updated the community outreach and education program for wellhead protection.

In the susceptibility assessment, the vulnerability of ground water wells to contamination is evaluated by characterizing the hydrogeologic setting, conducting an inventory of the water supply wells, delineating wellhead protection areas, and conducting an inventory of potential contamination sources in each wellhead protection area.

Two wellhead protection areas were delineated based on the flow boundaries approach and available hydrogeologic mapping. Wellhead Protection Area 1 (Area 1) is the southern upland area of the Reservation and includes most of the Lummi Peninsula and Portage Island. Wellhead Protection Area 2 (Area 2) is the northern upland area and extends north of the Reservation boundary.

As part of the susceptibility assessment, potential sources of aquifer contaminants from agricultural, residential, municipal, commercial, and industrial land uses in each of the wellhead protection areas were inventoried. Available literature and emissions inventories were used to identify potential aquifer contaminants associated with each source. Based on the location of each potential contaminant source, the quantity of potential contaminants associated with the source, and the

hazard represented by the contaminants, each potential source was assigned a potential hazard rating of low, moderate, or high.

Salt water intrusion caused by over pumping is a major threat to the Lummi Nation's ground water resources in both Area 1 and Area 2. The Reservation is located in a coastal area and most of the existing water supply wells on the Reservation are within a half mile of marine waters. Progressive salt water intrusion induced by over pumping of nearshore wells has already led to the closure of several wells on the Reservation. Other major threats to the ground water supply in Area 1 include: horses and goats fenced within residential areas near Hermosa Beach, single family residential units relying on private water supply wells and/or septic systems, and an abandoned landfill along Chief Martin Road. In Area 2, the major threats to the ground water supply (after salt water intrusion) include: single family residential units relying on private water supply wells and/or septic systems, roadways (i.e., transportation corridors for the Cherry Point Heavy Impact Industrial Zone), manure lagoons north of the Reservation, and the ConocoPhillips petroleum oil refinery.

Using current water price information and a simplified equation, it was determined that obtaining water from Bellingham costs about six times more than obtaining water from local ground water wells. At current prices, every 20 gallons per minute (gpm) of lost pumping capacity would cost about $3,280 per month to obtain the same amount of water from the City of Bellingham. To recover this increased cost, the Lummi Tribal Water District's rates would have to be raised an average of $3.33 per month for the current 986 residential customers if one 20 gpm well was lost. This increase represents about a 15 percent increase over the current average monthly Lummi Water District residential customer bill of $22.00. However, the simplified equation used to estimate the water replacement cost does not address the cost to the Lummi Nation of depleting a ground water resource in a region with a limited water supply. It is impossible to put a true value on a resource that is essential to life, is finite, and is irreplaceable.

(This page intentionally left blank)

1. INTRODUCTION

The overall purpose of the Lummi Nation Wellhead Protection Program is to protect ground water within the Lummi Indian Reservation ("Reservation") from contaminants. The Program is intended to reduce the risk of the Lummi Nation's ground water resources becoming impaired or otherwise unusable as the primary water supply for the Lummi Nation and residents of the Reservation.

As described in the Lummi Nation Water Resources Protection Code (Lummi Code of Laws [LCL] Title 17), the Lummi Nation finds that contamination of ground water resources on the Reservation has a direct, serious, and substantial effect on the political integrity, economic security, health, and welfare of the Lummi Nation, its members, and all persons present on the Reservation. Further, the Lummi Nation finds that those activities posing threats of contamination, if left unregulated, could cause adverse effects. Accordingly, the Lummi Natural Resources Department, in conjunction with the Lummi Planning Department, has developed and will implement this wellhead protection program for the Reservation.

The program is based on the foregoing findings and the following considerations:

- As a finite resource, ground water is one of the most important and critical of the Lummi Nation's resources.
- Over 95 percent of the residential water supply for the Reservation is currently pumped from local ground water wells, and contamination of wellheads carries the risk of adversely affecting the health of persons drinking or using water from these supplies.
- The salmon hatchery program, which is culturally and economically significant to the Lummi Nation and its members, is dependent on ground water. No suitable alternative water sources exist on or near the Reservation for the salmon egg incubation program and salmon rearing operation.
- Ample supplies of high quality ground water are essential to serve the purposes of the Reservation as a permanent, economically viable homeland of the Lummi Nation and its members.
- Ground water resources of the Reservation are vulnerable to pollution through saltwater intrusion.
- Ground water resources are vulnerable to contamination by pollutants introduced on or near the ground surface by human activities. Agricultural, residential, community, commercial, and industrial land uses increase the potential for ground water contamination.
- Ground water contamination could lead to the loss of the primary water supply source for the Reservation because water supply wells are difficult to replace, ground water contamination is expensive to treat, and some damages to ground water caused by contamination may be irreversible.

- Alternative water sources to serve the needs of the Reservation are expensive and may not be available in amounts sufficient to replace existing supplies and to provide for anticipated tribal economic and residential growth in the future.

The Lummi Nation Wellhead Protection Program was originally developed in three phases. The Wellhead Protection Program Phase I included a susceptibility assessment and development of contingency and public involvement plans (LWRD 1997). Phase II included implementing the community involvement plan, spill prevention and response planning, and the development of protection measures (LWRD 1998a). Phase III included the development and adoption of the Lummi Nation Water Resources Protection Code (LCL Title 17) and associated regulations.

As listed below, major components of the Lummi Nation's Wellhead Protection Program are a susceptibility assessment, a contingency plan, wellhead protection measures, a wellhead protection action plan, and a community involvement plan.

- **Susceptibility Assessment:** The purpose of the susceptibility assessment is to evaluate the vulnerability of ground water wells to contamination. Key elements of this assessment are an understanding of the hydrogeologic setting, an inventory and characterization of ground water wells on and adjacent to the Reservation, delineation of wellhead protection areas, and an inventory of potential ground water contaminant sources in each wellhead protection area.
- **Contingency Planning:** A contingency plan is an analysis of water supply replacement options and associated costs. The purpose of a contingency plan is to prepare for an emergency that would render a portion of the water supply unusable. The estimated cost to replace the existing water supplies also helps define the economic context of any proposed wellhead protection measures. That is, although a wellhead protective measure may have associated costs, the true economic cost of the protective measure should be evaluated in light of the replacement cost of the water source. This knowledge can help elected leaders justify the protective measure(s) to their constituents.
- **Development of Protection Measures:** Defining and implementing effective wellhead protection measures are the primary means to achieve the program goal of preventing ground water contamination. Wellhead protection measures on-Reservation include: the surface and ground water monitoring program, the comprehensive water resource management program, the Water Resources Protection Code and regulations, the Spill Prevention and Response Plan, the Lummi Ground Water Negotiations and Settlements, water conservation, the decommissioning of abandoned wells or wells not intended for future use, the general land use plan, the Technical Review Committee (TRC), the Integrated Solid Waste Management Plan, the Lummi Tribal Water and Sewer District Code, and similar activities.

- **Wellhead Protection Program Action Plan:** The long term goals of wellhead protection cannot be achieved overnight. Therefore determining short term objectives within the framework of a larger plan becomes critical to reaching the ultimate goal. Setting achievable goals has allowed for the Lummi Wellhead Protection Program to successfully complete all three phases in the program. The 2012-2017 action plan for the wellhead protection program is to continue to implement all of the wellhead protection measures that were initiated in Phase III of the Wellhead Protection Program.
- **Community Involvement:** Community involvement is a critical element of a wellhead protection program. The community involvement plan consists of a public education and outreach element and solicitation of interjurisdictional coordination and cooperation. Articles will be presented in the Lummi Nation monthly newspaper *Squol Quol* and information about wellhead protection activities and measures will be posted on the Lummi Natural Resources Department website.

This update of the 1997 Wellhead Protection Program documents includes the following primary changes to the earlier version:

- Combined the information from Phase I, Phase II, and Phase III into this single updated document.
- Updated the delineated wellhead protection areas.
- Updated the inventory of potential pollutant sources.
- Updated water supply replacement options.
- Added a new section describing on-Reservation wellhead protection programs.
- Updated the community outreach and education program for wellhead protection.

This Wellhead Protection Program report is organized into ten sections and three appendices. The ten sections of the report are:

- Section 1 is this introductory section.
- Section 2 is a description of the wellheads on the Reservation.
- Section 3 is a review of the methods used to delineate wellhead protection areas and a description of the Lummi wellhead protection areas.
- Section 4 presents the inventories of potential contaminant sources and associated potential contaminants in each wellhead protection area.
- Section 5 presents an analysis of water supply replacement options and associated costs.
- Section 6 is a description of the existing wellhead protection measures on the Reservation.
- Section 7 is an outline of the Wellhead Protection Action Plan.

- Section 8 presents the community education and outreach plan for the Wellhead Protection Program.
- Section 9 summarizes the Lummi Nation Wellhead Protection Program plan.
- Section 10 lists the references cited in this report.

2. LUMMI RESERVATION WELLHEADS

A wellhead is a physical structure, facility, or device at the land surface from or through which ground water flows or is pumped from water-bearing formations (i.e., aquifers). A wellhead can be a developed spring or a ground water well that was hand dug or constructed by machine.

To evaluate the vulnerability of wellheads to contamination, information is needed about the following conditions:

- Topography and climate,
- Ground water resources,
- Locations and characteristics of nearby wellheads,
- Water sources for the wellheads,
- Methods that can be used to define and map wellhead protection areas, and
- Potential contaminants that could make the ground water resources unusable.

This section describes the topography and climate, the ground water resources of the Reservation, a wellhead inventory, and the wellhead characteristics. In the sections that follow, the wellhead protection areas are identified and an inventory of potential contaminant sources in the mapped areas is presented.

2.1. Topography and Climate

The Lummi Indian Reservation (Reservation) is located in northwest Washington State, approximately eight miles west of Bellingham, Washington (Figure 2.1). The Reservation includes approximately 13,000 acres of uplands and 11,000 acres of tidelands. The Nooksack River drains a watershed of approximately 786 square miles, flows through the Reservation near the mouth of the river, and discharges to Bellingham Bay (and partially to Lummi Bay during high flows).

The Lummi Reservation is comprised of two relatively large upland areas, a smaller upland area on Portage Island, and the low lying areas of the Lummi River and Nooksack River flood plains and the Sandy Point peninsula (Figure 2.2). The maximum elevation of the northwestern upland area of the Reservation is about 216 feet above the North American Vertical Datum 1988 (ft NAVD88). The southern upland area is the Lummi Peninsula with a maximum elevation of about 178 feet NAVD88. The floodplain of the Lummi River and Nooksack River, with an average elevation of approximately 10 feet NAVD88, is located between the northern and southern upland areas. The Nooksack River and the Nooksack River delta are

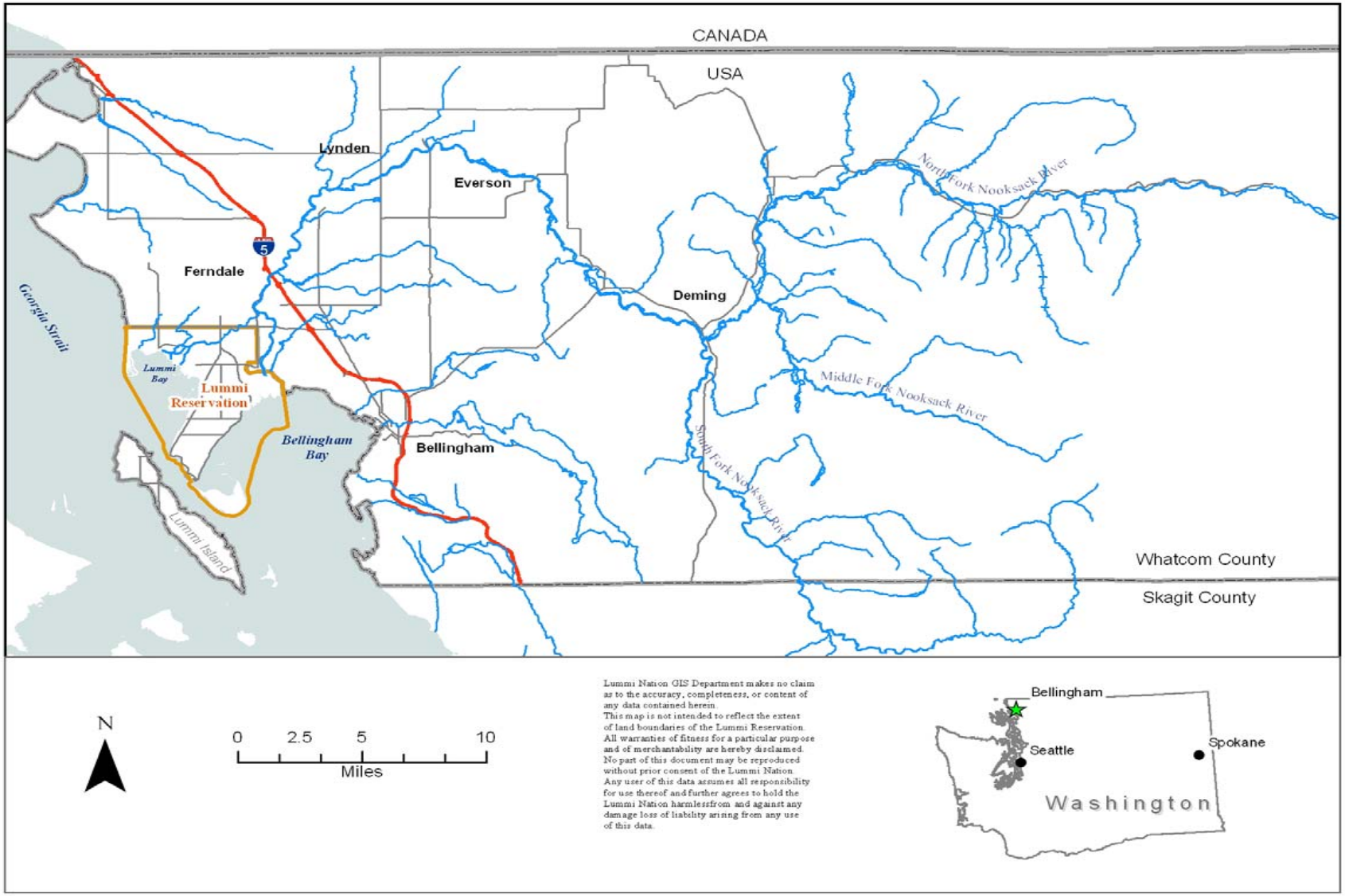

Figure 2.1. Regional Location of the Lummi Indian Reservation

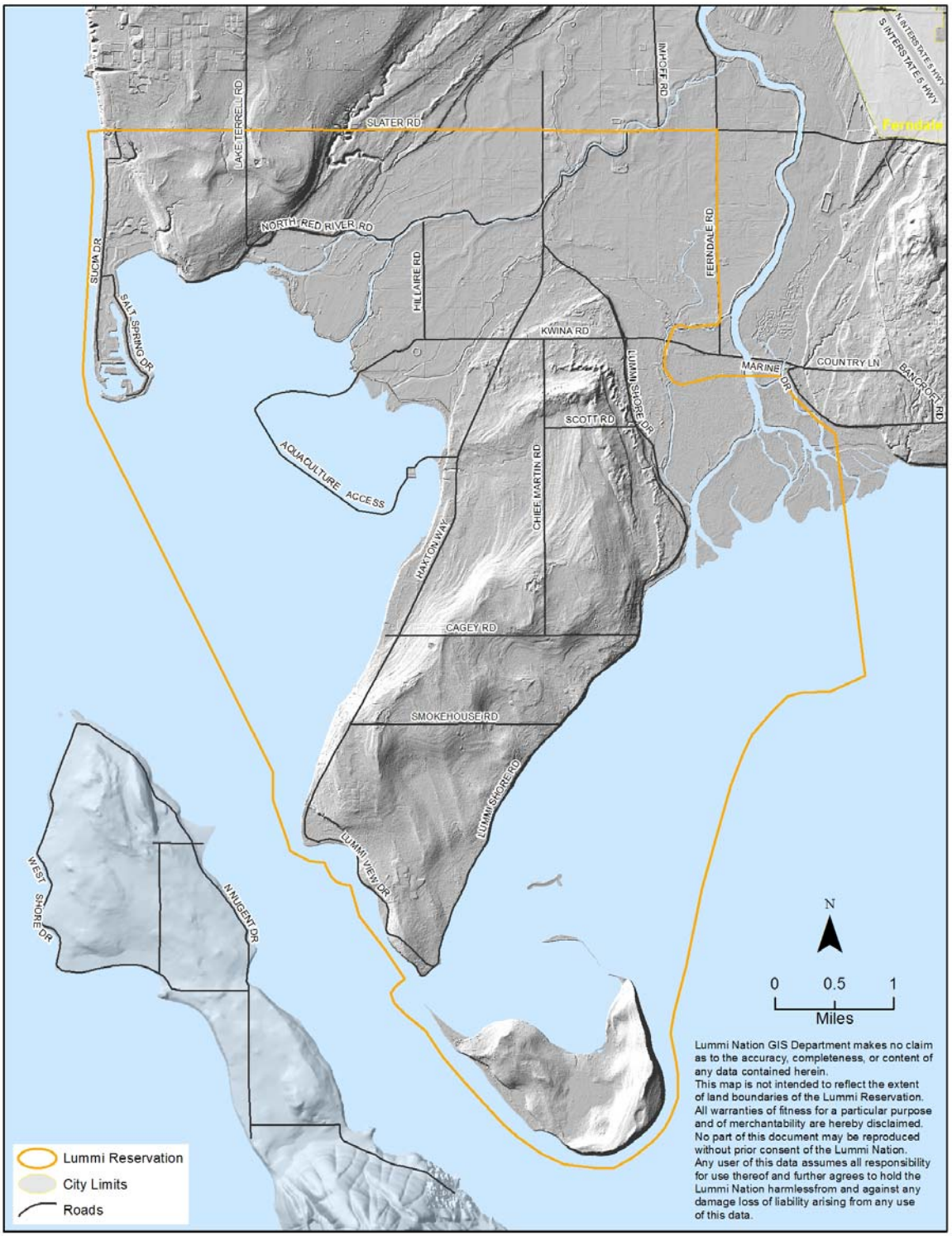

Figure 2.2. Topography of the Lummi Reservation and Adjacent Areas

located along the northeastern extent of the Reservation. The Sandy Point peninsula lies to the southwest of the northwestern upland. Portage Island lies at the southeastern tip of the Lummi Peninsula and has a maximum elevation of approximately 209 feet NAVD88.

The two relatively large upland areas are drained by short, intermittent streams and numerous springs both above and below the line of ordinary high water. These streams and springs discharge onto tribal tidelands along Bellingham Bay, Hale Passage, Lummi Bay, Onion Bay, Georgia Strait, or to the floodplains of the Lummi and Nooksack rivers. The floodplain areas are drained by a network of agricultural drainage ditches and the Lummi River and Nooksack River. The drainage on Portage Island consists of at least two intermittent streams that drain northward to Portage Bay. Springs along the upland areas of Portage Island and below the line of ordinary high water also discharge to marine waters and Reservation tidelands.

Pacific Northwest (PNW) climate and ecology are largely a result of the interactions that occur between seasonally varying precipitation patterns and the mountain ranges that characterize the region. Approximately 75 percent of the PNW precipitation occurs in just half the year (October through April) when the PNW is on the receiving end of the Pacific storm track. Based on climate data collected at the nearby Bellingham International Airport, the average annual precipitation on the Reservation is approximately 36 inches. On average, November, December, and January are the wettest months; June, July, and August are the driest months.

Temperatures on the Reservation are relatively mild year round. Temperature data collected at the Bellingham Airport from 1948-1985 (USDA 1992) indicate that the warmest months are July and August. During these months the average maximum daily temperature is approximately 74 degrees Fahrenheit (^{o}F). December and January are the coldest months and the average maximum daily temperatures during these months are about 44°F. The growing season is “the portion of the year when soil temperature (measured 20 inches below the surface) is above biological zero (5°Celsius [C] or 41°F). May through September is the approximate growing season for agricultural crops in the area (Gillies 1998).

Evapotranspiration is the combined loss of water to the atmosphere through evaporation from the soil surface, evaporation of intercepted water, and plant transpiration. Evapotranspiration has not been measured directly on the Reservation but has been estimated. Phillips (1966) estimated the average annual actual evapotranspiration for a 6-inch water holding capacity soil at the Marietta 3 NNW station to be approximately 18.8 inches. This estimate represents about 52 percent of the mean annual precipitation. Evapotranspiration was also calculated from meteorological variables measured on the Reservation from 1997 though 2001 as part of the Lummi Peninsula ground water investigation (Aspect Consulting 2003). The Penman Monteith method with a grass reference crop was used in this study. The average annual reference evapotranspiration for the Lummi Indian Reservation from 1997 through 2001 was calculated to be 21.1 inches (Aspect

Consulting 2003). The average annual precipitation measured during this same period was 32.8 inches, indicating that approximately 64 percent of the average annual precipitation is lost to evapotranspiration. A review of evapotranspiration estimates from 27 studies conducted in the Puget Sound Lowland (Bauer and Mastin 1997) suggests an average evapotranspiration rate of about 17.3 inches. On average, the estimated mean annual evapotranspiration from the 27 studies was about 46 percent of the mean annual precipitation (Bauer and Mastin 1997).

Wind data for Bellingham indicates that the prevailing wind direction on the Reservation is from the south southeast with gusts upward of 80 miles per hour. Winds from the west are not as common and generally not as strong (Corps 1997). A wind rose developed from meteorological data collected near the north boundary of the ConocoPhillips oil refinery over the August 1982 through March 1984 period (Mobil Oil Corporation 1986) indicated that the wind direction is from the north or northwest about 6 percent of the time. The wind rose for the area north of the Reservation and near Georgia Strait indicates that the wind direction is from the northeast about 20 percent of the time. A wind energy development feasibility study is being conducted on the Reservation during 2011 and will provide more accurate wind data for the Reservation.

Because most of the precipitation occurs during the winter months when evapotranspiration demand is low, most of the ground water recharge occurs during this season. After the rainy season and during the summer months when evapotranspiration demand is high, little water is available for downward percolation and recharge of the aquifer.

2.2. Ground Water Resources

The hydrogeologic conditions on the Lummi Reservation have been described previously by the USGS and others (Washburn 1957, Cline 1974, Easterbrook 1973, Easterbrook 1976, Aspect Consulting 2003). In general, the Reservation is underlain by unconsolidated sediments deposited as glacial outwash, glaciomarine drift, glacial till, and floodplain or delta deposits of Quaternary age (Washburn 1957). The unconsolidated deposits consist of clay, silt, sand, gravel, and boulders. Because the composition of the deposits commonly change laterally over short distances, it is difficult to distinguish between the different stratigraphic units from existing well log data.

2.2.1. Geology

During the Pleistocene, the sea level rose and fell dramatically as the climate changed and the earth's crust warped. Inundation by seawater caused the glaciers to float and deposit layers of clay, silt, sand, gravel, and boulders. After the glacier receded, the Nooksack River occupied an old channel formed by the glacial melt water and began depositing material on either side of the Lummi Peninsula (then an island). As the river delta grew, it connected the Lummi Peninsula to the mainland.

The sediment units that occur on the Reservation, as described by Cline (1974) and Easterbrook (1976) in order from youngest to oldest, are summarized below.

- **Alluvium:** The alluvium is derived from sediment carried by the Lummi River and Nooksack River and deposited on the floodplain and Reservation tidelands. It is comprised mostly of clay, silt, sand, and some gravel.
- **Beach Deposits:** The beach deposits are laid by littoral drift processes. The deposits are mostly sand with some gravel and occur mainly at the western part of the Reservation from Neptune Beach to Sandy Point, at Gooseberry Point, and near Fish Point.
- **Older Alluvium:** The older alluvium was deposited by the Lummi River and Nooksack River when the valley floor was relatively higher than at present. The unit consists mostly of fine sand with some silt and clay located on stream terraces flanking the uplands above the floodplain. These deposits occur along the southeast flank of the Mountain View Upland and the northeast flank of the Lummi Peninsula.
- **Gravel:** A thin unsaturated gravel unit is exposed at the surface at several locations on the Reservation. The unit consists of gravel and sand/gravel. In places, this unit appears to have been reworked by beach processes during post-glacial uplift and overlies glaciomarine drift.
- **Glaciomarine Drift:** The Glaciomarine Drift unit was deposited late in the Fraser Glaciation (from about 20,000 years ago to about 10,000 years ago [Easterbrook 1973]). The drift is comprised of unsorted clay, silt, sand, gravel, and some cobbles and boulders. The deposits include both Kulshan and Bellingham drifts.
- **Glacial Till:** The glacial till from the Vashon Stade of the Fraser Glaciation is comprised of poorly sorted clay, silt, sand, gravel, and some cobbles and boulders. Because the presence of till is noted in only a few well logs and has been observed at only a few locations along the Lummi Peninsula bluffs, the occurrence of till is believed to be limited.
- **Esperance Sand:** The Esperance Sand unit (Easterbrook 1976), formerly named Mountain View Sand and Gravel, is advance outwash comprised of stratified beds of sand and gravel with stratified lenses of sand. The unit overlies the Cherry Point Silt unit and underlies the glaciomarine drift and till; it is the major water-yielding unit beneath the Reservation.
- **Cherry Point Silt:** The Cherry Point Silt unit is the oldest known unconsolidated stratigraphic unit in the northern Puget Sound lowland. The unit is comprised of a thick sequence of blue to brownish gray stratified clay and silt with minor sandy beds.
- **Bedrock:** The Bedrock underlying the Reservation consists mostly of sedimentary rocks such as sandstone, siltstone, shale, and conglomerate. The bedrock is deeply buried by unconsolidated glacial deposits.

2.2.2. Reservation Aquifers

Ground water in the Reservation aquifers is obtained primarily from outwash deposits of sand and gravel in the unconsolidated glacial sediments, which are generally recharged by local precipitation. Glaciomarine drift is at or near the ground surface over much of the upland areas on the Reservation. The glaciomarine drift overlays the outwash deposits and contains substantial amounts of clay. This clay restricts the recharge to the underlying aquifer and promotes storm water runoff.

Two separate potable ground water systems occur on the Reservation. One system is located in the northern upland area. This northern system flows onto the Reservation from the north and drains to the west, south, and east (Aspect Consulting 2009a). The second potable ground water system is located in the southern upland area of the Reservation (Lummi Peninsula) and is completely contained within the Reservation boundaries (LWRD 1997, Aspect Consulting 2003). The floodplain of the Lummi River and Nooksack River, which contains a surface aquifer that is saline (Cline 1974), separates the two potable water systems. A third potable water system may exist on Portage Island, but information on the water quality and the potential yield of this system is limited and inconclusive.

In general, both the northern and southern ground water systems contain two aquifer types (Washburn 1957, Easterbrook 1976). The upper aquifer type is comprised primarily of lenses of sand or sand and gravel that are in or above the glaciomarine drift. These relatively permeable lenses are not continuous throughout the area. The lower aquifer layer is comprised of advance outwash sand and gravel. The thickness of the lower aquifer, which appears to be semi-confined in places and unconfined in other places, is variable and generally not known. The pebbly clay in the drift sediments and scattered deposits of till greatly slow the downward percolation of water to the lower aquifer and may act locally as a confining layer.

Because the hydrogeologic conditions on the Reservation vary considerably over short horizontal and vertical distances, the precise locations of the aquifer recharge zones are not definitively known at this time. It is likely that aquifer recharge areas are distributed over the upland areas. However, given the high runoff potential of the glaciomarine drift that covers much of the Reservation upland, it is also possible that aquifer recharge areas are of limited areal extent and are located primarily in only a few locations around the Reservation. Until information that is more precise is developed, all of the northern and southern upland areas on the Reservation are assumed to be aquifer recharge zones.

2.3. Wellhead Inventory

Wellheads and/or the ground water resources on the Reservation have been inventoried by the U.S. Geological Survey (USGS) and others on several occasions since the late 1940s (Newcomb et al. 1949, Washburn 1957, Cline 1974, Charles Howard and Associates Ltd. 1991, Golder 1992, Drost 1996, Aspect Consulting

2003). The information from these inventories, along with information collected by the Lummi Natural Resources Department Water Resources staff since 1991, was used to identify the wellhead locations on the Reservation. In addition, information from the previous USGS work, well logs obtained from the Washington State Department of Ecology, and an aquifer study conducted in the Mountain View Upland (Aspect Consulting 2009a) were used to identify the locations of wells north of the Reservation in the watersheds that contribute surface water to the Reservation. These wells located beyond the exterior boundaries of the Reservation were inventoried because they may share an aquifer that extends onto the Reservation.

Two separate numbering systems are used to identify wellheads on the Reservation. The primary wellhead identification system is a simple numbering system that starts with the number 1. This system builds on the work of Cline (1974). Wells numbered 1 through 99 were inventoried by Cline (1974). The 19 test holes drilled in 1956 (Washburn 1957) and wells constructed or identified after the 1971 inventory conducted by Cline have a local identification number greater than 99. This simple numbering system was slightly modified during 2006 as part of a database upgrade project. Well numbers are now preceded by the letters GW (e.g., GW001, GW002, GW141). The second wellhead identification system is used by the USGS. Both systems were used so that the well information is interchangeable between the USGS and the Lummi Natural Resources Department.

The USGS wellhead identification system is based on the wellhead location within a township, range, and section of the Public Lands Survey System (PLSS). For example, a well located along Lummi View Drive south of the Mackenzie Road intersection could have the identification number 37N/01E-03H01. This identification number indicates that the well is in Township 37 north of the Willamette base line (37N), in Range 1 east of the Willamette Meridian (01E), and in Section 3 within the township (03). The letter following the section number ("H") indicates the quarter-quarter section (40-acre) that contains the well. The number following the letter (01) is the sequential number of the wellhead within the 40 acre subsection. The letters "S" or "D" following the sequence number indicates respectively that the wellhead is either a spring or a deepened well. This location based numbering system is illustrated in Figure 2.3.

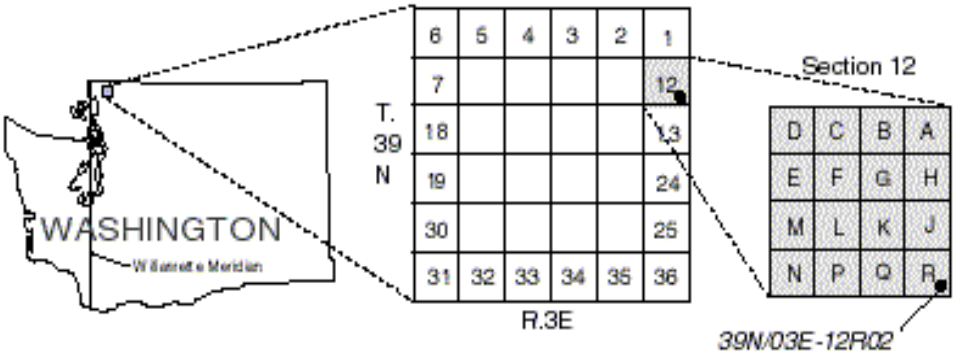

Figure 2.3. Well Numbering System Used by the USGS in Washington

A database about Reservation wellheads was developed in 1996 using information provided by the USGS, information from well logs, and information collected by the Lummi Water Resources Division. This database currently contains the following fields:

1. Lummi Number (local identification number)
2. Location (USGS identification number)
3. Owner (owner identified on well log or current owner if known)
4. X Coordinate (UTM coordinate (X-axis) in meters)
5. Y Coordinate (UTM coordinate (Y-axis) in meters)
6. Z Coordinate (elevation of wellhead in feet above mean sea level [msl])
7. ZM Coordinate (elevation of well water level measurement point in feet)
8. Site Use (primary site use [e.g., withdrawl, destroyed, unused, standby or emergency, unknown])
9. Water Use (primary use of water [e.g., public supply, domestic, irrigation, test well, fish propagation, unused or destroyed, commercial, municipal, industrial, stock watering, other])
10. Tribal Owner (is the well owned by a Lummi Tribal Member [yes or no])
11. Chemical Data (chloride data, chloride and other data, or no chemical data)
12. Pump Test (pump test conducted using near by monitoring wells [yes or no])
13. Active (is the well actively being used [yes or no])
14. Monitor (is the well in the Lummi Natural Resources monitoring program [yes or no])
15. Reservation (is the well located on the Reservation [yes or no])
16. Accuracy of the Z Coordinate (accuracy of the elevation data in feet)
17. Field Visit (well has been visited in the field [yes or no])
18. Latitude (latitude of wellhead)

19. Longitude (longitude of wellhead)
20. Accuracy of Latitude and Longitude coordinates
21. Depth of the hole drilled for the well (feet)
22. Depth of the completed well (feet)
23. Well log on file with LIBC (yes or no)
24. Driller (well driller)
25. Year well drilled or dug
26. Well included in Lummi Peninsula Settlement (yes or no)

New fields, such as well diameter, screen size and type, length of casing, specific capacity, and watershed identification will be added to the database as time allows. In 2010, all well logs were scanned and linked to the corresponding well within the database. Similarly, wells north of the Reservation were identified from well logs and will be incorporated into the database as time allows. This database of wellhead characteristics is linked to a separate database that contains information from the Lummi Natural Resources Department's well monitoring program and from other water quality testing.

The wellhead inventory is presented in Figure 2.4 and in Appendix A. As of January 2011, a total of 264 wellheads, test holes, and undeveloped springs were identified within the boundaries of the Reservation. Of these 264 wellheads, test holes, and springs, 94 wellheads (36 percent) are currently active wells, the active status of 11 wellheads (4 percent) is not known, and the remaining 156 wellheads, test holes, or springs (59 percent) are either no longer active or were never active. Of the 94 known active wellheads, 90 wellheads are used for public or domestic water supply. Approximately 172 wellheads, test holes, and springs are located north of the Reservation. As illustrated in Figure 2.4, most of the water supply wells on the Reservation are concentrated in areas near the shoreline.

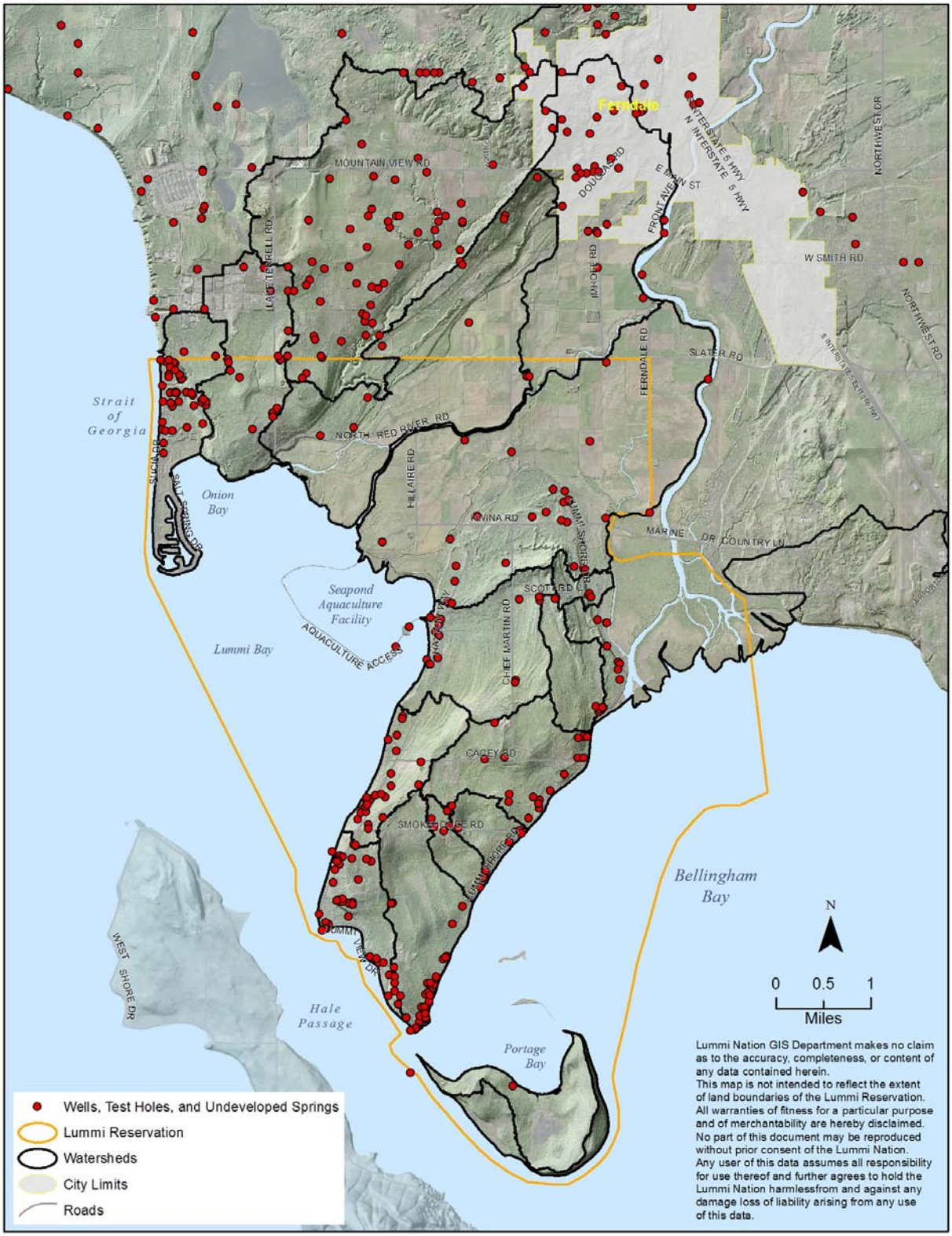

Figure 2.4. Wellheads of the Lummi Reservation and Adjacent Upland Areas

2.4. Wellhead Characteristics

Well logs are available for 190 of the 264 wellheads, test holes, and springs on the Reservation (72 percent). As possible, information from the available well logs and field measurements were used to determine the depth of the completed wells. The well logs, topographic maps, and published land surface elevation data (Cline 1974) were used to determine the land surface elevation of the Reservation wellheads. The land surface elevation of wells inventoried by the USGS in 1971 (Cline 1974) were reportedly surveyed and are believed to be accurate to ±0.1 foot. The Lummi Water Resources staff also surveyed the elevation of several wells on the Reservation. Elevation data determined from topographic maps are believed to be generally accurate to about ±10 feet.

To determine the number of wells completed below the elevation of mean sea level (ft msl), the well depth was subtracted from the land surface elevation. Of the 264 wellheads, test holes, and undeveloped springs in the on-Reservation wellhead inventory, 199 (75 percent) were completed below mean sea level, 55 (21 percent) were completed above mean sea level, and the depth of the completed wells relative to mean sea level is unknown for 10 wells (4 percent). Although the completed well depth relative to the mean sea level may be inaccurate in some cases (due to inaccuracies in the land surface elevation data or in the well depth data), the data indicate that approximately three-fourths of the inventoried wells on the Reservation are completed below sea level. Of the 105 wells that are still currently used for water supply (94 known wellheads, 11 wellheads with an unknown use status), 74 wells (84 percent) are completed below mean sea level, 5 wells (6 percent) were completed above mean sea level, and the depth of the completed well relative to mean sea level is unknown for 9 wells (10 percent).

As reported by Cline (1974), ground water is generally obtained from sand or sand and gravel deposits. Most of the wells tap the water-bearing deposits which are located below clay layers. The clay layer can range in thickness from 2 feet (e.g., Well No. GW056) to over 100 feet in places (e.g., Well No. GW115). The thick clay layer affords a level of ground water protection if it is immediately around the well but likely thins where the aquifer is recharged. Although the protective clay deposits are present where many of the wellheads are located, there are several wells (e.g., Well No. GW127) where the clay layer is absent.

The ground water yield of wells on the Reservation is generally low and can vary over short distances. Ground water wells on the Reservation generally yield from less than 1 gallon per minute (gpm) to approximately 60 gpm (Cline 1974). The highest yield reported on the southern upland area (i.e., Lummi Peninsula and Portage Island) is about 60 gpm. There is a limited area in the western section of the northern upland area of the Reservation where higher yields have been encountered. Three wells with reported yields greater than 200 gpm are located near the southeastern corner of Neptune Circle. Although these three wells have

relatively high yields, the yields reported for three wells near the western side of Neptune Circle (approximately 0.1 mile distance) range from 25 gpm to 30 gpm. Wells located approximately 0.25 miles to the east were not productive.

(This page intentionally left blank)

3. LUMMI WELLHEAD PROTECTION AREAS

A wellhead protection area is the area managed by a community to protect ground water sources of drinking water. As defined in the Safe Drinking Water Act (SDWA), wellhead protection areas are the surface and subsurface areas surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach the water well or wellfield. A contaminant is defined in the SDWA as any physical, chemical, biological, or radiological substance or matter in water. In addition to a sanitary control area immediately around a wellhead, in general a wellhead protection area includes the area that contributes water to a well or spring over a 1 to 10 year period.

There are several technical criteria that can be used as the basis for delineating wellhead protection areas. In addition, there are several methods available to implement the criteria and map the protection areas. The technical criteria for delineating the wellhead protection areas are presented briefly in this section of the plan, followed by a summary of the available methods for delineating wellhead protection areas. Finally, the criteria selected to delineate the wellhead protection areas for the 1997 and the 2011 update of the Lummi Nation Wellhead Protection Program are discussed and maps of the 1997 and 2011 Lummi wellhead protection areas are presented.

3.1. Wellhead Protection Area Delineation Criteria

The Environmental Protection Agency (EPA) recommends five technical criteria that can be used as the basis for delineating wellhead protection areas. The technical criteria recommended by the EPA and associated considerations (EPA 1987) are the following:

- **Distance:** The distance criterion is the simplest, least expensive, and most direct means for delineating a wellhead protection area. A specific distance from a well is selected based on past experience with ground water pollution control or on non-technical considerations. The selected distance is used as the radius for a circle that is drawn around the wellhead to delineate the protection area. This approach is only recommended as a preliminary step since it does not include the processes of ground water flow or contaminant transport.
- **Drawdown:** Drawdown is the decline in ground water elevation caused by pumping a well. The greatest drawdown occurs at the well and decreases with distance away from the well until an outer limit is reached where the water level is not affected by the pumping. This outer limit marks the areal

extent of the cone of depression around the well. This area of influence can be used as a wellhead protection area.

- **Time of Travel:** The time of travel criterion is used to represent the time required for ground water or a contaminant to flow from a point within the area of contribution to the well (DOH 2010). Using this criterion, contours of equal times of travel (i.e., isochrons) for selected time periods (e.g., 1-, 5-, and 10-years) are delineated on a map and the areas enclosed by the isochrons used as wellhead protection areas.
- **Flow Boundaries:** The flow boundary approach uses the locations of ground water divides and/or other physical and hydrologic features that control ground water flow to define the geographic area that contributes ground water to a pumping well. This area of contribution is used as the wellhead protection area. This approach assumes that contaminants entering the area of contribution will eventually reach the pumping well. This method can be interpreted as the most protective approach; it is especially appropriate for aquifers less than 10 to 20 square miles in area.
- **Assimilative Capacity:** The assimilative capacity approach takes into account the fact that through processes of dilution, dispersion, adsorption, chemical precipitation, and biological degradation, the saturated and/or unsaturated sections of an aquifer can reduce the toxicity of contaminants before they reach a pumping well. This approach requires knowledge of contaminant transport modeling, and extensive information on the hydrology, soils, geology, and geochemistry of the study area.

The technical merits of the different criteria depend on how well the selected approach represents the processes that affect ground water flow and contaminant transport (EPA 1987). As noted above, the distance criterion does not bring into consideration the processes of ground water flow or contaminant transport. The drawdown and the flow boundaries criteria only represent the physical processes controlling contaminant movement due to ground water flow (i.e., advection). These two criteria do not represent mechanical dispersion and molecular diffusion (i.e., hydrodynamic dispersion) nor do they represent adsorption and chemical reactions (i.e., solid-solute interaction) that may occur to the contaminant as it moves through the ground water system. The time of travel criteria can consider the processes of advection, hydrodynamic dispersion, and solid-solute interaction. The assimilative capacity approach considers hydrodynamic dispersion and solid-solute interaction but does not represent advection.

Conceptually, the time of travel wellhead protection area delineation criteria incorporates the most comprehensive evaluation of the physical processes of contaminant transport. As advection is the best understood of the physical processes that affect contaminant transport, time of travel calculations for wellhead protection area delineations are usually based on advection. The time of travel

delineation criteria is used by the Washington State Wellhead Protection Program (DOH 2010).

3.2. Wellhead Protection Area Delineation Methods

At least six methods exist for delineating the boundaries of wellhead protection areas. The methods and associated technical criteria applied are listed below in order of increasing complexity and accuracy (EPA 1987, EPA 1993, DOH 1995, EPA 2006, DOH 2010):

- **Arbitrary Fixed Radius Method**: The arbitrary fixed radius method is an application of the distance criterion for delineating wellhead protection areas. The arbitrary fixed radius method involves drawing a circle with a specified radius around each well. The radius length should reflect the hydrogeology of the area. The advantage of this method is that minimal data are necessary, it is quick and easy to draw a circle around a well, and the method can be implemented at low cost. The disadvantage is that it is not very accurate.
- **Calculated Fixed Radius Method:** The calculated fixed radius method is an application of the time of travel criterion. The calculated fixed radius method involves drawing a circular boundary around a well for a specified time of travel. The radius of the circle is calculated using an equation that relates the pumping rate of the well, the aquifer porosity, the well screen length, and the time of travel to the well. The time of travel is chosen based on hydrology and the location of contaminant sources. The advantage of this method is that limited hydrogeologic data are required, it is relatively quick and easy, and is inexpensive to implement. The disadvantage is that ground water rarely behaves as simply as the method predicts.
- **Simplified Variable Shapes Method:** The variable shapes method is an application of the flow boundaries and time of travel criteria. The simplified variable shapes method uses analytical computer models to produce "standardized forms" of wellhead protection areas using representative hydrogeological criteria, time of travel, and the locations of physical or hydrologic features controlling ground water flow. The most suitable standardized shape is selected for each well by determining how closely the form matches the hydrogeologic and pumping conditions at the wellhead. The standardized form is aligned around the wellhead based on the direction of ground water flow. The advantage of this method is that it is based on relatively little field data, it is still fairly quick and easy, and it can be accomplished at low cost if the data are available. The disadvantage is that it is not very precise in complex settings.
- **Analytical Methods:** The analytical methods are an application of the time of travel criterion. The analytical methods involve the use of mathematical equations to calculate the boundaries of wellhead protection areas. The calculations are generally performed using computer models. Hydrogeologic data such as hydraulic conductivity, transmissivity, hydraulic gradient, angle

of ambient flow, aquifer porosity, pumping rate, and saturated zone thickness are required as input to the models. Advantages of the method are that the equations are generally easily understood and solved, and the models take into account some site-specific hydrogeologic parameters. Disadvantages of the method are that aquifer heterogeneities and non-uniform rainfall, evapotranspiration, or infiltration over the contributing area are not represented.

- **Hydrogeologic Mapping:** The hydrogeologic mapping method uses geological, geophysical, and dye tracing methods to apply the flow boundaries and time of travel criteria. The flow boundaries are defined by variations in lithology or contrasts in permeability within the aquifer. Ground water levels may also be mapped to identify ground water drainage divides. The advantage of the hydrogeologic mapping method is that it is well suited to hydrogeologic settings dominated by near-surface flow boundaries as are found in many glacial and alluvial aquifers with high flow velocities. Disadvantages of the method are that it requires specialized expertise in geologic and geomorphic mapping and substantial judgment on what constitutes likely flow boundaries. The method is less suited for delineating wellhead protection areas in large or deep aquifers.
- **Numerical Flow/Transport Models:** The numerical flow/transport models are computer models that mathematically approximate ground water flow and/or solute transport. The models can map the drawdown, flow boundaries, and time of travel delineation criteria. The method typically uses a two-step approach. First, a hydraulic head distribution grid is generated with a numerical flow model under a prescribed set of hydrogeologic parameters and conditions. Second, a numerical solute transport model that uses the generated grid as input computes the wellhead protection area based on preselected criteria. These models are particularly useful for delineating wellhead protection areas where boundary and hydrogeologic conditions are complex, where the necessary data are available and accurate, and the hydrogeology of the area is known. The advantage of this method is that it provides a very high potential degree of accuracy and can be applied to nearly all types of hydrogeologic settings. The disadvantage of this method is that a considerable amount of technical expertise and accurate data are required, and the costs of applying the method are relatively higher than the others.

3.3. Lummi Wellhead Protection Areas Delineated in 1997

After considering the wellhead protection area criteria, the available methods, the local hydrogeology, the available hydrogeologic data, the wellhead inventory, the wellhead characteristics, the threat of lateral and vertical salt water intrusion, and the occurrence of ground water on the Reservation, the flow boundaries criterion was selected as the technical basis for delineating wellhead protection areas for the

Lummi Nation Wellhead Protection Program. The hydrogeologic mapping method was chosen to apply the flow boundaries criterion. During the preparation of the 1997 Wellhead Protection Program document, available hydrogeologic mapping (Cline 1974) and 1:24,000 scale USGS topographic maps were used to identify likely flow boundaries.

The flow boundaries criterion was selected as the most appropriate approach for the Lummi Wellhead Protection Program for several reasons including:

1. The flow boundaries approach is the most protective criterion.
2. Both public supply wells and private domestic supply wells of Reservation residents are included in the wellhead protection program.
3. Detailed hydrogeologic data are not available for most locations on the Reservation; in the northern upland area, the extent of the aquifer has not been determined.
4. The hydrogeologic conditions on the Reservation vary considerably over short distances.
5. The approach is well suited to hydrogeologic settings dominated by near-surface flow boundaries as are found in many glacial and alluvial aquifers.
6. The Reservation aquifers are believed to be less than 10 square miles in area.
7. The applicability of the time to travel criterion is limited because the time of travel to Reservation wellheads is likely less than 1 to 10 years.

The wellhead protection areas delineated through this approach during 1997 are illustrated in Figure 3.1.

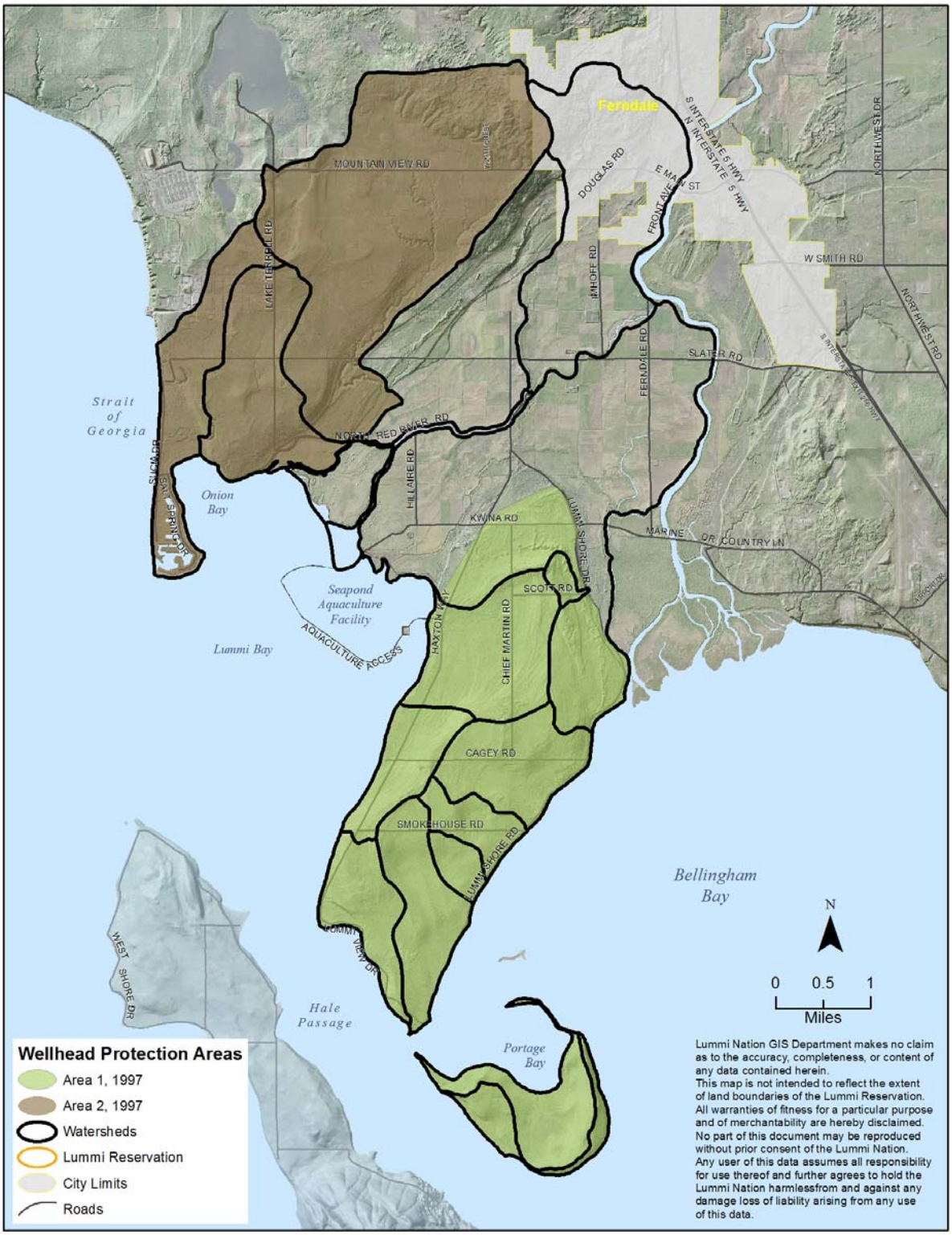

Figure 3.1. 1997 Lummi Nation Wellhead Protection Areas

3.4. Lummi Wellhead Protection Areas Delineated in 2011

The hydrogeologic mapping method was used again during 2011 to apply the flow boundaries criteria. The 2011 wellhead protection areas were delineated using available hydrogeologic mapping (Cline 1974) but the flow boundaries were developed from the Light Distance and Ranging (LiDAR) elevation data collected during 2005 rather than from the USGS topographic maps. As detailed in Appendix B, the LiDAR bare-earth point data were used during 2010 to develop digital terrain models (DTMs) using several grid cell sizes and interpolation methods. A root mean square error analysis was used to identify the surface model with elevation values most similar to professionally surveyed control points. A three-foot natural neighbor interpolation DTM was identified as the surface model with the highest level of precision and pixel sizes that were large enough to be manageably analyzed using available computer resources.

The three-foot natural neighbor DTM was incorporated into an ESRI ArcGIS 9.3 ArcHydro geodatabase along with point data of storm water facilities and line data of known stream channels and agricultural drainage ditches. The storm water data and surface water hydrography data were used to enforce hydrologic connectivity by computationally breaching LiDAR artifacts such as bridges or culvert passages under roads.

The hydrologically corrected surface model was analyzed using standard GIS procedures including sink filling, identifying flow directions, calculating flow accumulations, and identifying basin boundaries. The revised wellhead protection area map shown in Figure 3.2 is based on the 2010 revision of the surface water basins. Figure 3.3 shows a comparison of the 1997 wellhead protection areas developed from the USGS topographic maps and the 2011 wellhead protection areas developed using the LiDAR data.

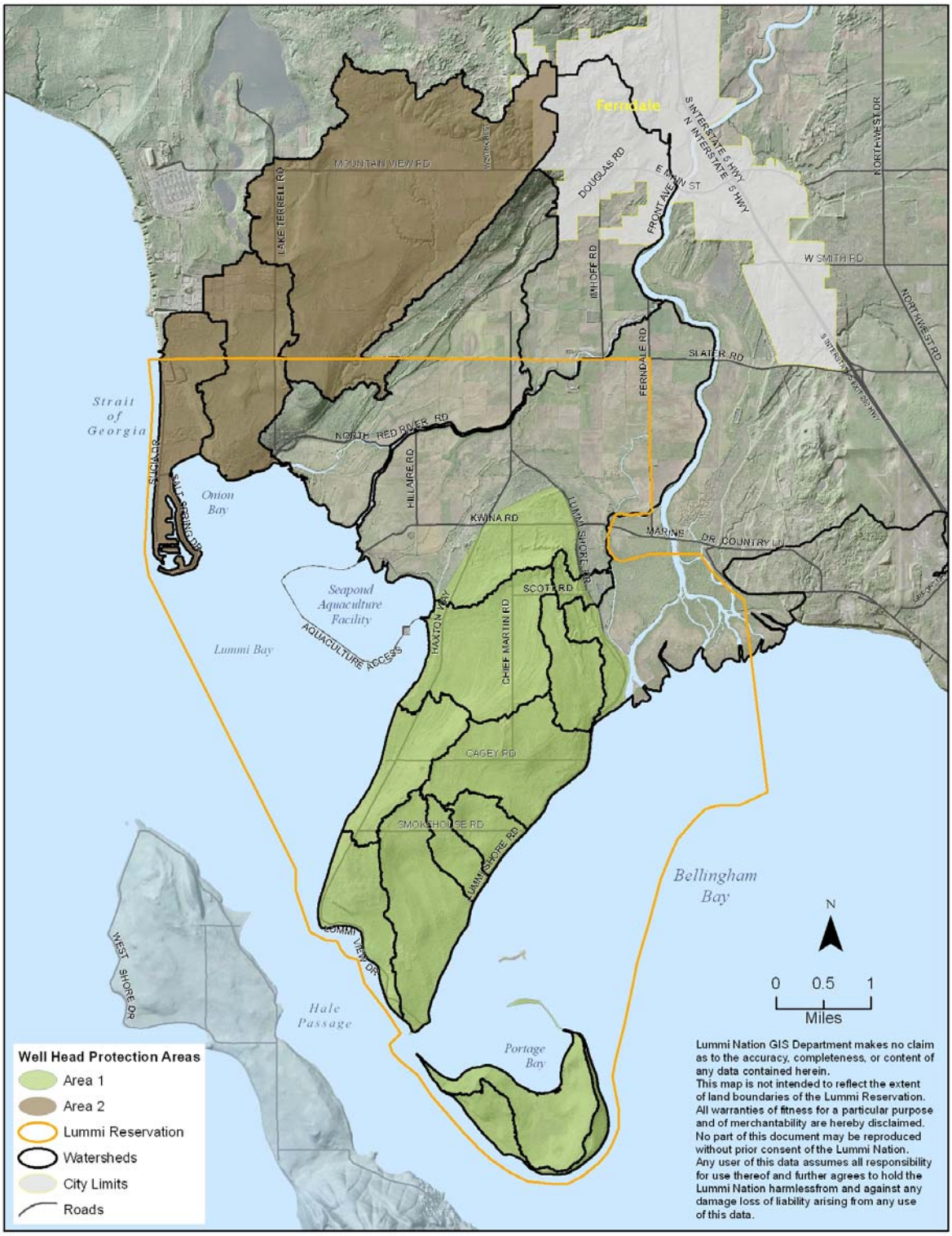

Figure 3.2. 2011 Lummi Nation Wellhead Protection Areas

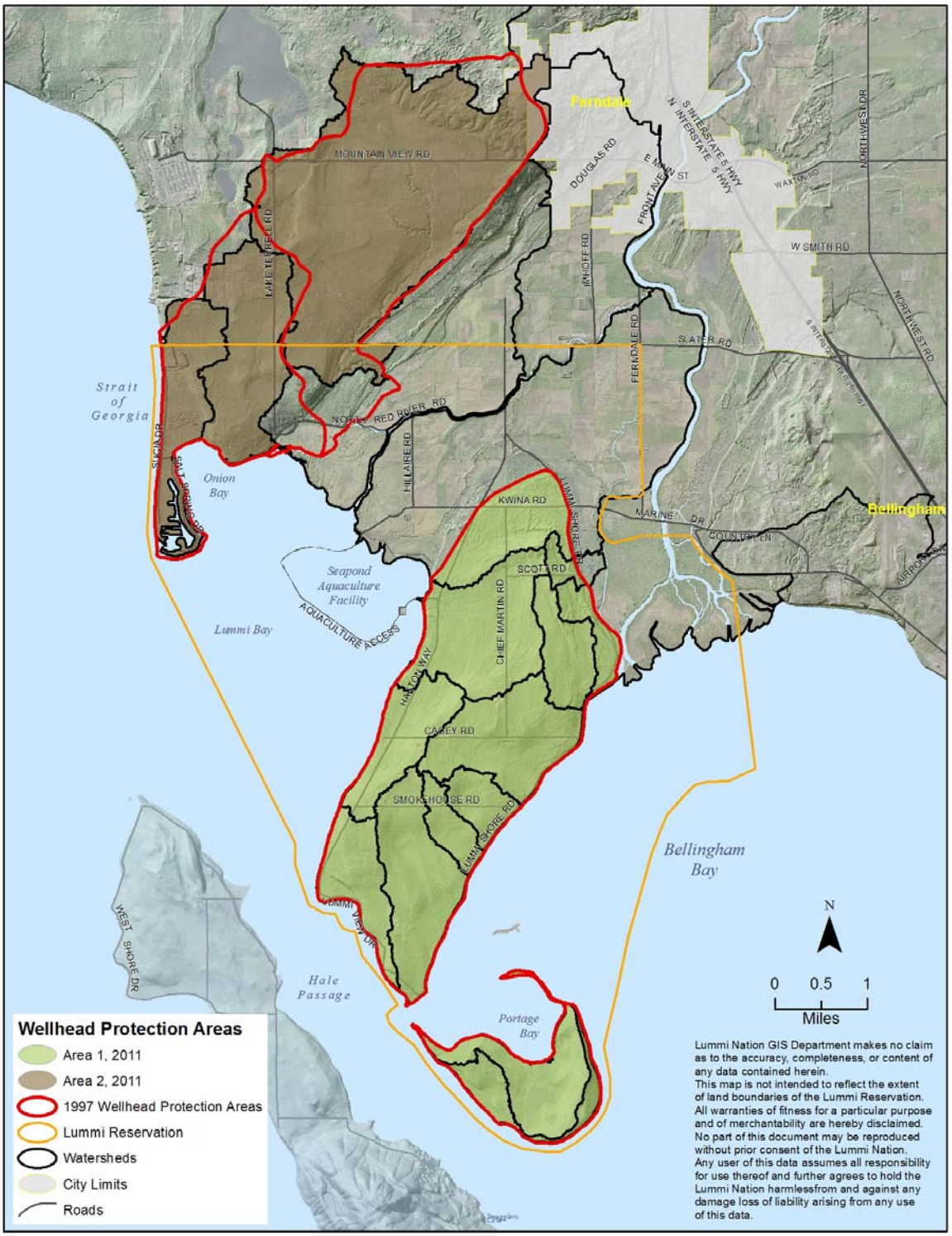

Figure 3.3. Comparison of the 1997 and 2011 Lummi Nation Wellhead Protection Areas

3.5. Lummi Wellhead Protection Areas

The two wellhead protection areas identified for the 2011 Lummi Wellhead Protection Program update are shown in Figures 3.2 and 3.3. Area 1 is located on the Lummi Peninsula and incorporates most of the southern upland area. Portage Island is included in Area 1. Wellhead Protection Area 1 did not change between the 1997 and 2011 delineation. Area 2 is located at the northwestern part of the Reservation. This area encompasses the northern upland area of the Reservation and extends up to about 3 miles north of the Reservation boundary. As shown in Figure 3.3, Area 2 was modified during the 2011 re-delineation of the wellhead protection areas.

The Lummi River and Nooksack River floodplains, as well as areas north of the Reservation that contribute flow to the floodplain (e.g., the City of Ferndale), are not in a Lummi wellhead protection area. Although there are areas on the floodplain where fresh water may be perched above salty ground water or directly overlie salty ground water, in general the floodplain is not suitable for ground water development (Cline 1974). Currently, there are no known uses of ground water obtained from the flood plain aquifer for domestic supply on the Reservation.

The northern extent of Area 1 corresponds to the northern extent of an area of fresh ground water in surface deposits identified by the USGS (Cline 1974) in a map showing areas of fresh and salty ground water on the Reservation (see Figure 3.4). Area 1 is approximately 6,625 acres in size (10.4 mi^2) and encompasses locations where fresh ground water was historically found to all depths penetrated by wells, a transition area where fresh ground water is adjacent to salty water or where salt water is encountered in places, and an area where salt water has been encountered (Cline 1974). The precise locations of the boundaries for these areas and the hydrogeologic relations between them are unknown due to a lack of data. Area 1 was extended to the north during the 1997 delineation into an area where saline water was encountered in order to encompass and protect wells that obtain fresh water from surface deposits along the northern and northeastern extents of the Lummi Peninsula. All of Area 1, except Portage Island is included as part of the case area for the Lummi Peninsula Ground Water Settlement (*United States, Lummi Nation v. Washington State Department of Ecology, et al*, Civ. No. 019047Z [W.D. Wash.]).

Exactly delineating a ground water basin is very difficult in the absence of precise data. However, because a USGS map of the water-table contours and directions of ground water movement on and adjacent to the Reservation suggests that the water table and the ground water flow generally follows the topographic contours of the land surface (Cline 1974), the surface water basins were used to approximate the ground water recharge area. It is recognized that the relatively flat topography and the complex geology of variable glacial sediments of different depositional events allows for error in delineating ground water basins based on surface topography.

Area 2 is approximately 5,910 acres in size (9.2 mi^2) and is comprised of three surface water basins. The western surface water basin drains to Georgia Strait and Lummi Bay, the central basin drains to Lummi Bay at Onion Bay, and the eastern basin drains to the Lummi River floodplain. The western and central subbasins contain all public water supply wells and all active individual domestic supply wells in the northern upland part of the Reservation. The potential for developing ground water resources on-Reservation in the eastern subbasin of Area 2 is not known. The wells that have been drilled in this part of the Reservation are low in productivity or are nonproductive.

The eastern subbasin of Area 2 corresponds to the watershed of an intermittent stream known as Jordan Creek. While it is unlikely that this entire subbasin serves as a recharge area for the on-Reservation portion of the aquifer, until data are developed that establish the predominant ground water flow directions in this area, the surface water boundaries are used to approximate this portion of the area. This inclusive approach is also intended to protect the on-Reservation aquifer from contaminated surface water originating from the watershed and infiltrating into the aquifer as it flows toward the Lummi River floodplain and into Lummi Bay.

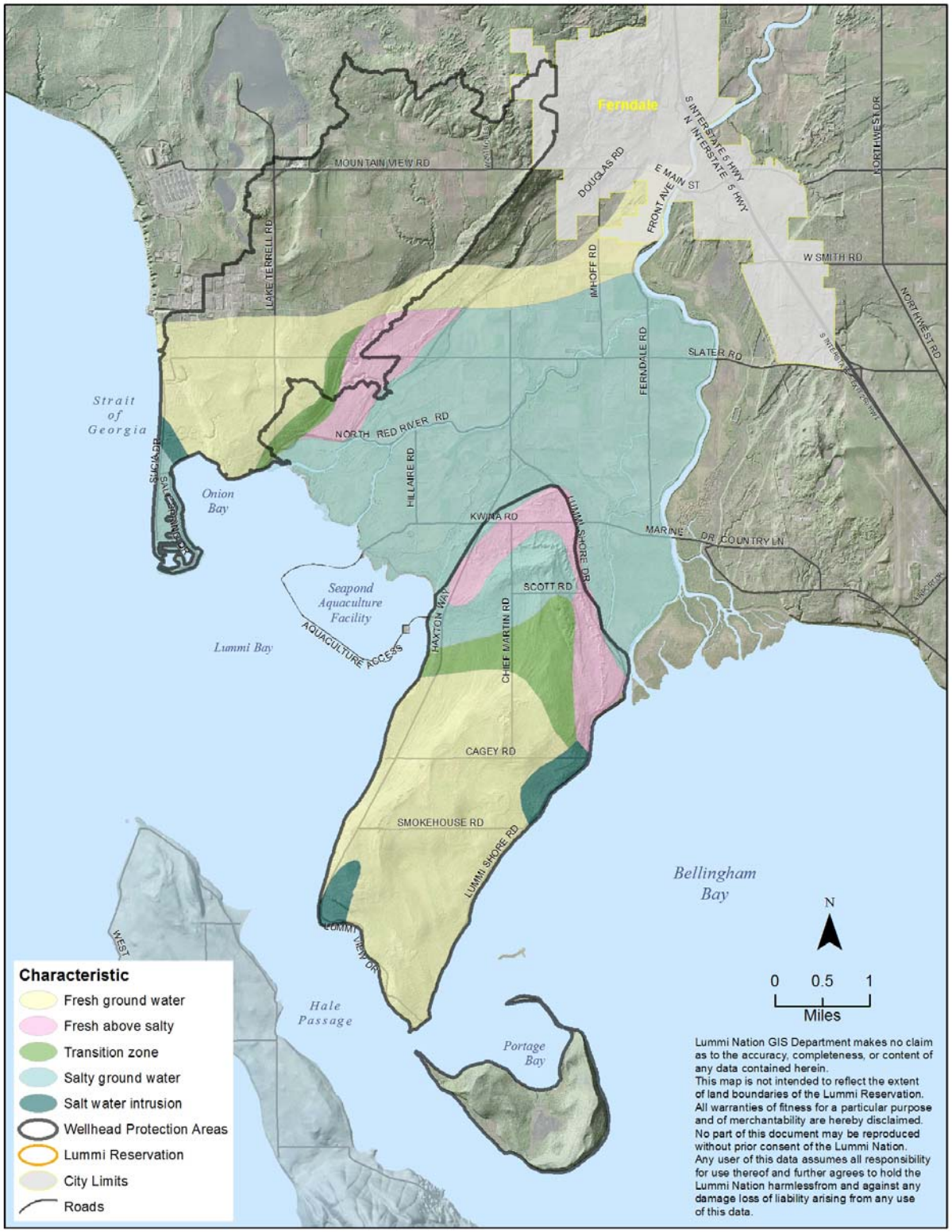

Figure 3.4. Lummi Reservation Ground Water Characteristics (Cline 1974)

4. INVENTORY OF POTENTIAL CONTAMINANTS

As described previously, the purpose of the susceptibility assessment is to evaluate the vulnerability of wellheads to contamination. A contaminant, as defined in the Safe Drinking Water Act (SWDA), is any physical, chemical, biological, or radiological substance or matter in water. The vulnerability of a wellhead to contaminants is determined by two factors: 1) the physical susceptibility of the wellhead to the infiltration of contaminants, and 2) the risk that the wellhead will be exposed to contaminants.

The physical susceptibility of wellheads to contaminants is determined by factors such as the well depth, well construction, geology of the area, pumping rate, source(s) of recharge, and aquifer material. The risk that the wellhead will be exposed to contaminants is determined largely by the current and historic presence/use of contaminants in the area where water either recharges or is hydraulically connected to the aquifer.

In general, ground water contamination results from (EPA 1993, DOH 2010):

- Misuse and improper disposal of liquid and solid wastes.
- Illegal dumping or abandonment of household, commercial, or industrial chemicals.
- Accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks.
- Improper siting, design, construction, operation, or maintenance of agricultural, residential, municipal, commercial, and industrial drinking water wells and liquid and solid waste disposal facilities.
- Atmospheric pollutants.

In this section of the report, a rating system for potential ground water contaminant sources is described, seven categories of potential ground water contaminant sources discussed, and an inventory of potential contaminant sources and potential contaminants associated with each source in the two wellhead protection areas presented. The potential contaminant sources in each of the wellhead protection areas were identified from maps, field visits, aerial photographs, and local knowledge of current and historic land uses. The contaminants associated with each potential source were identified from the literature as typical for the specified land use (EPA 1993, DOH 2010) or from 2010 emissions inventory data provided by the Northwest Clean Air Agency (NWCAA 2011).

4.1. Rating System for Potential Contaminant Sources

A ranking system for the potential contaminant sources was developed to help prioritize wellhead protection measures (i.e., actions intended to prevent contamination of the Lummi Nation's ground water resources). The ranking system is based on three factors:

- Proximity of the potential source to ground water supply wells on the Reservation.
- The quantity of potential contaminants either on site or associated with the potential source.
- The hazard posed by the contaminants either to public health or the ground water resource.

The rating system developed for potential contamination sources has three possible ranks: Low (L), Moderate (M), and High (H). A potential source was assigned an "L" rating if only one of the three listed factors is a potential threat to the Reservation aquifers. Similarly, a potential source was assigned an "M" rating if two of the listed factors are present, and an "H" rating if all three of the factors are present. If the quantity of contaminants or the hazardous nature of the contaminants is unknown (e.g., the former landfill along Chief Martin Road), the potential source was assigned an "H" ranking.

Because all of the inventoried potential contaminant sources are located within the updated wellhead protection areas, all inventoried sources receive at least an "L" ranking. If a potential contaminant source is also associated with large quantities of a potential contaminant(s) or there is a hazard posed by the potential contaminants to either public health or the aquifer, the source was assigned an "M" ranking. If a potential contaminant source is associated with large quantities of a potential contaminant and there is a hazard posed by the potential contaminants to either public health or the aquifer, the source was assigned an "H" ranking.

4.2. Potential Ground Water Contaminants

The potential ground water contaminants were grouped by natural processes and land uses. The seven categories used to group the potential contaminants are (EPA 1987):

- Naturally Occurring Sources
- Agricultural Sources
- Residential Sources
- Municipal Sources

- Commercial Sources
- Industrial Sources
- Industrial Processes

The three categories of potential contaminants that are of most concern on the Reservation are; naturally occurring sources, municipal sources, and industrial processes.

The primary naturally occurring source of ground water contamination in the Lummi wellhead protection areas is salt water originating in Bellingham Bay, Hale Passage, Lummi Bay, and/or Georgia Strait. Although the source of contamination is naturally occurring marine waters, the contamination itself can be, and has been, the result of human activity. Salt water intrusion into the aquifer from overpumping of nearshore wells has been documented at several locations including the Gooseberry Point area near the southwestern extent of Area 1 and along the eastern part of Area 1 just north of Cagey Road (Cline 1974, Golder 1992). The salt water intrusion in the Gooseberry Point area has resulted in the closure of two public water supply wells.

In addition to the offshore sources of salty water, naturally occurring saline ground water in the northern portion of Area 1 could potentially contaminate fresh ground water to the south via the transition zone identified by Cline (1974). Golder (1992) identified another transition zone to saline water underlying Area 1 at an approximate elevation of -50 ft msl. Data from eight test wells drilled over the 1992 through 2010 period where increasing chloride levels were observed with increasing depth below ground surface support this hypothesis. Consequently, protection from both vertical and lateral migration of seawater is required.

Other naturally occurring ground water contamination sources include iron, arsenic, and manganese. Iron, arsenic, and manganese are common in the ground water regionally. It is difficult to predict or delineate the magnitude and distribution of iron and manganese levels due to the complex chemical and physical factors that control the precipitation of iron and manganese oxides in saturated sediments (Golder 1992). Naturally occurring arsenic levels that exceed the current Safe Drinking Water Act standard of 10 parts per billion have been encountered in several locations on the Reservation including the north western upland area (Area 2) and portions of the Lummi Peninsula along the northwestern (north of Cagey Road and west of Haxton Way) perimeter of Area 1 and the northern part of Area 1 (near Scott Road).

Potential ground water contamination from municipal sources includes the sewer lines of the Lummi Tribal Sewer District. Although a sewer system protects ground water quality by replacing septic systems, in all municipal sewer systems the sewer lines are subject to equipment malfunctions that could result in spills or overflows. In addition, spills or leaks could result from damage during construction activities or

from damage caused by natural events (e.g., floods, earthquakes). The alarm and emergency response system of the Lummi Tribal Sewer District and the automated pumps with backup generators in the majority of the pump stations throughout the Reservation should minimize the impact of any spills in the area serviced by its lines.

The Cherry Point Heavy Impact Industrial Zone is located immediately north and west of the Reservation watersheds. This heavy impact industrial zone, the largest such zone in Whatcom County, contains two petroleum oil refineries (ConocoPhillips and British Petroleum), an aluminum smelter (Alcoa-Intalco), and the Tenaska Cogeneration Station. One of the oil refineries (ConocoPhillips) is located adjacent to the northern Reservation boundary and is within Wellhead Protection Area 2. Previous owners of this facility include Mobil Oil, British Petroleum, and Tosco. Potential ground water contamination from industrial processes includes direct infiltration of contaminants from the ConocoPhillips petroleum oil refinery located adjacent to the Reservation boundary. Potential ground water contamination from industrial processes includes the deposition of atmospheric pollutants originating from the area directly north of the Reservation boundary, from industries along Bellingham Bay, or from the two petroleum oil refineries (Shell and Tesero) in Anacortes approximately 15 air miles from the Reservation. In addition to sources within the Cherry Point Heavy Impact Industrial Zone, ground water contamination is also possible through the deposition of atmospheric pollutants originating from the GN Plywood mill and the Encogen NW Cogeneration Plant in Bellingham.

A wind rose developed from meteorological data collected at the north boundary of the ConocoPhillips oil refinery over the August 1982 through March 1984 period (Mobil Oil Corporation 1986) indicates that the wind direction is from the Cherry Point industries and toward the wellhead protection areas about 6 percent of the time. In contrast, the average annual wind rose for Bellingham indicates that wind direction is generally from the south southeast (Phillips 1966), which is in the direction of the two petroleum oil refineries in Anacortes.

4.3. Potential Contaminant Sources Area 1

Table 4.1 lists an inventory of the potential contaminant sources in Lummi Wellhead Protection Area 1, identification of the contaminants generally associated with the potential sources (EPA 1993), the assigned potential aquifer contamination rating, and the justification for the assigned rating. Each of the potential contaminant sources are grouped by the seven categories of natural processes or land uses presented previously.

In summary, the greatest threats to the ground water resources in Area 1 appear to be: salt water intrusion due to over pumping throughout Area 1, family residences with private water supply wells and/or septic systems, and an abandoned landfill along Chief Martin Road.

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
1. Potential Natural Occurring Sources				
Saltwater	Saltwater	Bellingham Bay, Portage Bay, Hale Passage, Lummi Bay, saline ground water north of Area 1	H	• Location • Quantity • Salt water intrusion due to overpumping has already occurred and resulted in well closures
Iron and manganese deposits	Iron and manganese	Gooseberry Point Area	M	• Location • High levels near Gooseberry Point
Arsenic deposits	Arsenic	Along Robertson Road and isolated well sites in Area 1	M	• Location • High levels along Robertson Road
2. Potential Agricultural Sources				
Cattle	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and non-coliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal pests on livestock	Kwina Road	L	• Location near the northern extent of Area 1 • No active ground water wells nearby
Cattle	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and non-coliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal pests on livestock	Portage Island	L	• Location • Approximately 40 head of cattle over approximately 1,000 acres; currently being removed from the island • No active ground water wells nearby
Horses	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and non-coliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal pests on livestock	Haxton Way/Harnden Road Area Hermosa Beach Area	M	• Location – immediately up gradient of the shallow public supply well used by the Harnden Island View Water Association

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
3. Potential Residential Sources				
Single family homes with private supply wells and/or septic systems	Automotive wastes, general household hazardous waste products, effluents from barnyards, feedlots, septic tanks, water treatment chemicals, and well pumping that induces salt water intrusion into Reservation aquifers	Water Supply Wells: Isolated sites concentrated near Hermosa Beach and west of Haxton Way north of Smokehouse Road Septic Systems: Isolated sites generally toward the interior of Area 1 and along Harnden Road	H	• Location • No 50-feet sanitary control areas visible around many wells • Number of failing or improperly working septic systems unknown • Harnden Island View area obtains water from a shallow well down gradient from septic systems (and a horse paddock associated with a single family residence at 3635 Haxton Way).
Single family homes on municipal water and sewer systems	Automotive wastes, general household hazardous waste products	Throughout Area 1	M	• Location • Large number of potential contaminants
4. Potential Municipal Sources				
Roads	Automotive wastes (e.g., gasoline, antifreeze, transmission fluid, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic fluids, and motor oil), herbicides along road right-of-ways	Throughout Area 1	M	• Location throughout Reservation • Large number of potential contaminants
Northwest Indian College	Automotive wastes, general building wastes	Kwina Road/Lummi Shore Road	L	• Location, no active ground water wells nearby • Large number of potential contaminants
Lummi Nation K-12 School, Youth Academy, and Daycare Center	Automotive wastes, general building wastes	Blackhawk Way	M	• Location • Large number of potential contaminants

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
Lummi Tribal Health Center	Automotive wastes, general building wastes	Kwina Road	L	• Location, no active ground water wells nearby • Large number of potential contaminants
Tribal governmental offices	Solvents, pesticides, acids, alkalis, waste oils, machinery/vehicle servicing wastes, general building wastes	Kwina Road	L	• Location, no active ground water wells nearby • Large number of potential contaminants
Biosolids application site	Organic matter, nitrates, inorganic salts, coliform and noncoliform bacteria, parasites, and viruses	Haxton Way	M	• Location • Large number of potential contaminants
Stommish Grounds	Automotive wastes, general building wastes	Lummi View Drive	L	• Location
Wex li em Community Building	Automotive wastes, general building wastes	Blackhawk Way	L	• Location
Wastewater Treatment Plants (Gooseberry Point and Membrane BioReactor)	Wastewater, biosolids, treatment chemicals (e.g., chlorine), automotive wastes, general building wastes	Lummi View Road and Lummi Shore Road	L	• Location, no active ground water wells nearby • Large number of potential contaminants
Lummi Cemetery	Leachate, lawn and garden maintenance chemicals, automotive wastes	Lummi Shore Road	L	• Location • No wells down gradient
Abandoned landfill	Leachate, organic and inorganic chemical contaminants, wastes from households and businesses, nitrates, oils, metals	Chief Martin Road	H	• Location • Types and quantities of contaminants unknown • Potentially hazardous nature of contaminants
Sewer lines and sewer pump stations (break or malfunction)	Sewage, coliform and noncoliform bacteria, viruses, nitrates, heavy metals, synthetic detergents, cooking and motor oils, bleach, pesticides, paints, paint thinner	Throughout Area 1	M	• Location • Moderate quantity of potential contaminants • Potential public health hazard

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
Public water supply wells	Water treatment chemicals and well pumping that induces landward and/or vertical migration of sea water	Throughout Area 1 but concentrated along shoreline areas	M	• Location • Chloride, pumping rates, and water level monitored monthly • Large quantity of potential contaminants • Water quality monitored regularly in accordance with Safe Drinking Water Act
5. Potential Commercial Sources				
DO Construction	Oils, waste oils, solvents, grease, hydraulic fluids, transmission fluids, antifreeze, acids, paints, miscellaneous cutting oils, and miscellaneous wastes	Bay Shore Drive	M	• Location • Large number of potential contaminants
Lummi Auto Recyclers	Waste oils, solvents, acids, paints, antifreeze, and automobile wastes	Cagey Road	L	• Location, no active ground water wells nearby • Large number of potential contaminants
Eagle Haven Recreational Vehicle (RV) park	Septage, gasoline, diesel fuel pesticides, automotive wastes, and household wastes	Haxton Way	M	• Location • Large number of potential contaminants
Fisherman's Cove (boat storage and launching)	Gasoline, diesel fuel, oil, septage from boat waste disposal areas, automotive wastes, and hydraulic fluid	Gooseberry Point	L	• Location, no active ground water wells nearby • Large number of potential contaminants
Fisherman's Cove Marina (retail grocer and gas station)	Automotive wastes, gasoline (underground storage tanks) general building wastes	Gooseberry Point	L	• Location, no active ground water wells nearby
KMB Inc.	Automotive wastes, general building waste	Gooseberry Point	L	• Location, no active ground water wells nearby
Finkbonner Shellfish Inc.	Automotive wastes, general building wastes	Lummi View Drive	L	• Location, no active ground water wells nearby

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
Native American Shellfish Inc.	Automotive wastes, general building wastes	Lummi Shore Drive	L	• Location, no active ground water wells nearby
Crist Gravel Pit	Oils, waste oils, solvents, grease, hydraulic fluids, transmission fluids, antifreeze, acids, and miscellaneous wastes	Chief Martin Road	H	• Location • Large number of potential contaminants • The gravel mining has decreased the soil barrier between potential contaminant source and the aquifer
Utilities	PCBs from transformers and capacitors, oils, solvents, sludges, acid solution, metal plating solutions (chromium, nickel, cadmium)	Throughout Area 1	M	• Location • Large number of potential contaminants
6. Potential Industrial Sources				
No industrial sources of ground water contamination	N/A	N/A	N/A	N/A
7. Potential Sources of Industrial Processes (atmospheric deposition)				
ConocoPhillips Refining and Marketing (petroleum oil refinery)	Criteria Pollutants: Volatile Organic Compounds (VOCs), fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, butanes, cyclohexane, ethylbenzene, pentanes, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Unick Road (north of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants • Prevailing wind direction is away from Wellhead Protection Area 1
Alcoa-Intalco (aluminum plant)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: gaseous fluoride	Mt. View Road (north of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants • Prevailing wind direction is away from Wellhead Protection Area 1

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
British Petroleum, Inc (petroleum oil refinery)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, cyclohexane, ethylbenzene, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Grandview Road (north of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants • Prevailing wind direction is away from Wellhead Protection Area 1
Puget Sound Refinery (Shell Products US)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, cyclohexane, ethylbenzene, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Anacortes, WA (south of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants • Prevailing wind direction is toward Wellhead Protection Area 1 (approximately 15 air miles distance)
Tesoro Northwest Company (petroleum oil refinery)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, cyclohexane, ethylbenzene, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Anacortes, WA (south of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants • Prevailing wind direction is toward Wellhead Protection Area 1 (approximately 15 air miles distance)
GN Plywood, Inc. (plywood manufacturer)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide Toxic Pollutants: acetaldehyde, acetone, barium, benzene, chlorine, formaldehyde, manganese, naphthalene	Bellingham (east of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants

Table 4.1. Inventory of Potential Ground Water Contaminant Sources in Area 1

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
Encogen NW Cogeneration Plant	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: ammonia, formaldehyde	Bellingham (east of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
Tenaska Washington Partners Cogeneration Station	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: ammonia, benzene, cyclohexane, ethylbenzene, formaldehyde, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Lake Terrell Road (north of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants • Prevailing wind direction is away from Wellhead Protection Area 1

[1] Potential contaminant listings based on literature (EPA 1993b) and 2010 emission inventory information provided by the Northwest Clean Air Agency (NWCAA 2010). Other than emission inventories, site specific inventories of potential contaminants at each location were not conducted.

4.4. Potential Contaminants in Area 2

Table 4.2 presents an inventory of the potential contaminant sources in Lummi Wellhead Protection Area 2, identification of contaminants generally associated with the potential sources (EPA 1993), the assigned potential aquifer contamination rating, and the justification for the assigned rating.

The greatest potential threats to the ground water resources in Area 2 are: salt water intrusion due to over pumping along the western part of Area 2, single family residences with private supply wells and/or septic systems, roads, manure lagoons, and the ConocoPhillips refinery. The roads in Area 2 are assigned a higher potential aquifer contamination rating than the roads in Area 1 because of the industrial traffic that occurs along the road ways in Area 2 and because herbicides are used along some of the road right-of-ways.

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
1. Potential Naturally Occurring Sources				
Saltwater	Saltwater	Georgia Strait, Lummi Bay	H	• Location • Quantity • Salt water intrusion due to over pumping has already occurred in several nearshore wells
Arsenic deposits	Arsenic	Throughout Area 2	M	• Location – Arsenic Study (Aspect Consulting 2009b) • Quantity
2. Potential Agricultural Sources				
Farmlands used for raspberry, strawberry, silage, forage, grain, and other row crops	Pesticides (e.g., insecticides, herbicides, fungicides), fertilizers, pesticides and fertilizer residue from containers or storage areas; automotive wastes (e.g., gasoline, antifreeze, transmission fluid, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic fluids, and motor oil)	North of the Reservation in Area 2	M	• Location • Large number of potential contaminants
Horses, goats, cattle, sheep, and/or llamas	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and non-coliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal pests on livestock	Neptune Beach Area and north of the Reservation	M	• Location • Active water supply wells nearby • Small area
Cattle	Livestock sewage wastes; nitrates; phosphates; chloride; coliform and non-coliform bacteria; viruses; chemical sprays for controlling insect, bacterial, viral, and fungal pests on livestock	Sucia Drive and north of the Reservation	M	• Location • Active water supply wells nearby
Sewage disposal ponds (manure lagoons)	Organic matter, nitrates, inorganic salts, coliform and non-coliform bacteria, parasites, and viruses	North of the Reservation	H	• Location • Large number of potential contaminants • Potential hazard of contaminants

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
Agricultural drainage canals	Pesticides, fertilizers, bacteria, livestock sewage, nitrates	North of the Reservation	M	• Location • Large potential contaminants
3. Potential Residential Sources				
Single homes with private supply wells and/or septic systems	Automotive wastes, general household hazardous waste products, effluents from barnyards, feedlots, septic tanks, water treatment chemicals, and well pumping that induces salt water intrusion into Reservation aquifers	Water Supply Wells: Isolated sites concentrated along Sucia Drive, Neptune Circle, and north of the Reservation Septic Systems: Neptune Circle, southern extent of Salt Spring Drive, parts of Sandy Point Heights, isolated sites generally toward the interior of Area 2 and north of the Reservation	H	• Location • No 50-feet sanitary control areas visible around many wells • Large number of contaminants • Number of failing or improperly working septic systems unknown
Single family homes on municipal water and sewer systems	Automotive wastes, general household hazardous waste products, effluents from barnyards, and feedlots.	Throughout Area 2	M	• Location • Large number of potential contaminants

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
4. Potential Municipal Sources				
Roads	Automotive wastes (e.g., gasoline, antifreeze, transmission fluid, battery acid, engine and radiator flushes, engine and metal degreasers, hydraulic fluids, and motor oil), herbicides along road right-of-ways, industrial transportation corridor	Throughout Area 2	H	• Location • Large number of potential contaminants • Potential hazard of contaminants
Sandy Point Wastewater Treatment Plant	Wastewater, biosolids, treatment chemicals (e.g., chlorine), automotive wastes, general building wastes	Germaine Road	M	• Location • Large number of potential contaminants
Sewer lines and sewer pump stations (break or malfunction)	Sewage, coliform and noncoliform bacteria, viruses, nitrates, heavy metals, synthetic detergents, cooking and motor oils, bleach, pesticides, paints, paint thinner	Throughout many areas of the Reservation in Area 2	M	• Location • Moderate quantity of potential contaminants • Potential public health hazard
Public water supply wells	Water treatment chemicals and well pumping that induces landward and vertical migration of sea water	Concentrated in the residential areas along the southwestern parts of Area 2	M	• Location • Chloride, pumping rates, and water level monitored in all LTSWD wells • Large quantity of potential contaminants • Water quality monitored regularly in accordance with Safe Drinking Water Act • No alternative source currently available
6. Potential Commercial Sources				
Warrior Construction	Oils, waste oils, solvents, grease, hydraulic fluids, transmission fluids, antifreeze, acids, paints, miscellaneous cutting oils, and miscellaneous wastes	North Red River Road	M	• Location • Large number of potential contaminants

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
Barlean's Fisheries, Inc and Barlean's Organic Oil	Automotive wastes, general building wastes, process wastes	Lake Terrell Road (north of the Reservation	M	• Location • Uncertain sources from variety of commercial activities
Golf Course	Lawn and garden maintenance chemicals, automotive wastes	Decatur Drive	L	• Location, no active ground water wells nearby • Large number of potential contaminants
Utilities	PCBs from transformers and capacitors, oils, solvents, sludges, acid solution, metal plating solutions (chromium, nickel, cadmium)	Throughout Area 2	M	• Location • Large number of potential contaminants
7. Potential Industrial Sources				
ConocoPhillips Refining and Marketing (petroleum oil refinery)	Hydrocarbons, solvents, metals, miscellaneous organics, sludges, oily metal shavings, lubricant and cutting oils, degreasers, metal marking fluids, corrosive fluids, other hazardous and nonhazardous materials and wastes, diesel fuel, herbicides for rights-of-way, creosote for preserving railroad ties	Unick Road (north of the Reservation)	H	• Location • Large number of potential contaminants • Potential hazard of contaminants
8. Potential Sources of Industrial Processes (atmospheric deposition)				
ConocoPhillips Refining and Marketing (petroleum oil refinery)	Criteria Pollutants: Volatile Organic Compounds (VOCs), fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, butanes, cyclohexane, ethylbenzene, pentanes, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Unick Road (north of the Reservation)	M	• Large number of potential contaminants • Potential hazard contaminants
Alcoa-Intalco (aluminum plant)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen,	Mt. View Road (north of the	M	• Large number of potential contaminants

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
	carbon monoxide, oxides of sulfur Toxic Pollutants: gaseous flouride	Reservation)		• Potential hazard of contaminants
British Petroleum, Inc (petroleum oil refinery)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, cyclohexane, ethylbenzene, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Grandview Road (north of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
Puget Sound Refinery (Shell Products US)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, cyclohexane, ethylbenzene, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Anacortes (south of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
Tesoro Northwest Company (petroleum oil refinery)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: benzene, cyclohexane, ethylbenzene, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Anacortes (south of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
GN Plywood, Inc. (plywood manufacturer)	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide Toxic Pollutants: acetaldehyde, acetone, barium, benzene, chlorine, formaldehyde, manganese, naphthalene	Bellingham (east of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants
Encogen NW Cogeneration	Criteria Pollutants: VOCs, fine	Bellingham (east	M	• Large number of potential

Table 4.2. Inventory of Potential Ground Water Contaminant Sources in Area 2

Potential Contaminant Sources	Potential Contaminants[1]	Location	Potential for Contamination	Justification for Ranking
Plant	particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: ammonia, formaldehyde	of the Reservation)		contaminants • Potential hazard of contaminants
Tenaska Washington Partners Cogeneration Station	Criteria Pollutants: VOCs, fine particulate matter, oxides of nitrogen, carbon monoxide, oxides of sulfur Toxic Pollutants: ammonia, benzene, cyclohexane, ethylbenzene, formaldehyde, sulfuric acid, toluene, trimethylbenzene, xylene, and other toxins in quantities less than 5,000 lbs per year	Lake Terrell Road (north of the Reservation)	M	• Large number of potential contaminants • Potential hazard of contaminants

[1] Potential contaminant listings based on literature (EPA 1993) and 2010 emission inventory information provided by the Northwest Clean Air Agency (NWCAA 2010). Other than emission inventories, site specific inventories of potential contaminants at each location were not conducted.

5. WATER SUPPLY CONTINGENCY PLAN

The purpose of a contingency plan is to prepare for an emergency that would cause the current and/or future ground water supply of the Reservation to become unusable. Such an emergency could develop over several years (e.g., more extensive salt water intrusion due to over pumping, atmospheric deposition of toxic compounds) or could develop suddenly (e.g., a spill of toxic material in the wellhead protection area). While many of the contaminants identified in the susceptibility assessment have the potential to cause the closure of limited portions of the aquifer, it is unlikely that the entire ground water resource would become unusable. The Lummi Nation's ground water monitoring program, established in 1991, should help identify early signs of salt water intrusion and allow for corrective actions to minimize the extent of contamination should it occur.

The contingency plan is an analysis of water supply replacement options and associated costs. The plan examines replacement options for both current and future water supply needs on the Reservation. In addition to providing information for emergency preparedness, a simplified analysis of the estimated costs to replace the existing and future water supply will help define the economic context of any proposed wellhead protection measures.

5.1. Current Reservation Water Supply

Water supply replacement options on the Reservation are affected by the existing water systems, alternative water supply sources, and the estimated replacement costs.

5.1.1. Existing Water System

There are currently four categories of water purveyors on the Reservation. Three of these purveyor categories supply potable water and one provides untreated ground water primarily for salmon egg incubation and a limited salmon rearing operation. The four types of purveyors are listed below and their general service areas shown in Figure 5.1. Areas in Figure 5.1 that are not adjacent to the Lummi Water District water lines or are not within the claimed service area of a water association are either undeveloped or obtain water from individual/private wells. The four categories of water purveyors on the Reservation are the following:

1. **Lummi Water District:** The Lummi Water District is the largest and the most geographically comprehensive water system on the Reservation. The Lummi Water District operates a network of nine production wells and approximately 758,600 gallons of reservoir storage (in four storage tanks ranging in capacity from 90,600 to 317,000 gallons). The Lummi Water District can also purchase and import potable water from the City of Bellingham via a 10-inch ductile iron pipeline. In 2010, the Lummi Water District provided water to approximately 986 residential connections (about 50 percent of the

approximately 1,989 residential units identified on the Reservation by the 2010 Census) and to municipal and commercial operations.

2. **Non-Tribal Water Associations:** Eight small water systems operated by non-tribal water associations currently serve predominantly non-tribal members in dense residential areas located along the Reservation shorelines. Five of the eight remaining non-tribal water associations on the Reservation are located in Wellhead Protection Area 1: Sunset, Georgia Manor, Northgate-Leeward, Harnden Island View, and Kel Bay. Combined, these five non-tribal water associations provide water to approximately 132 residential units or about 7 percent of the total. Two of the eight remaining non-tribal water associations on the Reservation are located in Wellhead Protection Area 2: Neptune Beach and the Sandy Point Improvement Company. Combined, these two non-tribal water associations provide water to approximately 714 residential units or about 36 percent of the total. The Fertile Meadows Water Association obtains ground water from an off-Reservation source that is not located in either of the Lummi Nation Wellhead Protection Areas. This water association provides water to three residential units on the Reservation and to additional residential units located adjacent to the Reservation. All of the non-tribal water associations on the Reservation rely exclusively on local ground water wells for supply.

   During the 1980s there were twelve small water systems operated by non-tribal water associations on the Reservation. In 1990, recognizing the threatened state of the Reservation aquifers, the Lummi Nation offered to take over the operation and maintenance of all of the non-tribal water associations on the Reservation and to meet all of their contractual commitments to provide water service. The goal was to consolidate the management of the fragile ground water resource so that the chances of additional saltwater intrusion would be reduced. Only one of the water associations (Horizon Heights) accepted the Lummi Nation's offer at the time and the association's system was transferred to the Lummi Nation, upgraded, and integrated into the Lummi Water District's system. A second former non-tribal water association was purchased by the Lummi Nation in the late 1980s (Fisherman's Cove) and was upgraded and integrated into the Lummi Water District's system at about the same time. In 1991 the Lummi Water District shut down the former Fisherman's Cove Water Association well and another nearby tribal public supply well due to salt water intrusion. A third non-tribal water association, the Gooseberry Point Community and Water Association, negotiated a settlement with the Lummi Nation as part of a federal lawsuit (*United States, Lummi Nation v. Washington State Department of Ecology, et al*, Civ. No. 019047Z [W.D. Wash.]). This system was transferred to the Lummi Nation during September 2004 and then upgraded and integrated into the Lummi Water District system. The fourth non-tribal water association, Gulfside Mobile Home Park was purchased by the Lummi Nation in 2008 and integrated into the Lummi Water District system during 2011.

3. **Individual or Private Wells:** There is currently an estimated 157 individual or private wells that supply water to one or more residential units on the Reservation (8 percent of the total).

4. **Untreated/Non Potable Water Systems:** The Lummi Natural Resources Department operates two systems that supply untreated ground and surface water for the Lummi Nation salmon propagation program. A well along Neptune Circle currently provides untreated water to the Sandy Point Hatchery facility and two tribal homes near Germaine Road. The Sandy Point Hatchery is a salmon egg incubation facility that uses approximately 129,600 gpd for approximately four months of the year. The Lummi Bay salmon hatchery is supplied by surface water pumped from the Nooksack River. The pumped water is discharged into a settling pond located along Chief Martin Road on the Lummi Peninsula before flowing via gravity to the Lummi Bay Hatchery. The Lummi Bay Salmon Hatchery uses approximately 1,220,000 gpd of Nooksack River water for eight months of the year.

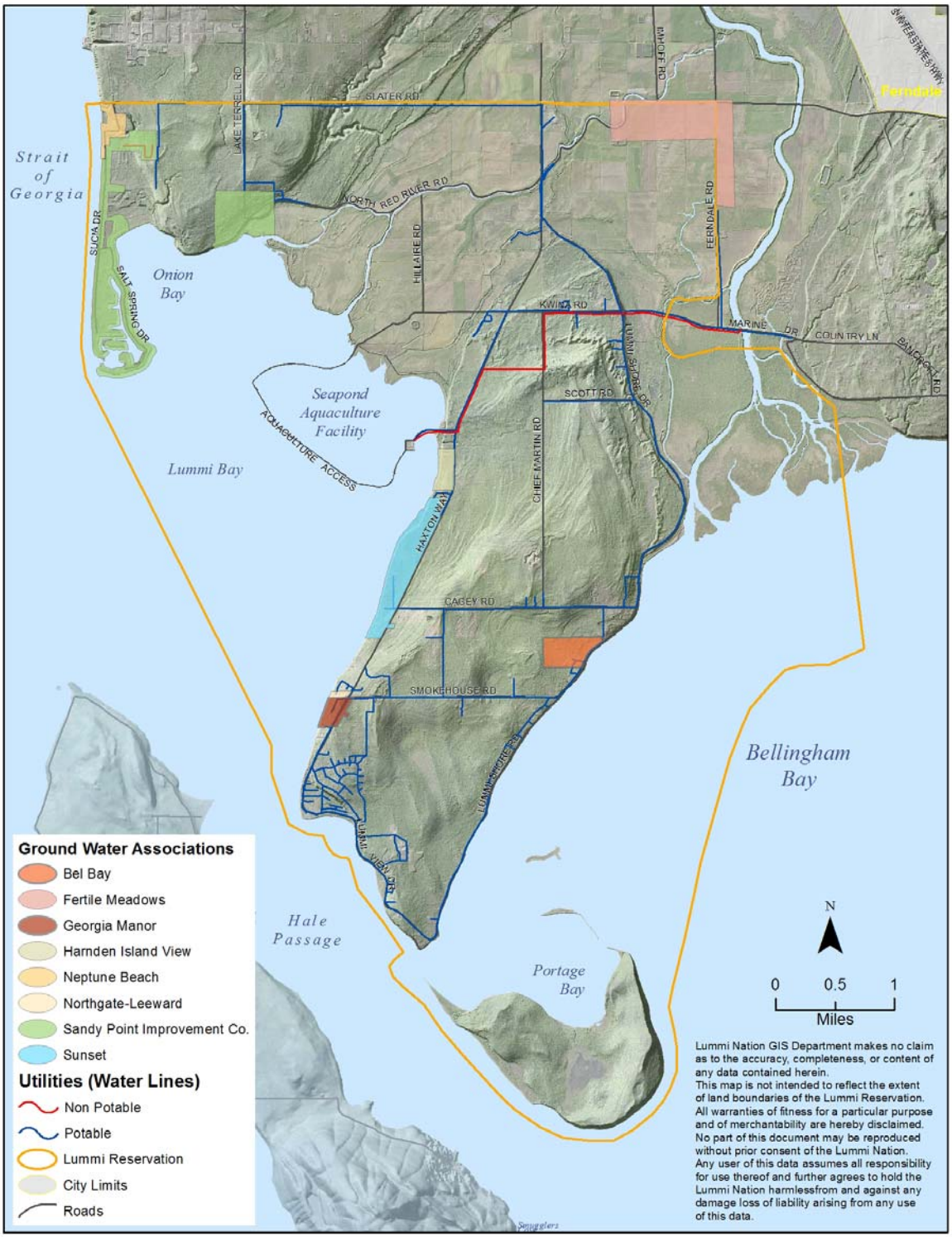

Figure 5.1. Lummi Water District Water Lines and Non-Tribal Water Associations

5.1.2. Alternative Water Supply

As noted above, local ground water is the only water source available to Reservation residents who are not supplied by the Lummi Water District. Although the Lummi Water District has access to an alternative water supply source, the high cost of the imported water and concerns about the impact of the City of Bellingham's diversion on Nooksack River fisheries resources limit the utilization of the Bellingham supply. Currently the Bellingham line is used only as a stand-by source for the Lummi Water District. In 2005, about 6.5 percent of the water supplied by the Lummi Water District came from the Bellingham waterline (BHC Consultants 2007). The current design capacity and contractual limits of this water line are approximately 1,000 gallons per minute (gpm) or about 1.4 million gallons per day (gpd).

As stated previously, the eight remaining non-tribal water associations on the Reservation use ground water and have no alternative supply. In 1990, the Lummi Nation offered to consolidate the non-tribal systems with the tribal system, to upgrade and manage the systems for aquifer protection, and to meet existing and future legal obligations for service. One of the water associations (Horizon Heights) accepted the offer and the system was upgraded and integrated into the Lummi Water District's system. A second former water association purchased by the Lummi Nation in the late 1980s (Fisherman's Cove) was upgraded and integrated into the Lummi Water District's system at about the same time. In 1991 the Lummi Water District shut down the former Fisherman's Cove Water Association well and another nearby tribal public supply well due to salt water intrusion. The Gooseberry Point Water Association was also transferred to the Lummi Water District in 2004 and two of the four wells were decommissioned due to salt water intrusion. The remaining eight non-tribal water associations refused the tribe's offer to become integrated into the Lummi Water District's system and are entirely dependent on wells adjacent to or within the association boundaries.

If it is assumed that the average annual water use per residential unit on the Reservation is 190 gpd (averaged from Lummi Peninsula System customer usage from 2003, 2004, and 2005), approximately 371,450 gpd are required to meet the current residential demand of the approximately 1,955 units on the Reservation (tribal and non-tribal). In addition to these residential water demands, the water use by the existing commercial and the salmon propagation program averages about 145,000 gpd. The current total average annual water demand for the Reservation is thus approximately 516,450 gpd or about 188,504,250 gallons per year (578 acre-feet). To supply the average daily water demand of 516,450 gallons, the wells on the Reservation would need to be pumped at a combined continuous average rate of about 359 gallons per minute (gpm).

If a portion of the Reservation aquifers were contaminated and no longer useable, the existing Bellingham water supply line could be used to meet the current potable water demands. Although the water line from the City of Bellingham could support the potable water supply demands, the chlorinated water could not be used to

replace the ground water for the salmon propagation program. The water supply to the salmon hatchery is non-chlorinated and cannot be mixed with chlorinated water since chlorine is toxic to salmon at very low concentrations.

Even though the Bellingham water line currently could replace ground water as a potable water supply if the aquifers became unusable, only Lummi Water District customers have access to the alternative source. The eight water associations and the Reservation residents supplied by individual domestic supply wells are not connected to the Lummi Water District's distribution network. In the event that a portion of the aquifer became unusable, these entities would have to develop an additional alternative source or become Lummi Water District customers under an arrangement with the Lummi Nation. In most cases, the existing water distribution system would have to be enlarged to serve these areas.

5.1.3. Estimated Replacement Costs

An extension or expansion of the Lummi Water District's distribution system would be costly. Although the total infrastructure needs and associated costs would have to be evaluated as part of an overall water system integration plan, water main costs about $110 per lineal foot including engineering costs. Additional reservoir storage capacity, additional pumping costs, valves, meters, fire hydrants, and other infrastructure would all have to be paid for as part of a system expansion. Additional water district staff would also be required to operate and maintain the expanded system.

For the purposes of this contingency plan, a general, simplified analysis was used to evaluate the monetary costs associated with a replacement water supply. A true economic analysis of replacement costs would require the services of a professional economist and is beyond the scope of the present effort. In this simplified analysis, it is assumed that any infrastructure needed to integrate the Lummi Water District and non-tribal water associations and/or tribal and non-tribal homes using private wells will be paid for by the water association members and individuals who will directly benefit from the integration. Consequently, the cost of an alternative water supply for the Lummi Water District was computed simply as the cost of replacing one water source (local ground water wells) with another (purchased water from the City of Bellingham). That is:

Cost of Alternative Source = Cost of Bellingham Water - Well Operation Costs

Despite its limitations, the simplified equation is useful to help evaluate the monetary value of ground water protection. The simplified equation allows for an approximation of the monetary costs associated with incremental increases in reliance on water purchased from the City of Bellingham. Incremental increases in reliance on the alternative source could occur if pumping rates were reduced to preclude salt water intrusion or if entire wells were shut down due to contamination from one of the potential sources. In Table 5.1, the lost ground water supply is expressed as a "well equivalent", as an average pumping rate, and as a lost volume.

Based on the pumping rates of Lummi Water District wells, one well equivalent was assigned an average pumping rate of 20 gpm.

The current monthly cost to the Lummi Water District for purchasing water from the City of Bellingham is a flat rate of $1,260 per month and $2.35 for every 100 ft^3 (748 gallons). The average annual cost to operate and maintain the pumps at the nine water supply wells (electric power, chlorine, miscellaneous repairs) operated by the Lummi Water District including labor/staff costs is approximately $179,000. The average annual operation and maintenance costs for the nine supply wells excluding labor is approximately $79,000 or about $8,800 per well (approximately $733 per month per well). These operation and maintenance costs would not be necessary if a well were shut down and the water supply replaced with water purchased from the City of Bellingham. It is assumed that routine water quality monitoring, pipeline maintenance, and the associated labor costs would continue even if additional supply is purchased from Bellingham.

As shown in Table 5.1, one 20 gpm well produces an average of 115,504 cubic feet (ft^3) per month. At an operation cost of $733 per month, the cost of obtaining this amount of water from a local ground water well is about 0.6 cents ($0.006) per cubic foot. Obtaining this quantity of water from the City of Bellingham would cost about $3,974 per month or about 3.44 cents ($0.0344) per cubic foot. In essence, obtaining water from Bellingham costs almost 6 times what it costs to obtain water from local ground water wells.

At current prices, water from the City of Bellingham costs approximately 2.84 cents ($0.0284) per cubic foot more than water pumped from local ground water wells. As a result, the monthly replacement cost of a single ground water well would be about $3,280. To recover the additional cost if the production equivalent to one 20 gpm well was lost, the Lummi Water District would need to increase the rates for its current 986 residential customers by an average of $3.33 per month. This increase represents about a 15 percent increase over the current average monthly Lummi Water District residential customer bill of $22.00.

Estimated current monthly incremental water supply replacement costs are shown in Table 5.1. It is noted that the monetary value of an alternative water supply computed by the simplified equation does not address the impacts to the Nooksack River fisheries resources that could result from any increased diversions necessary to supply the water. The simplified equation used to estimate the water replacement cost also does not address the cost to the Lummi Nation of depleting a ground water resource in a region with a limited water supply. It is impossible to put a true value on a resource that is essential to life, is finite, and is irreplaceable. For the Lummi Nation, ground water is also culturally significant as a component of the natural environment. A variety of experts, in consultation with the Lummi Nation, would be needed to assess and develop an estimate of the true cost of replacement and/or restoration of the Nation's trust resources.

Table 5.1. Estimated Current Monthly Incremental Water Supply Replacement Costs

Lost Well Equivalent (1 well = 20 gpm)	Lost Average Pumping Rate (gpm)	Lost Average Monthly Volume (ft^3)	Average Monthly Replacement Cost		
			Bellingham Water ($)	Reduced Well Operation Cost ($)	Total Estimated Monthly Replacement Cost ($)
0.5	10	57,754	1,987.17	366.50	1,620.67
1	20	115,504	3,974.34	733.00	3,241.34
1.5	30	173,262	5,961.51	1099.50	4,862.01
2	40	231,016	7,948.68	1,466.00	6,482.68
2.5	50	288,770	9,935.85	1,832.50	8,103.35
5	100	577,540	19,871.70	3,665.00	16,206.70

5.2. Future Reservation Water Supply

The 2010 Census reports that there were 1,989 housing units on the Reservation during 2010. Although as noted in Table 5.2 there are a number of assumptions that are not aligned with existing water right permits, tribal policy, and the settlement of the Lummi Peninsula Ground Water Lawsuit (*United States, Lummi Nation v. Washington State Department of Ecology, et al*, Civ. No. 019047Z [W.D. Wash.]), the Lummi Water District projected that there will be approximately 4,033 Reservation housing units by 2050 (BHC Consultants 2007). The population projections shown in Table 5.2, planned economic and institutional growth on the Reservation, the fact that there are currently nearly 900 tribal members on a waiting list for individual homes on the Reservation, and the small percentage of tribal land that has been developed all indicate that the available ground water supply on the Reservation is not adequate to support the future residential water supply needs on the Reservation.

In addition to the residential water demand, new and/or expanded commercial enterprises will likely be established on the Reservation in the coming years to meet the economic development needs of the current and future population. Existing institutional/municipal water needs will also increase in the coming years to service the demands of the larger population. For example, the Northwest Indian College is continuing to expand and the New Lummi Tribal Center is expected to be completed by 2013. Whether for domestic, commercial, municipal, industrial, agricultural, or hatchery uses, future water needs on the Reservation will substantially increase and exhaust the available ground water supply. A single commercial development project (e.g., green houses, golf course) could fully utilize the sustainable capacity of the Reservation aquifers.

Although the existing Bellingham water supply line and contract limit of 1.4 million gpd provides an alternative supply to the Lummi Water District and its customers and could support the existing potable water demands of the Reservation, neither the physical capacity of the line nor the contractual arrangement with the City of Bellingham would be adequate if the Lummi Nation's aquifers became completely unusable and existing water demand on the Reservation was tripled. There are no

assurances that the City of Bellingham would sell more water to the Lummi Nation or that funding would be available for the substantial upgrades required to increase the physical capacity of the pipeline. The cost to replace the water supply would be much greater if the salmon hatchery supply well became unusable and it became necessary to identify and develop an alternative source of non-chlorinated water.

In summary, the existing alternative water supply source cannot support the projected future demand of the Lummi Nation. Consequently, wellhead protection is imperative to ensure that the current water source remains available to supply the water demand and additional sources need to be secured.

Table 5.2. Projected Service by the Lummi Water District System[1]

Parameter[2]	2005	2010	2020	2030	2040	2050
Indian Population	3,229	3,713	4,642	5,663	6,795	8,087
Non-Indian Population	3,361	3,764	4,141	4,348	4,435	4,479
Total Reservation Population	6,590	7,478	8,782	10,011	11,230	12,566
Indian Homes and Service Connections						
Indian Homes	697	807	1,079	1,381	1,788	2,310
persons per home	4.8	4.6	4.3	4.1	3.8	3.5
Non-Indian Homes	1,167	1,298	1,479	1,553	1,642	1,723
persons per home	2.9	2.9	2.8	2.8	2.7	2.6
Total Reservation Homes	1,864	2,105	2,558	2,934	3,431	4,033
Non-Indian Water Purveyors and Service Connections						
Sandy Point Improvement Co.	679	730	760	800	840	880
Neptune Beach	70	71	72	73	74	75
Harnden Island	9	9	9	9	9	9
Sunset	92	93	95	97	99	101
Georgia Manor	28	29	30	31	32	33
Kel Bay	6	6	6	6	6	6
Total Non-Indian Home Services	884	938	972	1,016	1,060	1,104
Non-Indian Private Wells	110	170	280	280	310	350
Non-Indian Homes	173	190	227	257	272	269
Total Non-Indian Homes	1,167	1,298	1,479	1,553	1,642	1,723
Indian Homes not served	50	60	60	50	40	30
Indian Homes Served	647	747	1,019	1,331	1,748	2,280
Non-Indian Homes Served	173	190	227	257	272	269
Total Residential Customers	820	937	1,246	1,588	2,021	2,549

[1]Table prepared by BHC Consulting LCC (2007) for LTSWD – projected increases shown in this table for the number of service connections for the Sandy Point Improvement Company are not supported by the existing state-issued water right permit held by the Company. The Lummi Nation is actively opposing any further expansion of the Sandy Point Improvement Company due to a lack of available ground water supply and the senior federal reserved water rights of the Lummi Nation. Similarly, the projected number of Non-Indian Private Wells is not aligned with limitations on private well development that resulted from the settlement of the Lummi Peninsula Ground Water Lawsuit (*United States, Lummi Nation v. Washington State Department of Ecology, et al*, Civ. No. 019047Z [W.D. Wash.]).
[2]Non-residential customers are developed separately

(This page intentionally left blank)

6. WELLHEAD PROTECTION MEASURES

Developing and implementing effective wellhead protection measures and programs are the primary means to achieve the program goal of preventing ground water contamination. Twelve LIBC environmental programs on the Reservation directly relate to protecting ground water resources. The Lummi Natural Resources Department administers eight of the programs and the Lummi Planning Department administers four programs. Wellhead protection measures include a surface and ground water monitoring program, a comprehensive water resources management program, the Lummi Nation Water Resources Protection Code and associated regulations, spill prevention and response, ground water rights negotiations/litigation and settlement, water conservation, decommissioning abandoned wells or wells not intended for future use, permit review requirements, solid waste management, public education initiatives, and the water and sewer code.

The Lummi Nation Water Quality Monitoring Program is comprised of both a surface water monitoring program and a ground water monitoring program. The goal of the Lummi Nation Water Quality Monitoring Program is threefold: (1) to establish the baseline conditions of surface and ground waters on and flowing onto the Reservation, (2) to use this information to evaluate regulatory compliance of waters flowing onto the Reservation, and (3) to support the development and implementation of a water quality regulatory program (e.g., Lummi Code of Laws Title 17, water quality standards) on the Reservation.

6.1. Surface Water Monitoring Program

The Lummi Nation Surface Water Quality Monitoring Program was started in 1993 and currently consists of monthly sampling at 43 stations (sites) on and around the Reservation. The Surface Water Quality Monitoring Program has grown significantly since 1993 in the number of sites sampled, the parameters measured, and the ability to manage and analyze the collected data. Additional sites were added in the late 1990s to better evaluate the water quality impacts of Nooksack River water on Portage Bay and to better evaluate conditions in the Lummi Bay watershed. Many of the 43 sample sites are located along the Reservation border, with the majority of the contributing watershed located off-Reservation. Several intermittent streams and storm water systems are sampled as part of the program, along with the marine waters of Lummi Bay, Portage Bay, the Sandy Point Marina, and Bellingham Bay near the Nooksack River Delta.

Pursuant to the Shellfish Consent Decree (Order Regarding Shellfish Sanitation, *United States v. Washington [Shellfish]*, Civil Number 9213, Subproceeding 89-3, Western District of Washington, 1994) the Washington Department of Health (DOH), in consultation with the Lummi Nation, is responsible to the federal Food and Drug Administration (FDA) to ensure that the National Shellfish Sanitation Program (NSSP) standards for certification of shellfish growing waters are met on the

Reservation. The DOH currently samples 12 sites in Portage Bay six times a year as part of the Lummi Nation Surface Water Quality Monitoring Program. The Lummi Natural Resources Department provides logistical assistance to the DOH including monthly sampling at six additional sample sites in Lummi Bay and twelve sites in the Nooksack River delta.

At all of the surface water sample sites, water temperature, air temperature, water depth, specific conductivity, salinity, dissolved oxygen, pH, turbidity, fecal coliform bacteria, *E. coli*, and enterococci, are measured and recorded. Secchi depth is measured at the marine sites. In accordance with the Quality Assurance Project Plan for the water quality monitoring program (LWRD 2010), a contracted independent laboratory enumerates all bacteria from the same sample bottle, and fecal coliform bacteria and *E. coli* are measured from the same culture (LWRD 2010). Quarterly at selected sites, samples for total petroleum hydrocarbons, metals, and nutrients are collected and analyzed at a laboratory certified by Washington State. Due to the costs of analyzing water quality samples for metals and petroleum hydrocarbons, these parameters are only measured quarterly at two of the water quality monitoring sites (one fresh water site downstream from a petroleum oil refinery and one marine water site within a recreational boat marina). Similarly, due to cost considerations, nutrients are measured quarterly at only five of the surface water quality monitoring sites. All measurements are performed and recorded in accordance with a Quality Assurance Project Plan (QAPP) most recently approved by the EPA in May 2010 (LWRD 2010).

6.2. Ground Water Monitoring Program

The Lummi Nation Ground Water Monitoring Program also started in 1993 and currently consists of monthly monitoring of 28 wells on the Reservation. The number of wells sampled has increased over the years and the parameters measured have changed to include pH and salinity measurement. Wells were added as they were drilled or when access was granted to obtain better spatial resolution of aquifer conditions. Water level, pumping status, temperature, specific conductivity, pH, salinity, and chloride concentration are measured monthly or more frequently at each site. Well production is recorded from existing meters at the Lummi Water District water supply wells. If a well is not sampled when scheduled, the well is sampled as soon as possible afterwards. All measurements are performed and recorded in accordance with the Quality Assurance Project Plan for the water quality monitoring program (LWRD 2010).

The primary purpose of the Ground Water Monitoring Program is to collect baseline information about the quality and quantity of Reservation ground waters and to detect trends in chloride concentration to identify when and where salt water intrusion is occurring. The chloride concentration, pumping rate and amounts, and ground water levels in the water supply wells provide critical information about aquifer conditions, pumping regimes, and the need for protective measures as these data indicate whether seawater intrusion is occurring or if the likelihood of seawater intrusion has increased. For wells that are not used for water supply purposes (e.g.,

inactive wells), water level measurements provide information about aquifer conditions.

6.3. Comprehensive Water Resources Management Program

The Lummi Natural Resources Department's (LNR) Water Resources Division established a Comprehensive Water Resources Management Program in response to Lummi Indian Business Council (LIBC) resolutions 90-88 and 92-43. The purpose of the CWRMP is to ensure that land and water resources on the Reservation are safeguarded against surface and ground water degradation during planning and development activities. Environmental planning intended to protect the Nation's water resources has included development of a Wellhead Protection Program (LWRD 1997), a Storm Water Management Program (LWRD 2011b), a Wetland Management Program (LWRD 2000), a Nonpoint Source Management Program (LWRD 2001, LWRD 2002), Water Quality Standards for Reservation surface waters (LWRD 2008), surface and ground water quality monitoring (LWRD 2011a), and a spill prevention and response plan (LWRD 2005). The various Lummi Natural Resources Department programs are complemented by several programs associated with the Lummi land use permitting process. Fact sheets describing the Comprehensive Water Resources Management Program can be downloaded from the website: http://lnnr.lummi-nsn.gov/LummiWebsite/Website.php?PageID=52.

6.4. Water Resources Protection Code and Regulations

As part of the Comprehensive Water Resources Management Program, the Lummi Code of Laws (LCL) Water Resources Protection Code (Title 17) was developed to protect, enhance, and restore the quality in the Reservation surface and ground water including the Reservation estuaries and tidelands. Title 17 was adopted by the LIBC in January 2004 and is intended to provide for knowledge-based, integrated, efficient, and equitable management of Reservation waters. The wellhead protection ordinance (LCL 17.04) establishes wellhead protection areas where certain activities such as landfills (hazardous and solid waste), salvage yards, stockyards, feedlots, or similar sites containing discarded material having the potential to adversely affect ground water are prohibited.

The Lummi Indian Business Council adopted Lummi Administrative Regulations (LAR) for water quality standards (17 LAR 07) during 2008 and regulations for technical requirements for ground water wells (17 LAR 04), storm water management (17 LAR 05), wetland management (17 LAR 06), and a system of civil fines for violation of Title 17 (17 LAR 08) during 2010. The Water Resources Protection Code (LCL Title 17) and associated regulations can be downloaded from the website: http://lnnr.lummi-nsn.gov/LummiWebsite/Website.php?PageID=53.

6.5. Spill Prevention and Response Plan

The Lummi Natural Resources Department has been actively developing spill prevention and response capabilities since the mid-1990s and completed the Lummi Nation Spill Prevention and Response Plan in October 2005 (LWRD 2005). This plan identifies measures the Lummi Nation can take to prevent spills of polluting material on the Reservation and actions the Lummi Nation should take in response to spills on- or off-Reservation that threaten Reservation waters.

Large amounts of crude oil, petroleum products, and other hazardous materials are transported and stored near the Lummi Indian Reservation. These hazardous materials are transported by ships, pipelines, trucks, and railroad and are used, produced, and/or stored throughout the Reservation area, particularly in the Cherry Point Heavy Impact Industrial Zone located in Whatcom County immediately north of the Reservation boundary. Spills or releases of petroleum products, chemicals, or other hazardous materials to land or waters can threaten public safety, public health, and destroy some of the most productive and valuable ecosystems in the world. The Lummi Police Department and the Lummi Natural Resources Department, in cooperation with local spill response organizations (e.g., Marine Spill Response Corporation), local refineries, the Whatcom County Division of Emergency Management (in the county Sheriff's Department), and other local fire and police agencies, are trained and prepared to respond to minor spills or releases of some hazardous materials. In response to a major spill, experts from the EPA, Ecology, Marine Spill Response Corporation, and local industries would be called in to help control the damage. The Spill Prevention and Response Plan further describe the emergency response capabilities of these agencies.

The Lummi Natural Resources Department continues efforts to develop spill prevention and response capabilities through staff training, spill response drills including drills, equipment upgrades, planning, research, and public outreach. Spill prevention and response training for staff members is conducted through both dedicated classes and through table-top and boom deployment exercises. The oil spill prevention and response activities are publicized in the community through articles in the Lummi Nation monthly newspaper (*Squol Quol*). The Lummi Natural Resources Department staff also regularly conduct data collection activities and research in support of the oil spill prevention and response capability development through the documentation of background and ambient conditions (LNR 2010). This information will be useful in evaluating the effectiveness of response efforts and resource impacts in the event of an oil spill. These efforts contribute to achieving the Lummi Nation goals of protecting the public health and safety of Reservation residents and protecting treating rights to fish and gather throughout all usual and accustomed areas. Spill prevention and response activities and other information about the Lummi Nation's capabilities can be downloaded from the website: http://lnnr.lummi-nsn.gov/LummiWebsite/Website.php?PageID=213.

6.6. Lummi Ground Water Negotiations and Settlements

Saltwater intrusion into Reservation aquifers has been documented since the 1970s and was the subject of a federal lawsuit at that time (*United States v. Bel Bay Community et al*., Civil No. 303-71C2 (W.D. Wash.)). Assessments by the U.S. Geological Survey (USGS) and Ecology, presented as exhibits in *United States v. Bel Bay Community et al*., indicated that ground water withdrawals from two new wells will increase the likelihood of saltwater intrusion into the Lummi Peninsula Aquifer. The USGS report (Cline 1974) stated:

> "…the conclusion that must be reached from the available data is that, even under the most favorable conditions, the pumping of the Bel Bay well at the proposed rate (or pumping of any other well that would cause a lowering of the average water level in the Pierre well) would increase the risk of salty ground water reaching the Pierre well."

Further, the third affidavit of Duane Wegner (formerly an engineering geologist with Ecology and the Head of the Shorelands Division of Ecology at the time of the affidavit) stated:

> "This study [Cline 1974] shows, and subsequent data gathered by Department of Ecology personnel confirms, that there are no public ground waters available for appropriation in the area of the Lummi Peninsula on the Lummi Reservation. This is because the recharge to the ground water in the area is not adequate to support further ground water appropriation. When the appropriation in the Lummi Peninsula exceeds the recharge, there is increased saltwater intrusion into existing wells. Accordingly, no further waters can be developed without impacting existing rights by degrading water quality."

As described previously, in 1990, recognizing the threatened state of the Reservation aquifers, the Lummi Nation offered to take over all of the non-tribal water associations on the Reservation and to meet all of their contractual commitments to provide water service. The goal was to consolidate the management of the fragile ground water resource so that the chances of additional saltwater intrusion would be reduced. Only one of the associations (Horizon Heights) accepted the offer.

In 1992, the Lummi Nation formally and publicly declared its intent to quantify its water rights through negotiation if possible, or through litigation if necessary. The initial focus would be on the Reservation, with the off-Reservation stream flow issues to follow.

In July 1995, the state and federal governments agreed to government-to-government negotiations with the Lummi Nation. After lengthy negotiations and several failed proposals, the parties developed an Agreement in Principle to accomplish two things: (1) determine if there is an off-Reservation source of an

assured, uninterruptible water supply that is legally, politically, environmentally, and economically available; and (2) identify issues that need to be resolved before a final settlement agreement could be reached. The negotiation teams signed the Agreement in Principle on January 27, 1998. Although the parties successfully identified an off-Reservation water source, success was more limited in resolving the other outstanding issues. The negotiations effectively ended in April 2000 when one of the non-tribal water associations filed a lawsuit in state court that sought to prevent the Lummi Nation from using one of the tribal wells.

In response, a federal lawsuit was filed by the United States Department of Justice in January 2001 (Civ. No. C01-47Z [WD WA]). A final settlement was negotiated in 2007 to resolve the federal ground water lawsuit regarding the Lummi Peninsula Aquifer (*United States, Lummi Nation v. Washington State Department of Ecology, et al*, Civ. No. 019047Z [W.D. Wash.]). Following appeals by a few of the defendants, the settlement was finally approved by the federal courts in 2009. A copy of the settlement can be downloaded from the following website: http://lnnr.lummi-nsn.gov/LummiWebsite/Website.php?PageID=90.

6.7. Water Conservation

The Lummi Water Resource Division developed a water conservation plan in 2004 to provide guidelines to conserve the Reservation water supply. The water conservation plan is integral to the Lummi Nation Wellhead Protection Program (LWRD 1997, LWRD 1998b). The Lummi Water Conservation Plan identifies water conservation strategies that support efforts to reliably provide high quality potable water to a growing population within a developing service area. The three main approaches the Lummi Nation is using to conserve municipal water supplies are voluntary conservation measures, economic measures such as metering and pricing, and mandatory measures including regulations and restrictions. The Lummi Water District has taken the lead role in carrying out several water conservation programs including public education, rebate and retrofit, leak detection, and water reclamation and reuse. The Lummi Water Conservation Plan is intended to protect and conserve ground water quantity and quality on the Reservation. More information about the water conservation program can be downloaded from the website: http://lnnr.lummi-nsn.gov/LummiWebsite/Website.php?PageID=83.

6.8. Well Decommissioning

An abandoned well is any well that is no longer in use. Abandoned wells, besides being a physical danger to people and animals, can provide a direct pathway for contamination to quickly enter the ground water. The Lummi Water Resources Division has established a well decommissioning program for abandoned wells and wells no longer in use. As shown in Figure 6.1, eighteen wells were decommissioned throughout the Reservation over the 2006 through 2011 period. Wells will continue to be decommissioned as funding becomes available. More information about the well decommissioning program can be downloaded from the website: http://lnnr.lummi-nsn.gov/LummiWebsite/Website.php?PageID=83.

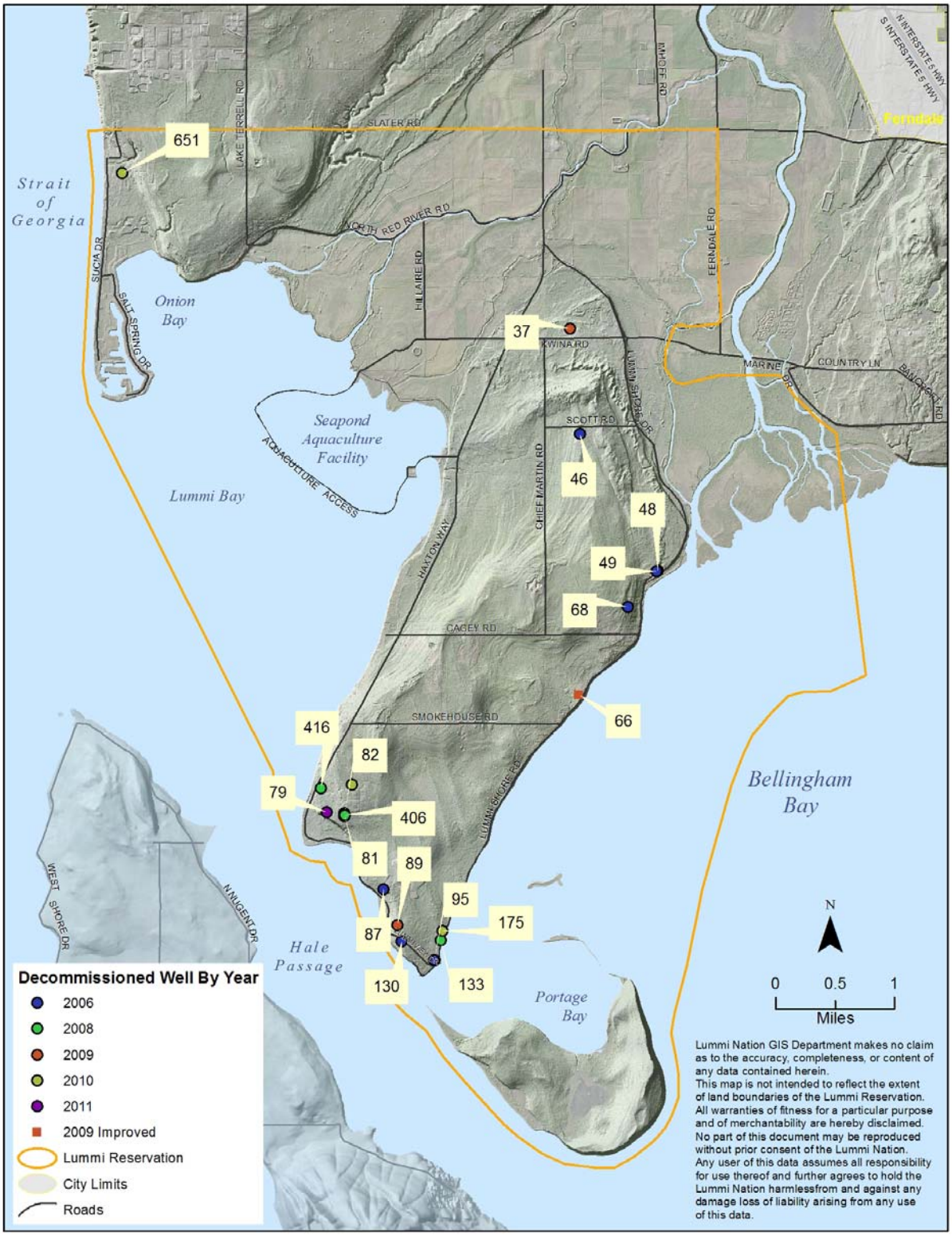

Figure 6.1. Wells Decommissioned on the Lummi Reservation between 2006 and 2011

6.9. General Land Use Plan

The Lummi Planning Department is in the process of developing a General Land Use Plan for the Lummi Reservation. The plan will show generally how land on the Reservation will be used over the next 20 years. The General Land Use Plan identifies areas that will be developed for residential, commercial, industrial, and agricultural purposes, as well as showing areas that require protection (e.g., wetlands and aquifer recharge zones). To date, a technical background document (LIBC 1996) has been developed, public-opinion surveys conducted, a preliminary version of the General Land Use Plan drafted, land use zoning designations approved, a second round of maps developed, and focused planning workshops and meetings with commissions and community groups conducted. The General Land Use Plan was codified in the Lummi Land Use Zoning and Development Code (LCL Title 15). The General Land Use Plan and the LCL Title 15 should prevent nonpoint source pollution by ensuring that land use is compatible with the landscape, that infrastructure is developed in a coordinated fashion, and that development should have the overall effect of minimizing land disturbing activities.

6.10. Technical Review Committee

The Technical Review Committee (TRC) was established by a LIBC resolution in 1997 (Resolution No. 97-104) in response to increasing development pressure on the Reservation and the need for coordinated review of proposed development projects. The TRC consists of representatives from the following departments or divisions of departments: Cultural Resources Protection, Economic Development, Police, Maintenance, Tribal Employment Rights Office, Natural Resources, Education, Lummi Tribal Sewer and Water District, Housing, Realty, and Planning. The TRC meets weekly to review land use permit applications distributed to committee members before the meeting. At the TRC meeting, comments and conditions are stated and the application is either delayed for further information or a Lummi Land Use Permit is approved, approved with conditions, or denied. The TRC also determines whether a tribal environmental assessment (TEA) is necessary to determine if significant environmental impacts will result from the proposed project or activity.

Land use activities can affect many people. Without careful planning, future opportunities for development may be lost to current land use activities. The TRC is providing for a comprehensive, interdisciplinary review of proposed land use activities on the Reservation. Participation of the Lummi Natural Resources department in the TRC provides for the protection of natural resources as well as an opportunity to provide information to applicants that can help avoid natural resource impacts or otherwise improve their projects.

6.11. Integrated Solid Waste Management Plan

The Lummi Planning Office began the solid waste planning process for the Lummi Indian Reservation in the mid-1970s with the preparation of the report entitled "*Solid*

Waste Disposal: A Preliminary Survey" (Lummi Planning Department 1978). This report was forwarded to the EPA for review in July 1978, and the Lummi Nation submitted a formal request for technical assistance to the EPA in September 1978. The 1979 Lummi Solid Waste Management Plan (Harper-Owes 1979) was prepared as part of an EPA technical assistance project under the provisions of the 1976 Resource Conservation and Recovery Act (RCRA). The Lummi Solid Waste Management plan was adopted by the LIBC in 1979. A draft of an Integrated Solid Waste Management Plan (ISWMP) has been developed and following public input will presented to the LIBC for approval during 2012.

The purpose of the Lummi Nation Integrated Solid Waste Management Plan (ISWMP) is to guide current and future efforts to effectively and efficiently manage solid waste on the Lummi Reservation. It also guides efforts to protect and restore environmental trust resources including water resources, shorelines, tidelands, and uplands through proper management and disposal of solid and hazardous waste. The Lummi Indian Business Council, through the Planning Department and the Natural Resource Department, is the solid waste planning and regulatory authority on the Reservation. A designated solid waste management program was initiated in 2002 by the LIBC and operated under the direction of the Vice Chairman's office through 2003 and funded through the LIBC general fund and EPA grants. In 2004, the solid waste management program, known as "Project Clean-Up", was institutionalized within the administrative structure of the LIBC by moving the program from the Office of the Vice Chairman to the Lummi Planning Department. This program was renamed "Lummi Waste Management." The Lummi Solid Waste Management Team was created out of this program consisting of a Waste Management Team Lead, the Water Resources Division Manager, the Land Development Division Manager, and the Lummi Housing Authority Director.

In 2004, the Lummi Nation adopted a Solid Waste Control and Disposal Code (LCL Title 18). Title 18 provides the policy framework and delegation of administrative authority for a coordinated program to address the accumulation, collection, and disposal of solid waste; the resource recovery, recycling and utilization of recyclable materials; and the creation and operation of disposal sites and transfer stations. The Lummi ISWMP is intended to minimize wellhead protection area contamination from solid waste and household hazardous wastes.

6.12. Lummi Tribal Sewer and Water District Code

The Lummi Sewer District, which is administratively within the Lummi Planning Department, operates a comprehensive, Reservation wide, sewage collection and treatment system that serves the majority of households on the Reservation. The sewer facilities consist of sewer collectors, sewer interceptors, 25 lift stations, a biosolids application site, and three treatment plants, including the Membrane BioReactor Plant completed in 2004. A new wastewater treatment plant is planned for construction during 2012 to replace the Sandy Point Wastewater Treatment Plant. In addition during 2011, new sewer lines are being installed along Salt Spring Drive to replace on-site septic systems. For residences not on a sewer line, the

Lummi Nation Sewer and Water Code (LCL Title 16) regulates sewage disposal for public health and safety and establishes criteria for the design, construction, alteration, and operation of on-site septic systems. The Lummi Tribal Sewer District enforces the sewer code and inspects on-site septic systems. The sewer district and sewer code serve to minimize NPS pollution by ensuring that appropriate sanitary sewer facilities are used by Reservation residents and that the systems are operated and maintained in a manner that protects public health.

The Lummi Water District is the largest purveyor of potable water on the Reservation. As detailed previously, the Lummi Water District operates a water system which consists of a network of nine production wells, four storage reservoirs and an inter-tie with the City of Bellingham. The Lummi Water District operates and maintains the potable water pumping and distribution system on the Reservation.

7. WELLHEAD PROTECTION PROGRAM ACTION PLAN

The long term goal of wellhead protection cannot be achieved overnight. Therefore, determining short term objectives within the framework of a larger plan is critical to reaching the ultimate goal (EPA 1993, DOH 2010). Setting achievable goals has allowed for the Lummi Wellhead Protection Program to successfully complete all three phases in the program; including development of a wellhead protection ordinance, a regulation for wellhead construction standards for wellhead protection, and continued implementation of community education and outreach program.

Table 7.1 summarizes the activities and implementation schedule over the next five years to address potential contamination and salt water intrusion of Reservation aquifers. The effectiveness of the action plan to protect Reservation aquifers will be evaluated based on the results of the LNR ground water monitoring program and monitoring results from the Lummi Water District's Safe Drinking Water Act sampling. If the levels of contaminants or chloride levels in water samples collected and analyzed by the Lummi Water Resources Division and/or the Lummi Water District do not increase over time or with increasing aquifer pumping within the duration of the Wellhead Protection Plan, the action plan will be judged to be effective. If not successful, subsequent versions of the management program will need to incorporate additional or more effective actions to preclude contamination and saltwater intrusion of Reservation aquifers.

Table 7.1. Action Plan to Address Contamination of Reservation Ground Water by Various Pollutants

Activity	2012	2013	2014	2015	2016	Comments
1) Implement on-Reservation Ground Water Monitoring Program	■	■	■	■	■	Program started in 1993; funded through LIBC appropriations and EPA and BIA grants
2) Implement Wellhead Protection, Storm Water Management, Nonpoint Source Pollution Management, and Stream and Wetland Management regulations and public education programs	■	■	■	■	■	Program started in 1996; funded through Bureau of Reclamation, EPA, and LIBC appropriations; future funding through Section 319 possible
3) Continue LNR participation on Technical Review Committee	■	■	■	■	■	Funded through EPA grants (Section 106, GAP) and LIBC appropriations; future funding through Section 319 possible

Table 7.1. Action Plan to Address Contamination of Reservation Ground Water by Various Pollutants

Activity	2012	2013	2014	2015	2016	Comments
4) Continue implementation of the Lummi Spill Prevention and Response Plan	■	■	■	■	■	Semiannual spill response drills with LNR, MSRC, and Lummi Police Department
5) Implement the Water Conservation Plan in conjunction with the Lummi Tribal Sewer and Water District	■	■	■	■	■	Pending funding; future funding through Section 319 possible
6) Implement the settlement agreement negotiated to resolve the federal ground water lawsuit regarding the Lummi Peninsula Aquifer (*United States, Lummi Nation v. Washington State Department of Ecology, et al*, Civ. No. 019047Z [W.D. Wash.])	■	■	■	■	■	Funding through LIBC appropriations
7) Ensure EPA oversight of Safe Drinking Water Act compliance of non-tribal water associations on the Reservation	■	■	■	■	■	EPA Program initiated during 2001; future funding through Section 319 possible
8) Implement the Integrated Solid Waste Management Plan	■	■	■	■	■	Pending funding, future funding through Section 319 possible
9) Potential purchase of wells that threaten aquifer water quality	■	■	■	■	■	Future funding through Section 319 possible
10) Continue the decommissioning of wells that are no longer in use and potentially threaten aquifer water quality	■	■	■	■	■	Pending funding; future funding through Section 319 possible
11) Pursue negotiated or litigated resolution of conflicting claims over water rights to Reservation ground water	■	■	■	■	■	Efforts on-going
12) Continue the implementation of community education and outreach program	■	■	■	■	■	Pending funding; future funding through the EPA Indian General Assistance Program possible
13) Purchase property in the Wellhead Protection Areas	■	■	■	■	■	Purchase property in critical aquifer recharge areas

8. COMMUNITY EDUCATION AND OUTREACH

Education and public involvement are essential elements of any wellhead protection program. While regulation and enforcement are important, implementing public education efforts is a proactive approach to protecting the ground water. Targeted and persuasive education and outreach is vital to changing the behavior of many individuals who collectively contribute to pollution (Ecology 1992).

Before community members are motivated to participate in wellhead protection program activities, they must first be aware of the importance of the local ground water resources, the potential sources of ground water contamination, and be educated about what they can do to prevent contamination. Public education activities should therefore be designed to involve and encourage the community to become aware of the problems and take action when appropriate to solve specific problems (Ecology 1992).

For wellhead protection, it is important that people are aware of:

- The importance of local ground water resources for community water supply;
- The value of wellhead protection and how it benefits the community;
- How wellhead regulations/ordinances affect their property and community;
- How they can ensure the safety of the ground water supply; and
- How they can get involved in wellhead protection in their community (i.e., opportunities for volunteer projects and/or community events).

The Lummi Nation Wellhead Protection Program will inform and involve the community through community education and interjurisdictional coordination and cooperation.

1. **Community Education:** The public education element of the Lummi Wellhead Protection Program will include articles in the Lummi Nation newspaper *Squol Quol* describing the effects of pollution and the progress of the Lummi Wellhead Protection Program development effort. The Lummi Planning Department and Lummi Natural Resources Department will continue providing copies of the Wellhead Protection Program fact sheet to community members. Also the Lummi Natural Resources department will post on their website wellhead protection materials including well drilling and decommissioning standards, on going Reservation wellhead protection projects, drinking water laws and regulations, and links to other wellhead and ground water protection websites.
2. **Interjurisdictional Coordination and Cooperation:** The interjurisdictional coordination and cooperation element of the plan will continue within the LIBC and with the U.S. Environmental Protection Agency, Washington State Department of Ecology, and Washington State Department of Health. The Lummi Natural Resources Department needs to continue working closely with the Lummi Planning Department and other LIBC agencies to implement the community education element of the wellhead protection program.

(This page intentionally left blank)

9. CONCLUSION AND SUMMARY

The overall purpose of the Lummi Nation Wellhead Protection Program is to protect ground water within the Lummi Indian Reservation ("Reservation") from contaminants. The Program is intended to reduce the risk of the Lummi Nation's ground water resources becoming impaired or otherwise unusable as the primary water supply for the Lummi Nation and residents of the Reservation.

As a finite resource, ground water is one of the most important and critical of the Lummi Nation's resources. The Lummi Nation is dependent on ground water for water supply. Over 95 percent of the residential water supply for the Reservation is currently pumped from local ground water wells. In addition the salmon hatchery program which is culturally and economically significant to the Lummi Nation and its members is dependent on ground water. No suitable alternative water sources exist on or near the Reservation for the salmon egg incubation program and salmon rearing operation.

Ground water on the Reservation is withdrawn from two separate aquifers on the Reservation. One system is located in the northern upland area. This system flows onto the Reservation from the north and drains to the west, south, and east (Aspect Consulting 2009a). The second potable ground water system is located in the southern upland area of the Reservation (Lummi Peninsula) and is completely contained within the Reservation boundaries (LWRD 1997, Aspect Consulting 2003). As of January 2011, a total of 264 wellheads, test holes and undeveloped springs were identified within the boundaries of the Reservation. The Lummi Water district, the largest water purveyor on the Reservation, operates ten production wells. The Lummi Water District can also purchase and import potable water from the City of Bellingham via a 10-inch ductile iron pipeline. In 2010, the Lummi Water District provided water to approximately 968 residential connections and all municipal and commercial operations on the Reservation. The remaining residential units on the Reservation obtain water from one of the eight non-tribal water associations or private wells.

The Lummi Nation delineated wellhead protections areas in order to protect the two aquifers which provide the primary drinking water source on the Reservation. Two separate wellhead protection areas were originally delineated and mapped in 1997. The northern of the two wellhead protection areas was revised as part of this update effort to align with the 2010 revision of the Reservation watershed boundaries. Both wellhead protection area delineations were conducted using the flow boundaries approach. Wellhead Protection Area 1 is the southern upland area and includes most of the Lummi Peninsula and Portage Island. Area 1 is approximately 6,625 acres in size (10.4 mi^2) and encompasses locations where fresh ground water was historically found to all depths penetrated by wells, a transition area where fresh ground water is adjacent to salty water or where salt water is encountered in places, and an area where saltier water has been encountered (Cline 1974). The precise locations of the boundaries for these areas and the hydrogeologic relations between

them are unknown due to lack of data. Wellhead Protection Area 2 is the northern upland area and extends north of the Reservation. Area 2 is approximately 5,910 acres in sixe (9.2 mi^2) and is comprised of three surface water basins. The floodplain area of the Lummi River and Nooksack River, and areas north of the Reservation that contribute flow to the floodplain (e.g., the City of Ferndale), are not in a Lummi wellhead protection area. Although there are areas on the floodplain where fresh water may be perched above salty ground water or directly overlie salty ground water, in general the floodplain is not suitable for ground water development (Cline 1974). Currently there are no known uses of this ground water for domestic supply.

As part of a susceptibility assessment, potential sources of aquifer contaminants from agricultural, residential, municipal, commercial, and industrial land uses in each of the wellhead protection areas were inventoried. Available literature and emissions inventories were used to identify potential aquifer contaminants associated with each source. Based on the location of each potential contaminant source, the quantity of potential contaminants associated with the source, and the hazard represented by the contaminants, each potential source was assigned a potential hazard rating of low, moderate, or high.

Salt water intrusion caused by over pumping is a major threat to the Lummi Nation's ground water resources in both Area 1 and Area 2. The Reservation is located in a coastal area and most of the existing water supply wells on the Reservation are within a half mile of marine waters. Progressive salt water intrusion induced by over pumping of nearshore wells has already led to the closure of several wells on the Reservation.

Other major threats to the ground water supply in Wellhead Protection Area 1 include: horses and goats fenced within residential areas near Hermosa Beach and along Haxton Way just south of the Seapond Aquaculture Facility, single family residential units relying on private water supply wells and/or septic systems, and an abandoned landfill along Chief Martin Road. In Wellhead Protection Area 2, the major threats to the ground water supply (after salt water intrusion) include: single family residential units relying on private water supply wells and/or septic systems, roadways (i.e., transportation corridors for the Cherry Point Heavy Impact Industrial Zone), manure lagoons north of the Reservation, and the ConocoPhillips petroleum oil refinery.

Using current water price information and a simplified equation, it was determined that obtaining water from Bellingham costs about six times more than obtaining water from local ground water wells. At current prices, every 20 gpm of lost pumping capacity would cost about $3,280 per month suggests that the Lummi Tribal Water District's rates would have to be raised an average of $3.33 per month for the current 986 residential customers if one 20 gpm well was lost. This increase represents about a 15 percent increase over the current average monthly Lummi Water District residential customer bill of $22.00. However, the simplified equation

used to estimate the water replacement cost does not address the cost to the Lummi Nation of depleting a ground water resource in a region with a limited water supply.

Although the existing Bellingham water supply line and contract limit of 1.4 million gpd provides an alternative supply to the Lummi Water District and its customers and could support the existing potable water demands of the Reservation, neither the physical capacity of the line nor the contractual arrangement with the City of Bellingham would be adequate if the Lummi Nation's aquifers became completely unusable and existing water demand on the Reservation was tripled. There are no assurances that the City of Bellingham would sell more water to the Lummi Nation or that funding would be available for the substantial upgrades required to increase the physical capacity of the pipeline. The cost to replace the water supply would be much greater if the salmon hatchery supply well became unusable and it became necessary to identify and develop an alternative source of non-chlorinated water.

In conclusion, the existing alternative water supply source cannot support the projected future demand of the Lummi Nation. Consequently, wellhead protection is imperative to ensure that the current water source remains available to supply the water demand and additional sources need to be secured. In addition, the ground water resources are culturally important to the Lummi Nation as a component of the natural environment and it is impossible to put a true value on a resource that is essential to life, is finite, and is irreplaceable.

(This page intentionally left blank)

10. REFERENCES

Aspect Consulting. 2003. *Lummi Peninsula Ground Water Investigation Lummi Indian Reservation, Washington*. Prepared for the Bureau of Indian Affairs.

Aspect Consulting. 2009a. *Aquifer Study of the Mountain View Upland – Lummi River Area: Whatcom County and Lummi Nation Washington*. Prepared for the Lummi Indian Business Council, Bellingham, Washington.

Aspect Consulting. 2009b. Preliminary Groundwater Source Evaluation, Lummi Tribal Sewer and Water District Arsenic Study. Prepared for RH2 Engineering Inc.

BHC Consultants LLC. 2007. *Lummi Tribal Sewer and Water District Water Facilities Plan.* Report prepared for the Lummi Tribal Sewer and Water District, Bellingham WA.

Bauer, H.H and M.C. Mastin. 1997. *Recharge from Precipitation in Three Small Glacial-Till-Mantled Catchments in the Puget Sound Lowland, Washington.* U.S. Geological Survey Water Resources Investigation Report 96-4219.

Charles Howard and Associates Ltd. 1991. *Ground Water Resource Evaluation, Lummi Reservation Phase 1 Report*. Report prepared for the Lummi Indian Business Council.

Cline, D.R. 1974. *A Ground Water Investigation of the Lummi Indian Reservation Area, Washington*. Tacoma, U.S. Geological Survey, Open-File Report. Pg 66.

Drost, B.W. 1996. *Selected Ground Water Data for the Lummi Indian Reservation, Whatcom County, Washington, 1995*. Tacoma, U.S. Geological Survey Open-File Report 96-166. Pg 21.

Easterbrook, D.J. 1973. *Environmental Geology of Western Whatcom County, Washington*. Western Washington University, Bellingham, Washington. Pgs 3-29.

Easterbrook, D.J. 1976. *Geologic map of Western Whatcom County, Washington*. U.S. Geologic Survey Map I-854-B, 1:62,500.

Gillies, John. 1998. Personal Communication - Meeting Notes April 13, 1998.

Golder and Associates, Inc (Golder). 1992. *Water Quality Evaluation of the Lummi Indian Reservation*. Report prepared for the Lummi Indian Business Council. Pg 15.

Harper-Owes. 1979. *Lummi Solid Waste Management Plan*. Peat, Marwick, Mitchell & Company Seattle, Washington. Prepared for Lummi Indian Business Council, Bellingham Washington.

Lummi Indian Business Council (LIBC). 1996. *Lummi Nation Comprehensive Environmental Land Use Plan: Background Document*. LIBC, Lummi Reservation.

Lummi Natural Resources Department (LNR). 2010. *Lummi Intertidal Baseline Inventory*. Prepared for the Lummi Indian Business Council

Lummi Planning Department. 1978. *Solid Waste Disposal: A Preliminary Survey.* Prepared for the Lummi Indian Business Council, Bellingham.

Lummi Water Resources Division (LWRD). 1997. *Lummi Nation Wellhead Protection Program --Phase I*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 1998a. *Lummi Nation Wellhead Protection Program --Phase II*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 1998b. *Lummi Nation Water Reclamation and Reuse*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 2000. *Lummi Indian Reservation Wetland Management Program Technical Background Document*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 2001. *Nonpoint Source Assessment Report.* Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 2002. *Nonpoint Source Management Plan*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 2005. *Lummi Nation Spill Prevention and Response Plan*. Prepared for the Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 2008. *Water Quality Standards for Surface Waters of the Lummi Indian Reservation.* Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 2010. *Quality Assurance Project Plan Lummi Nation Water Quality Monitoring Program*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 2011a. *2010 Lummi Nation Water Quality Assessment Report.* Prepared for Lummi Indian Business Council, Bellingham, Washington.

Lummi Water Resources Division (LWRD). 2011b. *Lummi Reservation Storm Water Management Program Technical Background Document*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Mobil Oil Corporation. 1986. *RCRA Part B Permit Application for Ferndale Refinery, Ferndale, Washington - Volume I, Section A - C*. Submitted to Washington Department of Ecology and U.S. Environmental Protection

Newcomb, R.C., J.E. Sceva, and O. Stromme. 1949. *Ground Water Resources of Western Whatcom County, Washington.* U.S. Geological Survey. Pg 134.

Northwest Clean Air Agency. 2011. *Air Operating Permits for Island, Skagit, and Whatcom Counties*. http://www.nwcleanair.org/aqPrograms/airPermits_pg2.htm. Accessed May 25, 2011.

Phillips, E.L. 1966. *Washington Climate for these Counties: Clallam, Jefferson, Island, San Juan, Skagit, Snohomish, Whatcom*. Washington State Cooperative Extension Service, Washington State University. Pg 64.

U.S. Army Corps of Engineers (Corps). 1997. *Detailed Project Report: Lummi Shore Protection Project, Lummi Indian Reservation, Whatcom County, Washington*. Corps of Engineers, Seattle District, Washington.

U.S. Environmental Protection Agency (EPA). 1987. *Guidelines for Delineation of Wellhead Protection Areas*. Office of Ground Water Protection, Washington, D.C. EPA 440/6-87/010.

U.S. Environmental Protection Agency (EPA). 1993. *Wellhead Protection: A Guide for Small Communities*. Seminar Publication. Office of Water, Washington, D.C. EPA/625/R-93/002.

U.S. Environmental Protection Agency (EPA). 2006. *How to Manual: Update and Enhance Your Local Source Water Protection Assessments.* Office of Water, Washington, D.C. EPA/816/K-06/004.

Washburn, R.L. 1957. *Ground Water in the Lummi Indian Reservation, Whatcom County, Washington*. Tacoma, U.S. Geological Survey, Open-File Report. Pg 31.

Washington State Department of Ecology (Ecology). 1992. *Stormwater Management Manual for the Puget Sound Basin*. Volume 1 (Pub. No. 92-32) and Volume 2 (Pub. No. 92-33).

Washington Department of Health (DOH). 1995. *Wellhead Protection Program Guidance Document.* Wellhead Protection Program, Olympia WA. DOH #331-018.

Washington Department of Health (DOH). 2010. *Washington State Wellhead Protection Program Guidance Document*. Wellhead Protection Program, Olympia WA. DOH #331-018 (Revised).

APPENDIX A

Wellhead Inventory

Lummi Nation Wellhead Inventory (December 2011)

Lummi No	Location	Owner	Active	Well Log	Year
GW001	39N/02E-29M01	WHATCOM CO HWY	N	Y	1972
GW002	39N/02E-31H02	WHATCOM CO HWY	N	Y	1972
GW003	39N/01E-35N01	CLEMO, BECK N.	N	Y	1962
GW004	39N/01E-34R01	JORDAN AND LARSON	N	N	999
GW005	39N/01E-34Q01	LOUIS UNICK	N	N	999
GW006	38N/01E-05A01	HERBERT SHERMAN	N	Y	1947
GW007	38N/01E-05A02D1	BAKER,M. PETE	Y	Y	1953
GW008	38N/01E-05A03	BURNETT, JACK	N	N	999
GW009	38N/01E-04D03	NEPTUNE BEACH WATER ASOC	N	Y	1953
GW010	38N/01E-04D04D1	NEPTUNE BEACH WATER ASOC	Y	Y	1970
GW011	38N/01E-04D05	NEPTUNE BEACH WATER ASOC	Y	N	999
GW012	38N/01E-04E01	SANDY POINT IMPROVEMENT COMPANY	N	Y	1960
GW013	38N/01E-04E03	SANDY POINT IMPROVEMENT COMPANY	Y	Y	1969
GW014	38N/01E-04E02	SANDY POINT IMPROVEMENT COMPANY	Y	Y	1971
GW015	38N/01E-04M02	FINKBONNER, FRED	N	Y	1964
GW016	38N/01E-04M01	FINKBONNER, FRED	N	Y	1964
GW017	38N/01E-08A01	USGS	N	Y	1956
GW018	38N/01E-04J04	SANDY POINT IMPROVEMENT COMPANY	N	Y	1969
GW019	38N/01E-03D01	HILLAIRE, BENJAMIN	N	Y	1964
GW020	38N/01E-03D02	HILLAIRE, BENJAMIN	N	Y	1971
GW021	38N/01E-04J01	JOSEPH, DAVID	N	Y	1964
GW022	38N/01E-04J02	JOSEPH, JAMES	N	Y	1964
GW023	38N/01E-03M01	ESTATE OF A. CAGEY	N	Y	1964
GW024	38N/01E-03M02	PAIGE,VICTORIA	N	N	999
GW025	38N/01E-03Q01	JAMES,CALVIN	N	Y	1964
GW026	38N/01E-03H01	KINLEY, MAY (ESTATE)	N	Y	1964
GW027	38N/01E-01B01	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1946
GW028	38N/01E-01B02	LUMMI INDIAN BUSINESS COUNCIL	N	N	999
GW029	38N/02E-06B01	IMHOFF, FRANK	N	N	999
GW030	38N/02E-05B01	ROBERT E TAWES	N	Y	1972
GW031	38N/02E-07J01	JOHNSON, V.V.	N	Y	1972
GW032	38N/02E-07Q01	MCKAY,J. & OTHERS	N	Y	1972
GW033	38N/02E-07M01	LUMMI SCHOOL	N	Y	1933
GW034	38N/02E-07M02	LUMMI SCHOOL	N	N	999
GW035	38N/02E-07E01	JAMES,BILL	N	Y	1958
GW036	38N/01E-12H01	KINLEY, LARRY & ELLIE	N	N	999
GW037	38N/01E-12K01	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1952
GW038	38N/01E-11R01	KINLEY, EVA	N	Y	1971
GW039	38N/01E-11N01	LUMMI INDIAN BUSINESS COUNCIL	N	N	999
GW040	38N/01E-11N02	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1952
GW041	38N/01E-14J02	CHARLES, NORBERT	N	Y	1971
GW042	38N/01E-14J01	HILLAIRE, NEDDIE	N	Y	1964
GW043	38N/01E-14Q01	TWINER, WILLIS	Y	Y	1970
GW044	38N/01E-13K01	TOM, ISADORE	N	Y	1971
GW045	38N/01E-13J01D1	MARTIN, FRANK	N	Y	1965
GW046	38N/01E-13J02	CHURCHOF JESUS CHRIST L.D.S.	N	Y	1969
GW047	38N/01E-13J03	EDWARDS, SANDRA	N	Y	1970
GW048	38N/02E-19L03	COSTELLO, ROBERT	Y	Y	1956
GW049	38N/02E-19L04	COSTELLO, ROBERT	N	Y	1956
GW050	38N/02E-19L01	LARSEN, CHRIS	N	N	999
GW051	38N/02E-19L02	CRUIKSHANK, N.P.	N	Y	1946
GW052	38N/02E-19P01	HUBBARD, VIC & BRAINARD, DIANE	Y	N	999
GW053	38N/01E-24G01D1	HUMPHREY, A. JR	N	Y	1964
GW054	38N/01E-23B03	HARNDEN ISLAND VIEW	Y	Y	1958
GW055	38N/01E-26D01	OWSLEY& DURKIN	N	Y	1965
GW056	38N/01E-26G01	LUMMI WTR DST, CULTEE	N	Y	1971
GW057	38N/01E-26E01	BOYNTON SUNSET	Y	Y	1962
GW058	38N/01E-27R01	LUMMI WTR DST, HORIZON	Y	Y	1968
GW059	38N/01E-26Q01	LUMMI WTR DST, KINLEY WAY	Y	Y	1971
GW060	38N/01E-26R04	WIGGIN, CHARLES JR	N	Y	1964
GW061	38N/01E-26J01	KINLEY, FLORENCE	N	Y	1967
GW062	38N/01E-26R03	PIERRE, JOHN	N	Y	1964
GW063	38N/01E-25D01	LUMMI WTR DST, ROSS	N	Y	1971
GW064	38N/01E-25K01	BELL BAY INC	Y	Y	1961
GW065	38N/01E-25J03	USGS (LUMMI TW1)	N	Y	1971
GW066	38N/01E-25J02	PIERRE, ENEAS	N	Y	1964
GW067	38N/01E-25Q02	PLASTER, JIM	N	Y	1964

Lummi Nation Wellhead Inventory (December 2011)

Lummi No	Location	Owner	Active	Well Log	Year
GW068	38N/02E-30D03	CAGEY, MARY HELEN	Y	Y	1971
GW069	38N/02E-30D01	GREEN, RICHARD	Y	Y	1971
GW070	38N/02E-30D02	GREEN, EDMUND	N	Y	1964
GW071	38N/02E-30E01	VICTOR, JOHN & PETE	N	Y	1964
GW072	38N/01E-35R01	JOHNSON, V.	N	Y	1946
GW073	38N/01E-34A01	GEORGIA MANOR WATER	N	Y	1959
GW074	38N/01E-34B01	CHARLES, KATHY	Y	Y	1971
GW075	38N/01E-34G02	SALISBURY, LEONARD	Y	Y	1969
GW076	38N/01E-34G03	BALLEW, WAYNE	N	Y	1963
GW077	38N/01E-34P01	WHATCOM COUNTY (HIGHWAY DEPT)	N	Y	1959
GW078	38N/01E-34K03	LUMMI WTR DST, FISHERMANS COVE	N	Y	1968
GW079	38N/01E-34K04	LUMMI WTR DST, FISHERMANS COVE	N	N	999
GW080	38N/01E-34K01D1	LUMMI WTR DST, FISHERMANS COVE	N	Y	1946
GW081	38N/01E-34J01	GOOSEBERRY POINT	N	N	999
GW082	38N/01E-34R01	GOOSEBERRY POINT	Y	Y	1968
GW083	38N/01E-34Q01	JONES BROTHERS	N	Y	1947
GW084	37N/01E-03H01	TOBY, VERLE	N	N	999
GW085	37N/01E-02E01	JONES, VICTOR	Y	N	999
GW086	37N/01E-02E02	JONES, VICTOR	N	Y	1964
GW087	37N/01E-02E03	WHATCOM COUNTY, LUMMI MARINE PARK	N	Y	1971
GW088	37N/01E-02M02	HILLAIRE, PENNY	Y	N	999
GW089	37N/01E-02M03	SOLOMON, RALPH	Y	Y	1973
GW090	37N/01E-02M01	SOLOMON, NICK	Y	N	999
GW091	37N/01E-02H01	NAVARETTE, PETE	N	Y	1964
GW092	37N/01E-02K07	ADAMS,JAMES	N	N	999
GW093	37N/01E-02K06	NOLTE,F. W.	Y	N	999
GW094	37N/01E-02Q02	BARBER, JAMES	N	Y	1946
GW095	37N/01E-02Q04	SOLOMON, VICTOR	Y	N	999
GW096	37N/01E-11B01	MORSE	Y	Y	1970
GW097	37N/01E-11C01D1	LUMMI WTR DST, SOLOMON & LEWIS	N	Y	1954
GW098	37N/01E-11K01	WHATCOM COUNTY (HIGHWAY DEPT)	N	Y	1959
GW099	37N/01E-12L01	WHATCOM COUNTY (PARK DEPT)	N	Y	1964
GW100	38N/01E-05A09	UNKNOWN	N	Y	999
GW101	38N/01E-05J01	SKOLROOD, JOHN	N	Y	1982
GW102	38N/01E-04B03	INDIAN HEALTH SERVICE	N	Y	1976
GW103	38N/01E-04B04	INDIAN HEALTH SERVICE	N	Y	1976
GW104	38N/01E-05A05	BURNETT, MICHEAL	Y	Y	1985
GW105	38N/01E-05H04	PUGLIA, JOHN	N	Y	1976
GW106	38N/01E-05A07	PETERSON, MARGE	N	Y	1974
GW107	38N/01E-04E04	SANDY POINT IMPROVEMENT COMPANY	Y	Y	1985
GW108	38N/01E-04E08	FINKBONNER, ARNOLD, WELL II	N	N	999
GW109	38N/01E-05R02	FINKBONNER, JOE	Y	Y	1983
GW110	38N/01E-04E07	FINKBONNER, ARNOLD, WELL I	N	Y	999
GW111	38N/01E-14Q02	LUMMI TRIBE, HOPKINS	N	Y	1991
GW112	38N/01E-26C01	JEFFERSON, RALPH	N	Y	1989
GW113	38N/01E-23P01	WILLIAMS, VIRGIL	Y	Y	1991
GW114	38N/01E-26M02	KENNEDY, KATHY	Y	Y	1988
GW115	38N/01E-26N01	LUMMI WTR DST, BALCH	Y	Y	1987
GW116	38N/01E-27J04	SMITH, MICHAEL	Y	Y	1981
GW117	38N/01E-27J02	RICHARDSON, TOM	Y	Y	1974
GW118	38N/01E-27R04	MURPHY, WAYNE & AUTRY, NICOLE	Y	Y	1980
GW119	38N/01E-27J01	ROBB, GEORGE M.	Y	Y	1974
GW120	38N/01E-27R05	MOORE, GERALD	Y	Y	1976
GW121	38N/01E-27J03	BRIAN,OLIVER	Y	Y	1976
GW122	38N/01E-27R02	NORTHGATE SHORT PLAT	Y	Y	1981
GW123	37N/01E-02E04	KINLEY, MARCELLINE	Y	Y	1979
GW124	37N/01E-02E05	HILLAIRE, PENNY	N	Y	1982
GW125	38N/01E-34H02	HENDRICKSON, JAY & JOAN	Y	Y	1977
GW126	NONE	NONE	N	N	999
GW127	38N/01E-34G04	LUMMI WTR DST, BALLEW-REVEY	N	Y	1973
GW128	38N/01E-34J02	LUMMI WTR DST, MACKENZIE I	Y	Y	1982
GW129	38N/01E-35E01	LUMMI WTR DST, MACKENZIE II	Y	Y	1987
GW130	37N/01E-02P02	LUMMI SEWER PLANT	Y	Y	1982
GW131	37N/01E-02M04	ORERIO, DAVE	Y	Y	1980
GW132	37N/01E-02P03	LANE,CARL	Y	Y	1987
GW133	37N/01E-02Q13	WORMALD, MARTIN & LAURIE	Y	Y	1987
GW134	37N/01E-02H02	SMITH,JIM	Y	Y	1985

Lummi Nation Wellhead Inventory (December 2011)

Lummi No	Location	Owner	Active	Well Log	Year
GW135	38N/02E-06P01	HOOD,PERCY	Y	Y	1948
GW136	38N/02E-18Q01	MAMOYA PONDS	N	Y	1990
GW137	NONE	NONE	N	N	999
GW138	38N/01E-05R03	FINKBONNER, DARRIN	Y	Y	1989
GW139	38N/01E-05H05	JACKSON, ROBERT	N	Y	1989
GW140	38N/01E-05A08	UNICK,FRANCIS	Y	Y	1968
GW141	39N/01E-34N03	BARLEANS	N	Y	1988
GW142	38N/01E-04E05	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1991
GW143	38N/01E-34H01	BERG	Y	Y	1977
GW144	38N/01E-04B01	ADAMS,BEVERLY & RON	Y	N	999
GW145	38N/01E-04E06	LUMMI INDIAN BUSINESS COUNCIL - JOHNSON	Y	Y	1993
GW146	38N/01E-34A03	LUMMI WTR DST, WEST SHORE	Y	Y	1994
GW147	37N/01E-02Q09	BEZONA, ROBERT	Y	Y	1994
GW148	NONE	NONE	N	N	999
GW149	38N/01E-05A04	BURRELL, NORMAN	Y	Y	1993
GW150	37N/01E-02Q06	DRUMHELLER, DOROTHY	Y	Y	1994
GW151	38N/01E-27R03	PAUL DEGRAAF	N	Y	1995
GW152	38N/01E-05H03	MCKAY, KENNETH	Y	Y	1993
GW153	38N/01E-27R06	SCHNOBRICH, WILLIAM	N	Y	1994
GW154	38N/01E-14H01D2	KOSEL,HORST	N	Y	1994
GW155	38N/01E-14Q03	THRALL, TOM	N	Y	1991
GW156	38N/02E-07M01S	LECKMAN & SHOEMAKER	N	N	999
GW157	38N/01E-12J01	WILLIAMS, VIRGIL	N	Y	999
GW158	38N/01E-13C01	JONES,SADIE	N	N	999
GW159	38N/02E-19B01S	CHARLES, GORDON	N	N	999
GW160	38N/02E-19G01S	CHARLES, ELLEN	N	N	999
GW161	38N/02E-07M03S	REVEY,BILL	N	N	999
GW162	38N/02E-07M02S	JAMES,JEWELL	N	N	999
GW163	38N/02E-18D01	JEFFERSON, FRANCIS & MIKE	N	N	999
GW164	37N/01E-02H03D1	BEWLEY, KEN	N	N	999
GW165	38N/02E-19B02	MCCLAUSKEY, RUSSELL	N	N	999
GW166	38N/01E-26R01	PIERRE, JOHN	N	N	999
GW167	38N/01E-36C01	SOLOMON, DORA	N	Y	999
GW168	38N/01E-36E01	SOLOMON, FELIX	N	Y	999
GW169	38N/02E-18L01S	WILLIAMS, MARTHA	N	N	999
GW170	38N/01E-36M01	WASHINGTON, BUCK OR DEAN	N	N	999
GW171	38N/01E-25Q01	PLASTER, JIM	Y	N	999
GW172	37N/01E-02K01	BEZONA	Y	N	999
GW173	37N/01E-02K02	BEZONA, BOB D.	Y	N	999
GW174	37N/01E-02K03	YORKSTON	Y	Y	1947
GW175	37N/01E-02K05	FILBERT, FRED	Y	N	999
GW176	37N/01E-02K08	WALKER, WAYNE	Y	Y	1956
GW177	37N/01E-02Q03	LELAND, TROY & SUSAN	Y	N	999
GW178	37N/01E-02Q08	HARRIMAN, LARRY	Y	N	999
GW179	37N/01E-02Q10	OTT, JANET	Y	N	999
GW180	37N/01E-02Q11	TRECKER, MARTECK C.	Y	N	999
GW181	37N/01E-02Q12	HOLCOMB, LEE	Y	Y	1956
GW182	38N/01E-26M01	ROBBINS, CAROLE	Y	N	999
GW183	38N/01E-27J05	FADDEN & FISHER	Y	Y	1988
GW184	38N/01E-27J06	HOVANDER, STEVE	N	Y	1981
GW185	NONE	NONE	N	N	999
GW186	38N/01E-34A02	GEORGIA MANOR WTR ASSC	Y	Y	1992
GW187	38N/01E-34G05	SALHUS, ROBERT	Y	N	999
GW188	38N/01E-34G06	CLARK,JACK	Y	Y	1985
GW189	38N/01E-35R02	LANE,JIM	Y	Y	1991
GW190	37N/01E-11C02	LUMMI WTR DST, SOLOMON & LEWIS	N	N	999
GW191	38N/01E-34B01S	LUMMI INDIAN BUSINESS COUNCIL	N	N	999
GW192	37N/01E-02K09	FRANCISCO, J. E.	N	N	999
GW193	37N/01E-02Q01	BARBER, ZILPHA	N	N	999
GW194	37N/01E-11C01S	LUMMI INDIAN BUSINESS COUNCIL	N	N	999
GW195	38N/01E-01N01	JEFFERSON, DAVE	N	N	999
GW196	38N/01E-01Q01	USGS	N	Y	1956
GW197	38N/01E-12M01	JOHNS,HERBERT	N	N	999
GW198	38N/01E-13J04	USGS	N	Y	1956
GW199	38N/01E-13J05	MARTIN, FRANK	N	Y	999
GW200	38N/01E-14A01	USGS	N	Y	1956
GW201	38N/01E-23B01	HARNDEN, M.F.	N	Y	999

Lummi Nation Wellhead Inventory (December 2011)

Lummi No	Location	Owner	Active	Well Log	Year
GW202	38N/01E-23B02	HARNDEN, M.F.	N	Y	999
GW203	38N/01E-24G02	HUMPHREYS, ART	N	Y	1956
GW204	38N/01E-25C01	USGS	N	Y	1956
GW205	38N/01E-25J01	PETERS, AL	N	N	999
GW206	38N/01E-25J04	USGS	N	Y	1956
GW207	38N/01E-26Q02	USGS	N	Y	1956
GW208	38N/01E-26R02	PIERRE, ART	N	N	999
GW209	38N/01E-34R01S	GOOSEBERRY PT WTR ASSC	N	N	999
GW210	38N/01E-36B01	USGS	N	Y	1956
GW211	38N/01E-36E02	USGS	N	Y	1956
GW212	38N/02E-07M03	USGS	N	Y	1956
GW213	38N/02E-18C01	JEFFERSON, FRANCIS	N	N	999
GW214	38N/02E-18C02	JEFFERSON, FRANCIS	N	Y	1956
GW215	38N/02E-18F01	USGS	N	Y	1956
GW216	38N/02E-18F02	USGS	N	Y	1956
GW217	38N/02E-18P01	USGS	N	Y	1956
GW218	38N/02E-19G02	YUN, CHUNG	N	N	999
GW219	38N/02E-19G03	USGS	N	Y	1956
GW220	NONE	NONE	N	N	999
GW221	38N/02E-19P02	USGS	N	Y	1956
GW222	38N/01E-03J01	LEE BROTHERS	N	N	999
GW223	38N/01E-04B02	USGS TEST HOLE	N	Y	1956
GW224	38N/01E-04J03	USGS TEST HOLE	N	Y	1956
GW225	NONE	NONE	N	N	999
GW226	38N/01E-05A06	HARKLEROAD	N	N	999
GW227	38N/01E-05H01	DAWLEY, HARRY	N	Y	1951
GW228	38N/01E-05H02	O'DELL, ALLEN	N	Y	1951
GW229	38N/01E-05R01	FINKBONNER, JOHN	N	Y	999
GW230	38N/01E-34J03	GOOSEBERRY POINT WATER ASSOC	N	N	999
GW231	39N/01E-21G01D1	STATE GAME DEPT.	N	Y	1967
GW232	39N/01E-21N01	WAYLETT, JESS	N	N	999
GW233	39N/01E-21R01	HARVEY HANSON	N	N	999
GW234	39N/01E-22G01	S R ROBERSON	N	N	999
GW235	39N/01E-22J01	UNICK, VICK	N	Y	1994
GW236	39N/01E-23Q01	LARSON, EUGENE	N	Y	1973
GW237	39N/01E-25F01	HENRY DERR	N	N	999
GW238	39N/01E-25L01	O M SHEPPARD	N	N	999
GW239	39N/01E-26B01	MORELANDER, GEORGE	N	Y	1946
GW240	39N/01E-26C01	GILBERTSON, JIM	N	Y	1991
GW241	39N/01E-26D01	AMUNDSON, SAM	N	N	999
GW242	39N/01E-26E01	MACGUIRE, JOHN	N	Y	1940
GW243	39N/01E-26F01	ROBERTS, BILL	N	Y	1992
GW244	39N/01E-26F02	HAMILTON, LEON & JANINE	N	Y	1991
GW245	39N/01E-26G01	BARNES, GEORGE	N	Y	1993
GW246	39N/01E-26H01	KELLN, GOTFRIED	N	N	999
GW247	39N/01E-26H02	KOLSTAD, JULIA	N	Y	1980
GW248	39N/01E-26H03	KELLN, GOTFRIED	N	N	999
GW249	39N/01E-26J02	WIDMAN, LLOYD	N	Y	1992
GW250	39N/01E-26J03D1	MATHIS, GENE	N	Y	1981
GW251	39N/01E-26K01	EASTON, JAMES	N	Y	1981
GW252	39N/01E-26K02	CHORNLSESKY, BILL	N	Y	1981
GW253	39N/01E-26K03	WIDMAN, LLOYD	N	Y	1977
GW254	39N/01E-26M02	HALIGAN, PAUL	N	Y	1991
GW255	39N/01E-26M03	SOFIE, MIKE	N	Y	999
GW256	39N/01E-26P01	KIMBLY, JAMES	N	Y	1988
GW257	39N/01E-26Q01	BUBB, DICK	N	Y	1981
GW258	39N/01E-26Q02	WIDMAN, LLOYD	N	Y	1988
GW259	39N/01E-26R01	BERARD, WILLIAM	N	Y	1972
GW260	39N/01E-26R03	SHANNON, PATRICK & FLORA	N	Y	1993
GW261	39N/01E-27B01	ANDERSON, A	N	N	999
GW262	39N/01E-27H01	BENSON, DEAN	N	N	999
GW263	39N/01E-27J01	WARREN, JIM	N	Y	1993
GW264	39N/01E-27L01	VAN SCHINDE L,J.	N	Y	1945
GW265	39N/01E-27P01	RIGHT, J. C.	N	Y	1988
GW266	39N/01E-27R01	BRESLAND, FRANK	N	Y	1989
GW267	39N/01E-28D01	BAILEY, JAY	N	Y	999
GW268	39N/01E-28E01	ANDERSON, CARL W.	N	Y	1940

Lummi Nation Wellhead Inventory (December 2011)

Lummi No	Location	Owner	Active	Well Log	Year
GW269	39N/01E-28E02	INTALCO	N	Y	1965
GW270	39N/01E-28M01	UNICK, LOUIS	N	Y	1947
GW271	39N/01E-28M02	INTALCO	N	N	999
GW272	39N/01E-29B01	KYNELL, FRED	N	Y	1947
GW273	39N/01E-29B02	KYNELL, FRED	N	Y	1946
GW274	39N/01E-29J01	DAY, JAMES	N	Y	999
GW275	39N/01E-32H01	GODDARD, WILLIAM F.	N	N	999
GW276	39N/01E-32H02	TOSCO REFINERY	N	Y	1981
GW277	39N/01E-32J01	TOSCO REFINERY	N	Y	1981
GW278	39N/01E-33A01	THIESSEN, H.W.	N	Y	1941
GW279	39N/01E-33B01	TOSCO REFINERY	N	Y	1981
GW280	39N/01E-33D01	UNICK, ELLSWORTH	N	N	999
GW281	39N/01E-33E01	TOSCO REFINERY	N	Y	1981
GW282	39N/01E-33H01	GENERAL PETROLEUM	N	Y	999
GW283	39N/01E-33N01	TOSCO REFINERY	N	Y	1982
GW284	39N/01E-33P01	WARNER, D. E.	N	N	999
GW285	39N/01E-34A01	NORDTVEDT, THOMAS	N	Y	1946
GW286	39N/01E-34A03	DOMPE, DEANNA	N	Y	1992
GW287	39N/01E-34B01	FORHAN, CRAIG	N	Y	1991
GW288	39N/01E-34C01	TROUT, ROBERT	N	Y	1991
GW289	39N/01E-34K01	BENNETT, JULIE	N	Y	1993
GW290	39N/01E-34D03	HOFFMAN, E.	N	Y	1991
GW291	39N/01E-34E01	NEVINS, J.A.	N	Y	1935
GW292	39N/01E-34F01	RENNER, ROGER	N	Y	1991
GW293	39N/01E-34J01	ONEAL, MICHEAL	N	Y	1981
GW294	39N/01E-34J02	DEMEYER, ROBERT C.	N	Y	1987
GW295	39N/01E-34J03	PARFOMCHUK, STEVE	N	N	999
GW296	39N/01E-34M01	WEED, ERNIE III	N	Y	1992
GW297	39N/01E-34N01	BLUNT, LYNN	N	N	999
GW298	39N/01E-34N02	LYNN BLUNT	N	N	999
GW299	39N/01E-34P01	UNICK, LOUIS	N	N	999
GW300	39N/01E-34P03	PARK, DAN	N	Y	1980
GW301	39N/01E-34P05	EDINGER SWINE FARM	N	Y	1980
GW302	39N/01E-34Q02	JONES, GERALD	N	Y	1981
GW303	39N/01E-35A03	ENFIELD, PAUL	N	Y	1980
GW304	39N/01E-35C01	STILLWELL, IDELLA	N	N	999
GW305	39N/01E-35D02	WILSON, RUSSEL	N	Y	1991
GW306	39N/01E-35D03	O'NEAL, JON	N	Y	1991
GW307	39N/01E-35E01	AMUNDSON, RAY	N	Y	1973
GW308	39N/01E-35E02	LEVIEN, JOHN	N	Y	1987
GW309	39N/01E-35M01	FERGNSON, JIM	N	N	999
GW310	39N/01E-35N02	BUSCH, JOHN	N	Y	1992
GW311	39N/01E-36F01WS	UNKNOWN	N	N	999
GW312	39N/02E-17E01	UNKNOWN	N	N	999
GW313	39N/02E-17K01	UNKNOWN	N	N	999
GW314	39N/02E-17M01WS	UNKNOWN	N	N	999
GW315	39N/02E-17N01	UNKNOWN	N	N	999
GW316	39N/02E-17Q01	UNKNOWN	N	N	999
GW317	39N/02E-17Q02	UNKNOWN	N	N	999
GW318	39N/02E-17R01	UNKNOWN	N	N	999
GW319	39N/02E-18B01	UNKNOWN	N	N	999
GW320	39N/02E-18B02	UNKNOWN	N	N	999
GW321	39N/02E-18C01	BIDLINGTON, YESTER	N	Y	1974
GW322	39N/02E-18D01	UNKNOWN	N	N	999
GW323	39N/02E-18F01	UNKNOWN	N	N	999
GW324	39N/02E-18F02	UNKNOWN	N	N	999
GW325	39N/02E-18G01	UNKNOWN	N	N	999
GW326	39N/02E-18H01	UNKNOWN	N	N	999
GW327	39N/02E-18K01	UNKNOWN	N	N	999
GW328	39N/02E-18K02	UNKNOWN	N	N	999
GW329	39N/02E-18N01	UNKNOWN	N	N	999
GW330	39N/02E-19A01	FRY, W.	N	Y	1946
GW331	39N/02E-19B01	IVERSON, OLE	N	Y	1947
GW332	39N/02E-19C01	UNKNOWN	N	N	999
GW333	39N/02E-19E01	CENTRAL CITY WATER ASSOCIATION	N	Y	1970
GW334	39N/02E-19F01	ESTEP, JOHN W.	N	Y	1969
GW335	39N/02E-19G02	UNKNOWN	N	N	999

Lummi Nation Wellhead Inventory (December 2011)

Lummi No	Location	Owner	Active	Well Log	Year
GW336	39N/02E-19H01	TOWN OF FERNDALE	N	Y	1936
GW337	39N/02E-19H02	UNKNOWN	N	N	999
GW338	39N/02E-19H03	UNKNOWN	N	N	999
GW339	39N/02E-19H04	UNKNOWN	N	N	999
GW340	39N/02E-19H05	UNKNOWN	N	N	999
GW341	39N/02E-19H06	UNKNOWN	N	N	999
GW342	39N/02E-19K01WS	UNKNOWN	N	N	999
GW343	39N/02E-19L01	UNKNOWN	N	N	999
GW344	39N/02E-19M01	UNKNOWN	N	N	999
GW345	39N/02E-19N01	UNKNOWN	N	N	999
GW346	39N/02E-19P01	BOHN, H.E.	N	Y	1945
GW347	39N/02E-19Q02	TOWN OF FERNDALE	N	Y	1955
GW348	39N/02E-19Q03	UNKNOWN	N	N	999
GW349	39N/02E-20C01	HEGGEN, H	N	Y	1942
GW350	39N/02E-20F01	UNKNOWN	N	N	999
GW351	39N/02E-20F02	UNKNOWN	N	N	999
GW352	39N/02E-20G01	UNKNOWN	N	N	999
GW353	39N/02E-30C01	SCHOESSLER, JACOB	N	Y	1944
GW354	39N/02E-30C02	UNKNOWN	N	N	999
GW355	39N/02E-30C03	HUGHES, HOMER H.	N	Y	1970
GW356	39N/02E-30C04	HONG, GEORGE R.	N	Y	1969
GW357	39N/02E-30C05WS	CITY OF FERNDALE	N	Y	1994
GW358	39N/02E-30F01	NASSON, HAROLD	N	Y	1974
GW359	39N/02E-30F02WS	UNKNOWN	N	N	999
GW360	39N/02E-30K01	Mitch Knutson	Y	N	999
GW361	39N/02E-30L01	HARLAND, C.H.	N	Y	1942
GW362	39N/02E-30L03	UNKNOWN	N	N	999
GW363	39N/02E-31C02	UNKNOWN	N	N	999
GW364	39N/02E-31H01	PETERSON, FRANK M.	N	Y	1947
GW365	39N/01E-13D01	ALDER GROVE WATER ASSOCIATION	N	Y	1971
GW366	39N/01E-13D02	ALDER GROVE WATER ASSOCIATION	N	Y	1949
GW367	39N/01E-13H01WS	UNKNOWN	N	N	999
GW368	39N/01E-13Q01	THORTON WATER ASSOCIATION	N	Y	1951
GW369	39N/01E-14C01	UNKNOWN	N	N	999
GW370	39N/01E-14N01	UNKNOWN	N	N	999
GW371	39N/01E-14P01	NORTH STAR WATER ASSOCIATION	N	Y	1966
GW372	39N/01E-14P02	NORTH STAR WATER ASSOCIATION	N	Y	1950
GW373	39N/01E-14Q01	UNKNOWN	N	N	999
GW374	39N/01E-14Q02	WENDAL, JOE	N	Y	999
GW375	39N/01E-15B01	UNKNOWN	N	Y	999
GW376	39N/01E-15B02	LAKE TERRELL WATER ASSOCIATION	N	Y	1970
GW377	39N/01E-15L01	UNKNOWN	N	N	999
GW378	39N/01E-16C01	UNKNOWN	N	N	999
GW379	39N/01E-17A01	UNKNOWN	N	N	999
GW380	39N/01E-17K01	UNKNOWN	N	N	999
GW381	39N/01E-17M01	UNKNOWN	N	N	999
GW382	39N/01E-17Q01	UNKNOWN	N	N	999
GW383	39N/01E-18E01	G.N. RAILROAD	N	Y	1944
GW384	39N/01E-18Q01	UNKNOWN	N	N	999
GW385	39N/01E-19D01	UNKNOWN	N	N	999
GW386	39N/01E-19H01	UNKNOWN	N	N	999
GW387	39N/01E-20H01	UNKNOWN	N	N	999
GW388	39N/01E-20M01	UNKNOWN	N	N	999
GW389	39N/01E-24B01	UNKNOWN	N	N	999
GW390	39N/01E-24C01	UNKNOWN	N	N	999
GW391	39N/01E-24D01	UNKNOWN	N	N	999
GW392	39N/01E-24H01	UNKNOWN	N	Y	999
GW393	39N/01E-24J01	UNKNOWN	N	N	999
GW394	39N/01E-24P01	UNKNOWN	N	N	999
GW395	39N/01E-24R01	MOSTROM, A.	N	Y	999
GW396	38N/01E-04M03	DAWSON, MARLENE	Y	Y	1996
GW397	38N/01E-05	MAYHEW, FRANCES	N	N	999
GW398	38N/01E-23A01	CURRAN, TROY	N	Y	1995
GW399	38N/01E-23A02	CURRAN, TROY	N	Y	1995
GW400	38N/01E-26M03	BOYD, JERRY	N	Y	1997
GW401	38N/01E-26M04	EDWARDS, FRANCIS	Y	Y	1997
GW402	38N/01E-05H06	KEATON, PAUL	Y	Y	1997

Lummi Nation Wellhead Inventory (December 2011)

Lummi No	Location	Owner	Active	Well Log	Year
GW403	38N/01E-23L01	MADSEN, EVERETT	Y	Y	1998
GW404	38N/01E-23L02	CORNING, BILL	Y	Y	1998
GW405	38N/01E-35N01	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1998
GW406	38N/01E-34R02	GOOSEBERRY POINT WATER ASSOC.	Y	Y	999
GW407	38N/01E-24P01	LUMMI INDIAN BUSINESS COUNCIL	N	Y	999
GW408	38N/01E-05A10	DUKE, MIKE	Y	Y	999
GW409	38N/01E-26K01	LUMMI INDIAN BUSINESS COUNCIL	Y	Y	1999
GW410	38N/01E-25L01	NIELSON BROTHERS	Y	Y	999
GW411	38N/01E-25L02	NIELSON BROTHERS	Y	Y	999
GW412	38N/01E-03C01	PAMEROY, FRANK	Y	Y	1990
GW413	38N/01E-05R04	TEETER, THERESA	Y	Y	1999
GW414	38N/01E-14Q04	KNIGHT, TERRY	N	Y	2000
GW415	38N/01E-14Q05	TEMPLE, JAMES K	N	Y	2000
GW416	38N/01E-34K05	MERHAUT, ROB	N	Y	2000
GW417	38N/01E-04F01	LUMMI INDIAN BUSINESS COUNCIL	N	Y	2001
GW418	38N/01E-04F02	LUMMI INDIAN BUSINESS COUNCIL	Y	Y	2001
GW419	38N/01E-34Q02	GOOSEBERRY POINT WATER ASSOC.	Y	Y	2001
GW420	38N/01E-34K06	GOOSEBERRY POINT WATER ASSOC.	Y	Y	2001
GW421	38N/01E-26K02	LUMMI INDIAN BUSINESS COUNCIL	N	Y	2001
GW422	38N/01E-35N02	LUMMI INDIAN BUSINESS COUNCIL	N	Y	2001
GW423	37N/01E-02Q14	BARTEL, DALE	Y	N	1996
GW424	38N/02E-19L05	HOLLAND, MARK	Y	N	999
GW425	38N/01E-34P02	DEGRUUF, PAUL	N	N	1988
GW426	38N/01E-34Q03	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1997
GW427	38N/01E-34Q04	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1997
GW428	38N/01E-34Q05	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1997
GW429	38N/01E-34Q06	LUMMI INDIAN BUSINESS COUNCIL	N	Y	1997
GW430	38N/01E-05A11	CONSTANTINE, PIERRE R	Y	Y	2002
GW431	38N/01E-14P01	NORTHWEST INDIAN COLLEGE	N	Y	2002
GW432	38N/01E-14P01D1	NORTHWEST INDIAN COLLEGE	N	Y	2002
GW433	38N/01E-23D01	NORTHWEST INDIAN COLLEGE	N	Y	2002
GW434	38N/01E-14K01	Lummi Indian Business Council	Y	Y	2005
GW435	38N/01E-05A12	Mike Marks	Y	Y	2003
GW436	38N/01E-05A13	Brian Sigurdson	Y	Y	2005
GW437	38N/01E-05A14	Jay and Sue Fjellman	Y	Y	2005
GW438	38N/01E-05R05	Don Finkbonner	Y	Y	2002
GW439	38N/01E-03B01	Grouse Ridge Holding	Y	Y	2005
GW440	38N/01E-27R07	David and Ruth Snead	Y	Y	2004
GW441	38N/01E-03C01	LUMMI INDIAN BUSINESS COUNCIL	Y	Y	2008
GW442	39N/01E-34D04	Kinder-Morgan	N	Y	2007
GW443	38N/02E-19L01	Michael Johnson	Y	N	999
GW444	38N/02E-19L02	Larry Beghoff	Y	N	999
GW445	37N/01E-02Q01	Jerome Vandenbroucke	Y	N	999
GW446	38N/01E-24B01	Art Howell	N	Y	2010

APPENDIX B

Delineation of Watershed Boundaries from 2005 LiDAR Bare Earth Sample Points

LUMMI INDIAN BUSINESS COUNCIL
2616 KWINA ROAD · BELLINGHAM, WASHINGTON 98226 · (360)384-1489

MEMORANDUM

DATE: October 8, 2010

TO: Jeremy Freimund, P.H., Water Resources Manager

FROM: Gerald Gabrisch, Geographic Information System Manager

SUBJECT: **Delineation of Watershed Boundaries of the Lummi Indian Reservation from 2005 LiDAR Bare-Earth Sample Points**

Purpose:

This memorandum details the methods and results of a Geographic Information Systems (GIS)-based analysis conducted to delineate watershed boundaries for those lands that contribute to overland flow on the Lummi Indian Reservation (Reservation). This watershed delineation utilized Light Distance and Ranging (LiDAR) bare-earth sample point data collected by Terrapoint USA Inc. (Terrapoint) in 2005. Pursuant to our discussion, the resulting watershed delineations will serve as the 'best available' GIS dataset of watersheds for the Reservation, and replace the 1998 watershed delineations developed through a manual interpretation of United States Geological Survey (USGS) 7.5 minute topographic maps (20-foot contour intervals) coupled with the results of a storm water facilities inventory (LWRD, 1998).

Data:

The data used for this watershed delineation include the following:

- XYZ text files of LiDAR bare-earth sample point data collected by Terrapoint in 2005;
- Lummi Nation GIS data of surface water hydrography including stream channels and agricultural irrigation/drainage ditches;
- On-Reservation storm water facility point locations collected by the Lummi Water Resources Division;
- Off-Reservation storm water facilities point location data collected by the Lummi Water Resources Division and/or Whatcom County; and
- Storm water facilities and catchment boundaries of the City of Ferndale (Ferndale) provided by the Ferndale Public Works Department.

All data were re-projected to the North American Datum of 1983, Washington State Plane North (NAD83WaSPN) coordinate system prior to analysis to conform to the datum, projection, and coordinate

system of the LiDAR data. All x and y coordinate values are measured in feet. All elevation values (z coordinates) represent feet above the North American Vertical Datum of 1988 (NAVD 88).

Methods:

Text files containing the x, y, and z values of individual LiDAR bare-earth sample points were used to construct an ESRI ArcGIS terrain data model. The resulting terrain model is a single continuous elevation surface model over the extent of the LiDAR collection area. Because this terrain data model cannot be used for hydraulic modeling, the data were subsequently transformed into ESRI Grid (raster) surface models. A total of eight ESRI Grid surface models were created using five different pixel sizes and two different interpolation methods available in the ArcGIS v 9.3 software package (Table 1). To reduce file sizes and speed computer processing time, each Grid surface model was clipped to only include the Reservation areas upland of the tidal vegetation line.

The areas covered by the catchment boundaries of Ferndale were also excluded from the GIS analysis because the natural flow regime within the Ferndale residential and commercial core area is altered by a network of storm water facilities. Additionally, since an extensive body of data was provided by the City of Ferndale including flow directions of storm sewers, outlet locations, and catchment boundaries, the Ferndale data were considered higher quality than the LiDAR/GIS analysis performed for this study for those areas.

Table 1. Surface model cell resolutions and interpolation methods.

Raster Grid Resolution/Cell Size	Interpolation Method	Used For Watershed Delineation
30-feet	Linear	Yes
30-feet	Natural Neighbors	Yes
6-feet	Linear	No
6-feet	Natural Neighbors	No
3-feet	Linear	Yes
3-feet	Natural Neighbors	Yes
1-foot	Linear	No
0.5-foot	Linear	No

Different raster cell sizes and different interpolation algorithms used to generate the raster surface models resulted in different watershed delineations. To assess the quality of the different surface models listed in Table 1, a root mean square error (RMSE) calculation was preformed on each dataset to determine which raster surface had the highest accuracy and therefore would likely result in the highest quality watershed delineation. The RMSE value determines the standard deviation for the interpolated pixel values of the surface model and the values of known surveyed locations (Equation 1)(Wu et al., 2008). The greater the RMSE, the less accurate the model.

Additionally, the RMSE value was generated for a 10-meter pixel USGS surface model for comparison. The surveyed sample points used for the RMSE included 50 locations where the land surface elevation had been determined using professional field survey techniques by Pacific Survey and Engineering and 13 locations surveyed by TerraPoint. Table 2 shows the RMSE values for each surface model.

Equation 1. Root Means Square Error equation to determine the difference in standard deviations (in feet) between the interpolated cell values and the surveyed point elevation values.

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(x_{1,i} - x_{2,i})^2}{n}}.$$

Where X_1 represents the interpolated pixel value at the location of X_2, X_2 is the surveyed elevation value, and n represents the total count of surveyed locations.

Table 2. Root Mean Square Error values showing the standard deviation in feet between the interpolated pixel value and the value at a surveyed location coincident to the interpolated cell.

Surface Model Resolution	Interpolation Method	RMSE (feet)
USGS 10-meter	Unknown	6.583
30-feet	Linear	1.478
30-feet	Natural Neighbors	1.473
6-feet	Linear	1.393
6-feet	Natural Neighbors	1.388
3-feet	Linear	1.393
3-feet	Natural Neighbors	1.387
1-foot	Linear	1.390
0.5-foot	Linear	1.469

The 3-feet grid, natural neighbors interpolation model was selected for the watershed delineation process based on the RMSE values and the available computer processing capabilities. The 1-foot and the 0.5-foot surface models were excluded from the watershed delineation process because the RMSE was similar to the 3-feet grid surface models and the file sizes were too large to process using available desktop computer processors. The surface models using the 6-feet grid cell size were excluded because the RMSE values were nearly identical to the 3-feet RMSE, which better captures elevation heterogeneity through increased cell resolution. The 30-feet and the 10-meter surface models were not used because the RMSE was larger than the surface models developed using the 3-feet grid cell size.

The LiDAR technology cannot capture the flow path of storm water facilities underneath roads because those flow paths are blocked from the aerial view of the LiDAR collection system. To enforce hydrologic connectivity in those areas traversed by raised road beds, 'culvert burning' was used to establish flow paths through storm water facilities (Duke, 2003). The point data of storm water facility locations collected by the Lummi Nation Water Resources Division and Whatcom County were combined into a single dataset of storm water facilities. A 50-feet buffer polygon around each storm water facility was created to sufficiently span the width of the raised road beds. The resulting storm water facility buffers were converted to a 3-feet raster Grid surface model and assigned an elevation value equal to the minimum value of the entire LiDAR dataset. The pixel values of the storm water facility grid were used to computationally replace the coincident pixels in the surface models, thereby establishing a connective flow path across the "obstruction" created by the raised road beds.

The hydrography vector lines were manually edited to ensure that for each individual line segment the line direction of flow matched the direction of flow detailed in the Lummi Nation Storm Water Facilities Inventory. The ESRI ArcHydro geoprocessor cannot calculate flow directions in a network of looping flow

paths, for example braided streams or interconnected drainage ditches(Maidment, 2002). For this reason, some hydrography lines had their uphill node disconnected from the network of flow paths to ensure that no flow lines formed closed loops.

The resulting 'culvert burn' surface model and the non-looping hydrography data set were imported into an ArcGIS/ArcHydro geodatabase. The ArcHydro database allowed the stream network (hydrography) to be 'burned' into the surface models, enforcing flow connectivity based on the configuration of the stream network (Maidment, 2002). The resulting hydrologically corrected surfaces were filled using the ArcGIS *fill* function to remove sinks and obstructions from the surface models that might impede the analysis.

The filled surface models were used to generate flow direction surfaces detailing the flow direction from each cell to one of its eight adjacent neighbors (Figure 1). The flow direction surfaces were then used to generate a flow accumulation surface where the numeric value of each pixel represents the total count of individual cells that flow into that cell (Figure 2). The flow accumulation surfaces were used to generate watershed boundaries where all cells that share a "pour point" are assigned a unique nominal numeric value (Figure 3). The basin output was transformed from its grid format into a polygon data structure.

Upon a manual inspection of the Ferndale storm water facility outfall, all Ferndale catchment polygons that contributed to overland water flow onto the Reservation were added to the polygons of basins.

Finally, the polygon data were manually aggregated into watersheds to mimic those watersheds delineated in 1998 based on the 7.5 minute USGS topographic maps (LWRD, 1998).

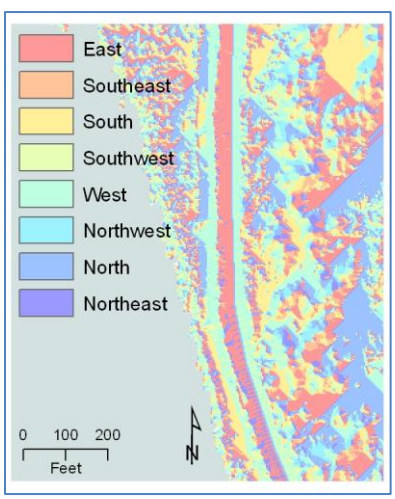

Figure 1. A typical flow direction surface. Each cell stores a numeric value detailing the flow direction in one of eight cardinal directions.

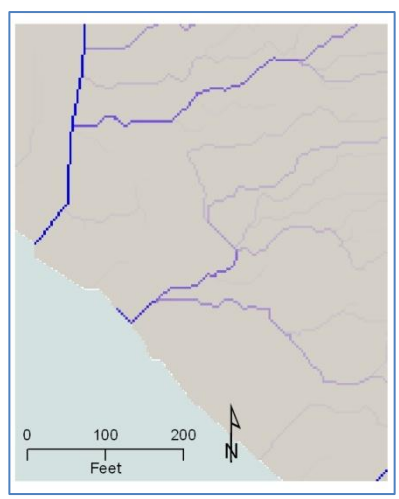

Figure 2. A typical flow accumulation surface; each cell stores the count of cells that pour into that cell. Higher cell counts are displayed as a darker blue. Coloration does not necessarily indicate a perennial or seasonal stream.

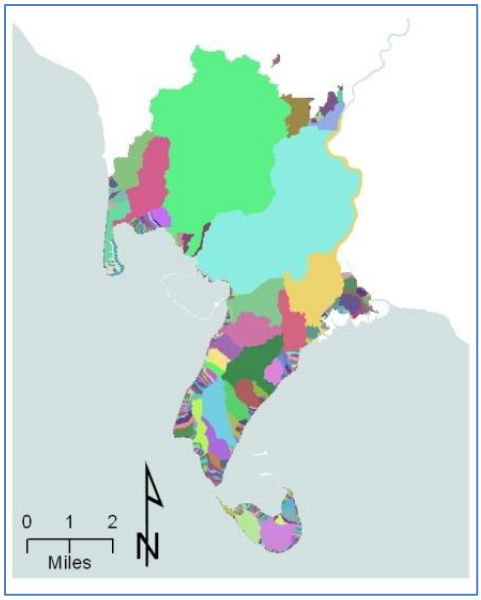

Figure 3. Resulting basin boundaries; each color represents an area that is hydrologically connected. (Catchments are not aggregated into Watersheds and City of Ferndale catchments were not incorporated into this figure.)

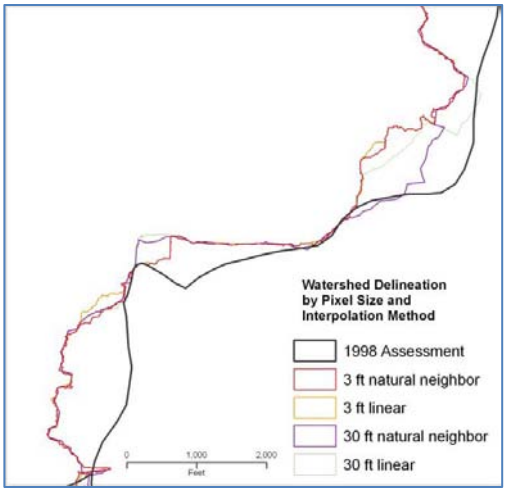

Figure 4. Detail showing the resulting watershed delineations based on different pixel cell sizes and interpolation methods compared with the 1998 topographic map delineation.

Results:

In the coarser surface models, for example in the 30-feet pixel surfaces, the value of the cell is the average value of all LiDAR points that fall within that cell. When the pixel size is larger than the density of the sample points, the RMSE should increase since the surface model is relying more heavily on the interpolation algorithm and therefore more prone to over-estimations and under-estimations(Aguilar, 2006). Because the 3-feet grid, natural neighbor interpolation surface model resulted in the lowest RMSE and provided the highest resolution surface that could be processed with available computers, the 3-feet natural neighbor model was selected as the best available surface from which to generate watershed boundaries. Figure 4 highlights some of the different catchment lines resulting from different pixel sizes and different interpolation algorithms.

Figure 4 demonstrates that given the same elevation sample data, different catchment boundaries will be calculated based on differences in pixel resolution (i.e., cell size). While the 3-feet raster resulted in the highest quality surface model, the catchments generated by this surface model are affected by error introduced in the LiDAR sampling and post processing, the data models, and the assumptions incorporated into the GIS functions and methods. The user of these data should be aware of the inherent abstraction of spatial data when making policy decisions. More extensive field surveys and sampling may be required to confirm/verify the delineated catchment boundaries.

Figure 5 shows the 1998 watershed boundaries developed from the USGS topographic maps compared to the watershed boundaries developed from the LiDAR data. As shown in Figure 5, the boundaries are generally similar with a few notable exceptions.

Table 3 shows a comparison of the 1998 delineation and the 2005 LiDAR-based delineation that resulted from this study. Approximately 933 acres were added to all watersheds that contribute overland flow to the Reservation. Two watersheds from the 1998 delineation (Watershed M and Watershed N) were discontinued. Watershed M was a small isolated island located at the mouth of the Lummi River channel and the Lummi River channel downstream from the Schell Creek confluence and waterward of the levees along the channel. This watershed was combined with Watershed L. Watershed N was combined with Watershed O as the LiDAR delineations did not identify these areas as separate catchments. Watershed T is a newly delineated watershed that isolates a portion of Watershed K from the 1998 delineation. Watershed S includes the entire Nooksack River drainage area, a vast majority of which is not covered by the 2005 LiDAR data. Although most of Watershed S extends off-Reservation and beyond the geographic scope of the LiDAR data, the LiDAR data were used to delineate the western extent of Watershed S on the Reservation. The acreage for Watershed S listed in Table 3 is the acreage total reported by the WRIA 1 Watershed Management Project (www.wria1project.whatcomcounty.org).

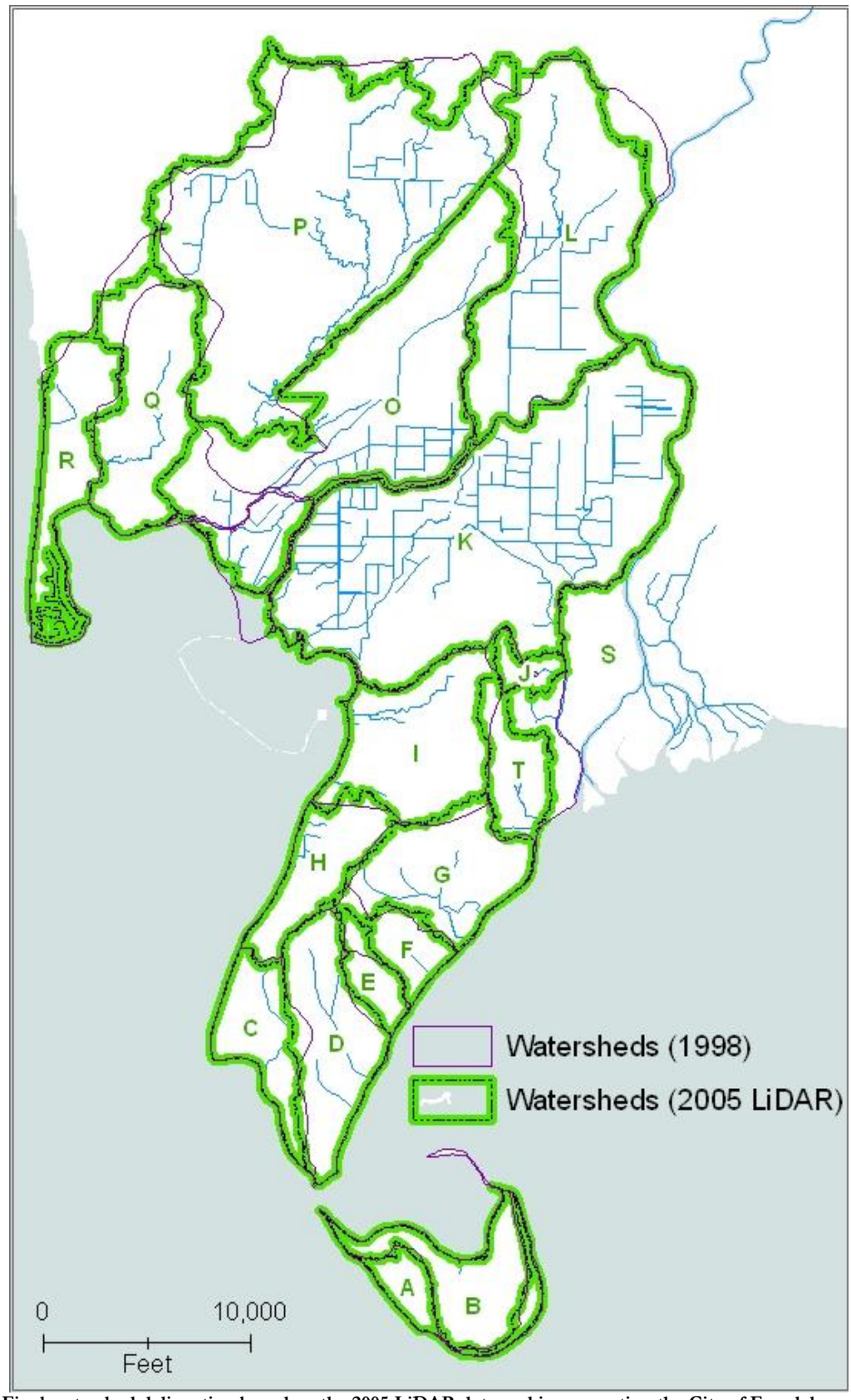

Figure 5. Final watershed delineation based on the 2005 LiDAR data and incorporation the City of Ferndale catchment boundaries.

Table 3. Watershed identifiers and acreage total comparisons between the 1998 delineation and the 3-feet natural neighbors surface model.

Watershed ID	Stream Name	1998 7.5 min Topographic Map Delineations (acres)	2005 LiDAR Delineations (acres)	Difference in Watershed Area (acres)	Difference in Watershed Area (percent difference)
A	Unnamed	306.8	279.7	-27.1	-9.7
B	Unnamed	633.9	616.7	-17.2	-2.8
C	Unnamed	583.3	493.8	-89.5	-18.1
D	unnamed	797.5	894.4	96.9	10.8
E	unnamed	183.2	218.3	35.1	16.1
F	unnamed	326	250.8	-75.2	-30.0
G	unnamed	836.1	883.3	47.2	5.3
H	unnamed	537.3	549	11.7	2.1
I	unnamed	1,142.3	1,058.9	-83.4	-7.9
J	unnamed	86.8	134.2	47.4	35.3
K	Smuggler Slough	4,696.50	4,091.1	-605.4	-14.8
L	Lummi River	2,384.0	2,306.5	-77.5	-3.4
M	unnamed	198.1	combined with Watershed L	n/a	n/a
N	unnamed	333.4	combined with Watershed O	n/a	n/a
O	Schell Creek/Northern Distributary of the Lummi River	1,964.3	2,746.8	782.5	28.5
P	Jordan Creek	4,228.9	4,097.1	-131.8	-3.2
Q	Onion Creek	1,291.7	1,096.4	-195.3	-17.8
R	unnamed	1,023.8	721.8	-302	-41.8
S	Nooksack River	517,718 (WRIA1 area)	south western extent of watershed only	n/a	n/a
T	unnamed	extracted from Watershed K	392.46	n/a	n/a
Total		21,553.9	22,486.7	932.5	4.2

Conclusions:

Using the 2005 Terrapoint LiDAR bare-earth point data, digital terrain models (DTMs) were developed using several grid cell sizes and interpolation methods. A root square mean analysis was used to identify the surface model with elevation values most similar to professionally surveyed control points. A 3-feet natural neighbor interpolation DTM was identified as the surface model with the highest level of precision and that had pixel sizes that were large enough to be manageably analyzed using available computer resources.

The 3-feet natural neighbor DTM was incorporated into an ESRI ArcGIS 9.3 ArcHydro geodatabase along with point data of storm water facilities, and line data of known stream channels and agricultural drainage ditches. The storm water data and surface water hydrography data were used to enforce hydrologic connectivity by computationally breaching LiDAR artifacts such as bridges or culvert passages under roads.

The hydrologically corrected surface model was analyzed using standard GIS procedures including sink filling, identifying flow directions, calculating flow accumulations, and generating basin boundaries to identify the basin boundaries. The final basin boundaries were combined into watershed administrative units based on the watershed units developed as part of the 1998 watershed delineation (LWRD, 1998).

The final watershed boundaries developed from the 2005 LiDAR data resulted in a 584-acre gain (or 4.2 percent increase) in area from the original 1998 delineation. Watershed M from the 1998 delineation was incorporated into Watershed L, Watershed N was incorporated into watershed O, and one new watershed (Watershed T) was added based on the refinement made possible with the 2005 LiDAR data. Watershed S includes those lands that contribute overland-flow to the Nooksack River. Because the 2005 LiDAR coverage does not include the entire Nooksack River basin, only the southwestern extent of Watershed S was determined as part of this analysis. The remainder of the Watershed S boundary was determined as part of the WRIA 1 Watershed Management Project and these results were adopted to estimate the acreage associated with the Nooksack River watershed.

The final dataset was loaded onto the Lummi Nation GIS data server and metadata was created. The final data detailed in this report is available at *Z:\Data\Boundaries\Watersheds\LummiWatershedsBestAvailable.shp*.

References:

Aguilar, F. J., Aguilar, Manuel A., Aguera, Francisco, Sanchez, Jaime. (2006). The accuracy of grid digital elevation models linearly constructed from scattered sample data. *International Journal of Geographical Information Science, 20*(2), 169-192.

Duke, G. D., Kienzel, S. W., Johnson, D. L., Byrne, J.M. (2003). Improving overland flow routing by incorporating ancillary road data into Digital Elevation Models. *Journal of Spatial Hydrology, 3*(2), 26.

Lummi Water Resources Division (LWRD). 1998. Lummi Reservation Storm Water Management Program Technical Background Document. Prepared for Lummi Indian Business Council. Lummi Reservation, Washington. December.

Maidment, D. (2002). *ArcHydro, GIS for Water Resources*. Redlands, Ca: ESRI Press.

Wechsler, S. P. (2007). Uncertainties Associated With Digital Elevation Models for Hydrologic Applications. *Hydrology and Earth System Sciences., 11*, 1481-1500.

Wu, S., Li, J., Huang, G. (2008). Characterization and Evaluation of Elevation Data Uncertainty in Water Resource Modeling. *Water Resources Management*, 959-972.

APPENDIX C

Lummi Tribal Sewer and Water District 2010 Consumer Confidence Report

Lummi Tribal Sewer and Water District-
Gooseberry Pt. Water System #105300002
2010 Consumer Confidence Report

Is my water safe?
Last year, as in years past, your tap water met all U.S. Environmental Protection Agency (EPA) drinking water parameters. The Lummi Tribal Sewer and Water District (LTSWD) safeguards it water supplies and once again we are proud to report that our system has not violated a maximum contaminant level. This report is a snapshot of last year's water quality. Included are details about where your water comes from, what it contains, and how it compares to standards set by regulatory agencies. We are committed to providing you with information because informed customers are our best allies.

Do I need to take special precautions?
Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/Centers for Disease Control (CDC) guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Water Drinking Hotline (800-426-4791).

Where does my water come from?
Local sources of water are wells that pump from an aquifer under the Lummi Nation Reservation. Lummi Tribal Sewer and Water occasionally purchases treated water from the City of Bellingham. Bellingham obtains its water from Lake Whatcom. Results from Bellingham's Consumer Confidence Report are included in this report

Source water assessment and its availability
Both the city of Bellingham and the Lummi Tribal Sewer and Water District conduct multiple analyses of water quality from the sources and distribution systems. Every effort is made to protect the quality of drinking water and provide customers with safe and reliable water.

Why are there contaminants in my drinking water?
Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's (EPA) Safe Drinking Water Hotline (800-426-4791). If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. Lummi Tribal Sewer & Water District is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to two minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline or at www.epa.gov/safewater/lead. (From National Primary Drinking Water Regulations Part 141.154, in the section called "Required Additional Health Information")

Where can I get more information?
Please contact Lummi Tribal Sewer and Water District at 360-758-7167, if you have any questions about water quality or utility operations.

Monitoring and reporting of compliance data violations
All monitoring and reporting requirements were met for 2010.

Variance and Exemptions
None

Water Quality Data Table

The table below lists all of the drinking water contaminants that we detected during 2010. The presence of contaminants in the water does not necessarily indicate that the water poses a health risk. The EPA requires us to monitor for certain contaminants less than once per year because the concentrations of these contaminants do not change frequently. Some of the data below is from tests conducted by the City of Bellingham.

Contaminants	MCLG or MRDLG	MCL, TT, or MRDL	Your Water	Range Low	Range High	Sample Date	Violation	Typical Source
TTHMs [Total Trihalomethanes] (ppb)	NA	80	18.6	0.9	14.0	2010	No	By-product of drinking water disinfection
Inorganic Contaminants								
Arsenic (ppb)	0	10	0.005	0.004	0.006	2010	No	Erosion of natural deposits; Runoff from orchards; Runoff from glass and electronics production wastes
Barium (ppm)	2	2	0.042	0.007	0.052	2010	No	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits
Fluoride (ppm)	4	4	0.76	0.1	1.4	2010	No	Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories
Nitrate [measured as Nitrogen] (ppm)	10	10	2.09	0.2	3.09	2010	No	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits
Sodium (optional) (ppm)		MPL	26.9	24.8	32.9	2010	No	Erosion of natural deposits; Leaching

Contaminants	MCLG	AL	Your Water	Sample Date	# Samples Exceed AL	Exceeds AL	Typical Source
Inorganic Contaminants							
Copper-action level at consumer taps (ppm)	1.3	1.3	.076	2007	0	No	Corrosion of household plumbing systems; Erosion of Natural deposits
Lead-action level at consumer taps (ppb)	0	15	.002	2007	0	No	Corrosion of household plumbing systems; Erosion of Natural deposits
Microbiological Contaminants							
Total Coliform (positive samples/month)	0	1	1	NA	2010	No	Naturally present in the environment
Turbidity (NTU) 100% of the samples was below the TT value of 0.5 (NTU) A value less than 95% constitutes a TT violation. The highest single measurement was 0.09. (NTU)					2010	No	Soil runoff
Radioactive Contaminants							
Alpha emitters (pCi/L)	0	15	ND		2010	No	Erosion of natural deposits
Beta/photon emitters (pCi/L)	0	50	4.48		2010	No	Decay of natural and man-made deposits. The EPA considers 50 pCi/L to be the level of concern for Beta particles.

Unit Descriptions

Term	Definition
ppm	ppm: parts per million, or milligrams per liter (mg/L)
ppb	ppb: parts per billion, or micrograms per liter (µg/L)
pCi/L	pCi/L: picocuries per liter (a measure of radioactivity)
NTU	NTU: Nephelometric Turbidity Units. Turbidity is a measure of the cloudiness of the water. We monitor it because it is a good indicator of the effectiveness of our filtration system.
Positive samples/month	Positive samples/month: Number of samples taken monthly that were found to be positive
NA	NA: not applicable
ND	ND: Not detected
NR	NR: Monitoring not required, but recommended.

Important Drinking Water Definitions

Term	Definition
MCLG	MCLG: Maximum Contaminant Level Goal: The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
MCL	MCL: Maximum Contaminant Level: The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.
TT	TT: Treatment Technique: A required process intended to reduce the level of a contaminant in drinking water.
AL	AL: Action Level: The concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.
Variances and Exemptions	Variances and Exemptions: State or EPA permission not to meet an MCL or a treatment technique under certain conditions.
MRDLG	MRDLG: Maximum residual disinfection level goal. The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
MRDL	MRDL: Maximum residual disinfectant level. The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
MNR	MNR: Monitored Not Regulated
MPL	MPL: State Assigned Maximum Permissible Level

Violations and Exceedances

None

For more information please contact:

Liam Carnahan P.E., District Manager
Lummi Tribal Sewer and Water District
2156 Lummi View Dr.
Bellingham, WA 98226
(360) 758-7167