

Groundwater Monitoring for Nitrates in the Rural Areas of Clallam County, Washington

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December 2008
Updated August 2009

Primary funding for this study was provided by Centennial Clean Water Fund grant no. G0500025 from Washington Department of Ecology with matching funds from Clallam County.

Summary

In 2006, Clallam County Environmental Health Services (EHS) prepared a Quality Assurance Project Plan for monitoring groundwater in relatively undeveloped regions of Clallam County, Washington. The purpose of the project was to investigate groundwater quality in areas not before studied. Sampling was conducted between early 2007 and September 2008 in four designated areas. Thirty-three wells were purged, measured for field parameters, and sampled for nitrates and bacteria. All nitrate and bacteria analyses were performed by an accredited laboratory.

Nitrate results indicate that groundwater quality is generally excellent in the four rural regions studied relative to the drinking water standard of 10 ppm (there were no exceedances). However, seven of 33 wells tested (21%) contain nitrates at or above 1 mg/L, the level considered to indicate human-caused degradation. The maximum level measured was 2.19 mg/L and the median was 0.6 mg/L. Nitrates are mapped in figures found in the Appendix; complete field and lab results are presented in Table 2.

In addition collecting nitrate data via scientific protocols described in the QAPP, EHS staff researched nitrate results submitted to Clallam County Environmental Health by building permit applicants. These data generally corroborate scientifically-obtained data for all study regions.

The finding of several nitrate concentrations slightly elevated above natural levels highlights the importance of protecting rural Clallam County's relatively uncontaminated groundwater quality. Nitrate contamination is generally considered "non-point source pollution" because sources may be multiple

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and diffuse, including sewage, animal waste, inorganic fertilizers, and potentially acid rain. Non-point pollution is by nature difficult to identify and remediate. Recommended actions for protecting groundwater quality from further degradation include identifying and repairing inadequate well seals, continuing inspections of farms and on-site septic systems, and educating residents on groundwater quality protection measures.

Background and Problem Statement

The grant obtained by Clallam County for this rural groundwater quality study addresses the need for current surface and ground water quality data County-wide, and the need for outreach with interpreted results.² Grant Task 2 involves two groundwater studies: one on rural areas (the subject of this report) and the other on high nitrates found in the Agnew community. Grant Task 3 involves two stream water quality studies. Grant Task 4 involves various outreach and education activities.

The objectives of the monitoring pertinent to this report were to provide a baseline snapshot of groundwater quality as represented by nitrate concentrations in areas of the County that have not previously been studied – but which are susceptible based on soils and land use. To achieve this objective, nitrate monitoring was conducted County-wide in four areas not previously studied.

The hydrogeology of Miller Peninsula, at the east end of the County, includes fairly continuous aquifers and confining layers with a northward dip and generally northward-flowing groundwater, following the description of the Dungeness watershed but without substantial recharge from a river such as the Dungeness (AES 1991). From Port Angeles to the Pacific Ocean, aquifers are much less substantial in depth and breadth, and water supplies are generally developed in relatively thin alluvial deposits overlying bedrock (Golder 2005), or bedrock fractures. These sources often provide enough water for incidental development, but rarely in quantities sufficient to supply a large community.

Nitrate is an indicator of groundwater contamination from various sources, including on-site sewage, commercial or residential fertilizers, and manure. The Washington State Department of Health has established a 10 mg/L drinking water standard (Maximum Contaminant Level or MCL) for nitrate-N in public water supply systems (Chapter 246-290 WAC). The criterion for nitrate-N in the Washington State Water Quality Standards for Ground Waters (Chapter 173-200 WAC) is also 10 mg/L.

Methods

The field portion of this study involved collection of groundwater samples from four distinct rural areas within Clallam County by EHS staff (Ann Soule) in 2007 and Northwestern Territories Inc. (Bill Payton) in 2008. The four regions include:

1. LaPush–Beaver
2. Sekiu–Clallam Bay
3. Joyce–Port Angeles
4. Miller Peninsula

The process of identifying potential study sites involved three newspaper press releases, email solicitation within the County institution, and the well log database at Ecology’s web site. In areas

² Ecology Centennial Clean Water Fund Grant no. G0500025, County-Wide Monitoring

where there were no well owners volunteering to participate we researched the state database for potential study wells; however, it was often difficult to confirm current ownership of wells matching older well logs found in the state database. In addition, some areas with no volunteering participants (especially the Sekiu–Clallam Bay region) are served by public water systems with few or no private wells in existence.

Study participants were confirmed via mail or over the phone prior to the first visit to each well. Table 1 lists construction information for all study sites; note that two sites are springs rather than wells.

For each study site, field staff located the well and elevation on aerial photos and Lidar, purged well water, measured field parameters, and collected samples according to the Quality Assurance Project Plan approved by Ecology (Soule 2006). Field measurements included static water level (when possible), groundwater temperature, pH, dissolved oxygen, and conductivity/specific conductance.

All nitrate samples were kept cool prior to analysis of nitrate-N at Clallam County Environmental Health Drinking Water Laboratory (CCEH Lab, using SM 4500-NO₃-D), or nitrate-N at Twiss Analytical Laboratories for 2 wells (using EPA 300.0). Bacteria samples were collected in bottles containing 10% sodium thiosulfate to reutilize any chlorine, and were kept cool prior to submittal to CCEH Lab for analyses of total coliform and E. coli (using Colilert 9223).

In addition to the field investigation, an analysis of nitrate data from the County’s database of development permit information was also conducted for the study period (Jan. 2006–Sept. 2008). In order for County approval of a building permit where the water source is a private well, the applicant is required to submit proof of potable water. This includes results of a well water nitrate test from an accredited laboratory. A results summary for this analysis is presented in the next section.

Results and Discussion

Nitrates

Nitrate results for 33 study sites are presented in Table 2. The nitrate-as-Nitrogen concentrations range from “not detected” to 2.19 mg/L, with a median of 0.6 mg/L. Figures in the Appendix illustrate the geographic distribution of nitrate concentrations in the four regions studied.

Seven sites (21%) have nitrates above 1 mg/L, the level above which is rarely natural, generally indicating that human activities have impacted groundwater quality. The trigger level for nitrates is 5 mg/L, above which more frequent testing (at least once per year) is recommended for nitrate and bacteria. Concentrations greater than 10 mg/L exceed the federal MCL (“Maximum Contaminant Level”) and an alternative source of drinking water should be obtained.

Nitrate concentrations within aquifers change from season to season and time to time, depending on the concentration, timing, and volume of contamination entering the aquifer; the aquifer media (clay, sand, etc.); chemical characteristics; and potential for dilution. The activities causing the contamination may be nearby or distant, as nitrates are very soluble and remain relatively unchanged as groundwater moves in the aquifer. The significance of a high level of nitrate, besides the health impact, is the indication that contamination from land activities has reached groundwater used for drinking, and therefore other contaminants from the same activities could also be present and ingested. For example, if the source of nitrogen is applied fertilizer then chemicals applied to the same ground could potentially be present. Similarly, if the source is septic effluent then other substances found in domestic waste such as bacteria or pharmaceuticals could be present.

Specific results for the four rural areas studied follow. In the LaPush–Beaver area, five of six wells sampled showed no evidence of nitrate contamination, and the sixth well, at 1.5 mg/L, is at the threshold of indicating human impact but far below the trigger level of 5 mg/L (shown on page A.1). The one well sampled near Sekiu–Clallam Bay had no detectable nitrates (page A.2). Of 24 sites sampled in the Joyce–Port Angeles region, one exceeded 2 mg/L, indicating that land activities have influenced shallow groundwater quality (this site was a 10’ deep spring); four samples were between 1 and 2 mg/L (page A.3). Finally, in the Miller Peninsula area, both wells sampled had less than 1.5 mg/L (page A.4).

After field sampling was complete, staff analyzed County building permit database records of nitrates for the study period (2006-2008). The following table summarizes both the field results and the database records for comparison.

Nitrate Data from Building Permit Records and Field Investigations, 2006-2008

	Building Permit Database				Field Investigation			
	Count	Max (mg/L)	Median (mg/L)	Min (mg/L)	Count	Max (mg/L)	Median (mg/L)	Min (mg/L)
Region 1 LaPush-Beaver	18	1.45	0.53	nd	6	1.5	0.62	nd
Region 2 Sekiu-Clallam Bay	0				1	nd	nd	nd
Region 3 Joyce-Port Angeles	38	7.70	nd	nd	24	2.19	0.56	nd
Region 4 Miller Peninsula	8	1.68	0.36	nd	2	1.32	1.01	0.69
nd = not detected, or <0.5 mg/L								

A comparison of these statistics shows that the Joyce–Port Angeles regional maximum is substantially higher than the maximum found in field sampling for the same region. Nitrates are typically higher where land uses are more intensive, so it isn’t surprising that a higher nitrate concentration would be present in a larger data set for an area with more intensive development. All other statistics between the two data sets are very close, suggesting that the building permit database is a good source of information for screening rural areas for potential nitrate hot spots.

For quality assurance relative to the sampling, field duplicates for nitrate samples were collected at 6 (18%) of 33 sites; 3 of these pairs had results high enough above the method detection limit to be useful in the data quality assessment (see Appendix). Nitrate data were verified and assessed for usability following the data quality assessment process in the approved QAPP, and all measurement quality objectives were met.

Bacteria

A surprisingly high number of sites (7 of 33, or 21%³) tested positive for coliform bacteria.⁴ While two of these were springs, where it wouldn’t be unusual to find coliform, two others were deep wells. Bacteria rarely survive in deeper aquifer conditions, so when they are found in a sample it is first assumed that it entered the water in the plumbing system or sampling hose. Of all samples with coliform present, only one was positive for E. coli (E. coli indicates the presence of fecal material). In all cases except one, coliform colonies were absent when a repeat sample was collected from indoor

³ With the exception of one site (a spring) the sites with positive bacteria are not the same seven that have elevated nitrates.

⁴ The Enterolert test used for total coliform measures the presence or absence of any colonies of any coliform bacteria species in a 100 mL sample. When the Colilert test is used, the number of coliform colonies in a 100 mL sample may be counted.

plumbing. In cases where indoor samples indicated the presence of coliform, well owners were encouraged to disinfect their well using chlorine and/or address construction issues likely contributing to the presence of coliform bacteria.

Field duplicates for bacteria samples were collected at 5 (15%) of 33 sites. Due to the non-quantitative nature of the Colilert test, duplicate pairs were compared; all matched in terms of presence/absence.

Well Construction and Static Water Levels

Six of 33 study sites (18%) are either springs or wells shallower than 50'. The deepest well in the sample group was 365' and the average well depth was 147'. A closer look at well construction shows that one deep (202') well testing positive for coliform was perforated starting at 60' down ("open interval start" column in Table 1). Several "deep" wells (>200') actually have water entering the casing from much shallower zones. This is usually only done when the well is drawing water from fracture zones in hard rock.

Three of seven samples with nitrates greater than 1 mg/L were from shallow springs or wells that tap groundwater less than 50' deep. The highest counts of bacteria were found at the two shallowest sites, which are springs.

Much may be learned from measurements of well water levels. When static or in equilibrium, the water level elevation expresses the regional water table or piezometric surface, and flow direction may be determined. Measurements made during pumping are used to describe the capacity of the aquifer. Wells in this study were chosen for water quality rather than hydrogeologic analyses such as these, but a static measurement was made when possible (12 sites). The water level depth below ground surface (BGS) for all measured wells ranged from flowing (a spring site) to nearly 200' BGS; the average was 66' BGS.

Other Contaminants

Nitrate and bacteria were used as the most common indicators of contamination from land activities, and neither was found at persistently-high levels in the rural areas studied. However, other contaminants that were not tested at this time may be generated by intensive land activities (for example, stormwater runoff from urban/industrial areas) and potentially impacting groundwater and drinking water sources where soil and aquifer conditions are susceptible.

Field Parameters

Several field measurements were made as part of the sampling process at each site; complete results are found in Table 2. A summary of all measurements follows, with results outside the normal range shaded:

Parameter	N (# of wells)	Min	Median	Mean	Max
Static water level (ft BGS)	12	flowing	56	66	196
Temperature (°C)	31	5.6	9.8	10	12.8
pH (standard units)	30	6.4	7.7	7.6	9.7
Specific Conductance (microsiemens/cm at 25°C)	31	81	262	268	640
Dissolved Oxygen (%)	31	3	63	54	96
Purge rate (gal/min)	33	1	9	9	15
Purge duration (min)	33	4	20	23	76

Notable results include cooler than average groundwater temperatures in the Joyce–Port Angeles region, where 3 sites were below the typical temperature range of 8-12°C (one was a spring). The only well sampled in the Sekiu–Clallam Bay region had an above-average temperature of 12.6°C. Groundwater temperature doesn't typically vary much over the seasons except when it is influenced closely by recharge.

pH plays many important roles in the chemical and biological systems of natural waters and can control the solubility of metal compounds and the rate or magnitude of chemical reactions. pH is regulated as a secondary (aesthetic) contaminant in drinking water at values less than pH 6.5 or greater than pH 8.5, since values outside this range may corrode plumbing fixtures or reduce the effectiveness of water treatment such as chlorination. pH values above the typical range (and therefore acidic) were found for four wells in the Joyce–Port Angeles region. In contrast, three of the seven wells tested further west were below typical (and therefore alkaline); these were also relatively shallow (less than 70' deep).

Specific conductance is a measure of water's ability to conduct an electrical current and is related to the concentration and charge of dissolved ions (salts) in water. Conductivity is regulated as a secondary (aesthetic) contaminant in drinking water at concentrations greater than 700 µS/cm. There were no wells above that level, but those in the LaPush–Beaver region had the lowest levels by far, averaging only 112 µS/cm.

Deeper wells often had lower dissolved oxygen (DO) levels, as might be expected. Note however that DO values are influenced by sampling technique; actual in-ground D.O. would probably be lower than the value measured in the field and reported here. It was not analyzed in the laboratory.

Conclusions

Project results generally confirm that Clallam County's rural area groundwater is not likely to contain widespread contamination. On the other hand, many activities can potentially contaminate groundwater, especially where soils are very permeable and/or the water table is shallow. Results reported here represent a snapshot of the water quality in certain wells and may not reflect seasonal or more localized problems.

Potential sources of nitrogen to the environment include sewage, animal waste, inorganic fertilizers, and to a lesser degree dry acid deposition from the atmosphere. In particular,

- Nitrogen contamination of groundwater can occur if on-site sewage systems are improperly installed, or improperly operated and maintained. In addition, groundwater aquifers can only assimilate the nitrogen load from septic systems to a limited degree (depending on many factors), after which aquifer nitrate concentrations will rise.
- Residents must be diligent about following the label requirements for fertilizer use to assure that groundwater under their property will not become contaminated by their activities. This also includes animal management. It is important to make sure that the wellhead is protected from animals which also contribute a nitrogen load.

Factors influencing nitrate concentrations found in study wells include:

- Integrity of the surface seal intended to seal the well casing from contamination at or near the land surface, and
- Location/depth of the well screen and/or perforations in the casing.
- Zone of the aquifer, and whether clay layers are present in the geologic profile

- Proximity to and volume/concentration of the source of contamination
 - The source may be current and ongoing or historic (“legacy” nitrogen contamination may persist in the unsaturated zone from historic land uses)
- Rate and direction of groundwater flow, which varies by season and pumping patterns
- Amount of dilution from uncontaminated ditches, ponds, and streams
- Whether the sample has been taken from the plumbing, well casing, or straight from the aquifer

There is no consistent pattern in the location or depth of wells with coliform bacteria, nor was one expected since this type of bacteria is not known to persist in aquifers. Bacteria found in drinking water tend to be localized to the infrastructure itself and can usually be remedied using standard disinfection procedures. The relatively high percentage of positive samples (21%) advises that private individual, un-regulated well owners should check for bacteria on a frequent and regular basis in case it enters through the plumbing system. (Regulated systems test for bacteria monthly or yearly, depending on the population served.) The state standard for coliform bacteria in drinking water is zero.

Follow-up studies of rural groundwater quality could effectively begin by utilizing County permitting database records of nitrates to locate potential problem areas, and utilizing the state database of well logs to select study wells in areas of interest, rather than publicly soliciting well owners.

Finally, things residents do where they live and work can have an affect on groundwater quality, so it is recommended that everyone:

- apply yard chemicals only when necessary and at the suggested time and rate (and especially NOT during rainy times);
- prevent motor oil spills and take your used oil to a recycling center;
- have your septic system inspected regularly, and pumped when needed (usually every 3-5 years);
- avoid non-biodegradable household cleaners, and dispose of any leftover toxic cleaners at a household hazardous waste collection (not down the drain); and
- use phosphate-free detergent for laundry and non-chlorine bleach.

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This report includes the following items inserted after this point:

Table 1. Rural Areas Groundwater Study Wells – Construction Information

Table 2. Rural Areas Groundwater Quality Results – 2006-08

Appendix

- A.1. Region 1, LaPush-Beaver Groundwater Quality, 2006-2008
- A.2. Region 2, Sekiu-Clallam Bay Groundwater Quality, 2006-2008
- A.3. Region 3, Joyce-Port Angeles Groundwater Quality, 2006-2008
- A.4. Region 4, Miller Peninsula Groundwater Quality, 2006-2008
- A.5. Nitrate Data Quality Assessment

TABLE 1. Rural Areas Groundwater Study Wells -- Construction Information

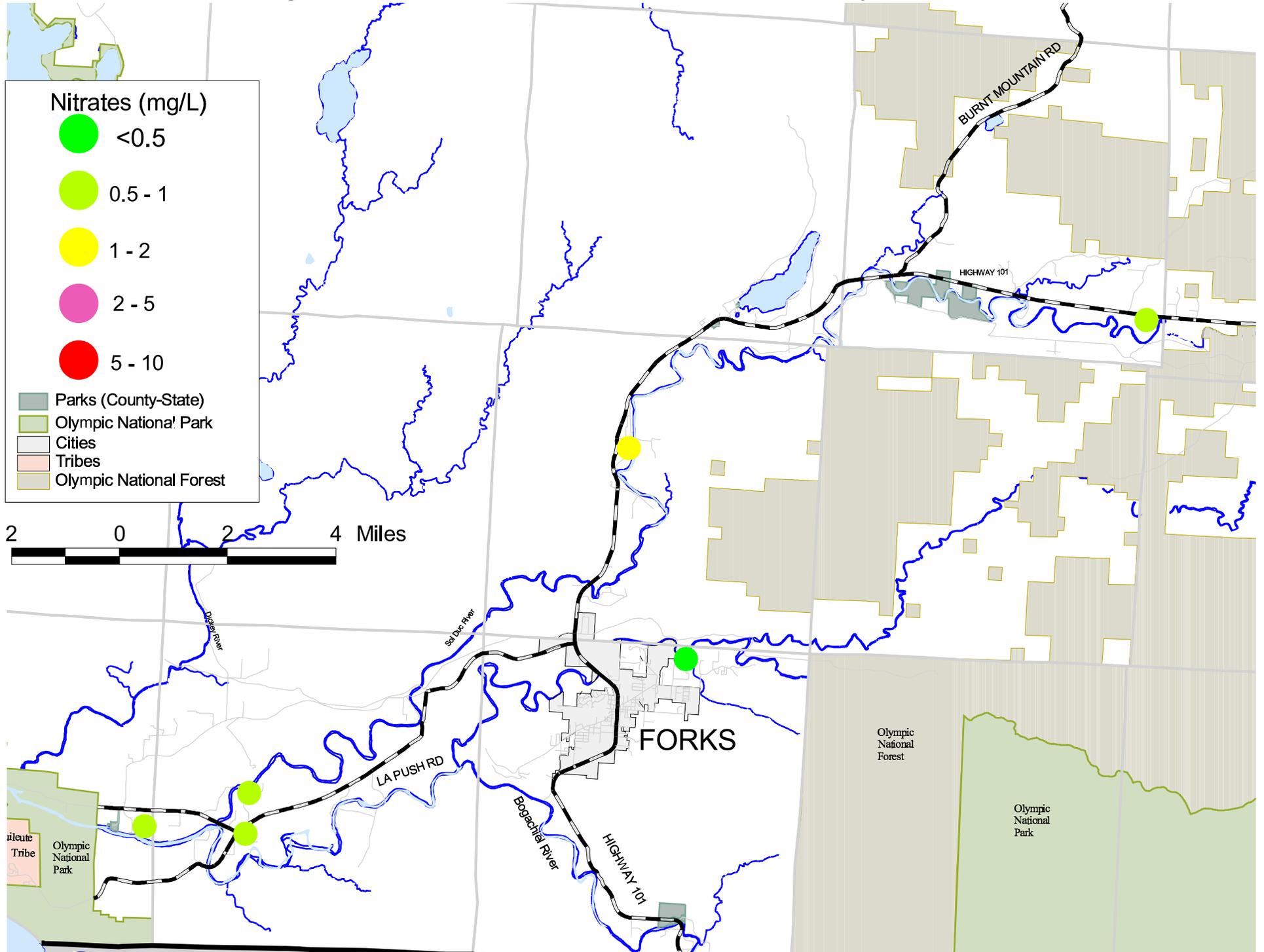
<i>Region</i>	Local ID	Well	State Tag #	Log Avail?	Year Drilled	Well Driller	Open Interval Start	Open Interval End	Static Level on Log	Elev. at Well	Construction and water use notes
1	28N/13W-03B71	106	none	yes	1987	Mel Williams	90	95	86		well goes dry if pumped too long, but recovers quickly
1	28N/14W-20B71	45	none	yes	1988	Stoican	45	45	20		open bottom
1	28N/14W-20Q71	75	none	no	1967?	unknown					no log; depth measured, according to owner
1	28N/15W-24R71	31	ABE 187	yes	1995	H2O Well Drilling	32.4	32.4	16		no screen, open bottom
1	29N/13W-16F71	45	none	no	?	owner	45	45			1000' gal tank sunk down 45', open bottom; two risers
1	30N/12W-36B71	85	none	no	1972?	unknown	85	85			open bottom
2	32N/13W-08H71	64	ACC 676	yes	1997	H2O Well Drilling	64	64	12		open bottom
3	30N/06W-08K71	340	AFC 843	yes	2001	Louie's	335	340	313		screen
3	30N/06W-08P71	10 (spring)	none	no	?	unknown	10	10			spring, open bottom
3	30N/06W-17A71	122	none	yes	1984	Louie's			107		open bottom? PVC?
3	30N/07W-08P71	203	none	yes	1995	Louie	161	203	161		perf PVC; used for irrigation only
3	30N/07W-08P72	290	none	n/a	1997	Tillia					can't locate log
3	30N/07W-09J71	228	none	yes	1991	Stoican					can't locate log
3	30N/07W-10D71	174	AFL 967	yes	2000	Mel Williams	174	174	151		open bottom
3	30N/07W-10E71	175	none	no	1970	unknown					no log; depth measured, according to owner
3	30N/07W-10L71	365	AGQ 654	yes	2003	Louie's	300	365	105		perf PVC
3	30N/07W-11J71	66	none	yes	1974	Haney	66	66	50		drilled to 100'
3	30N/07W-13G01	278	none	yes	1981	Stoican	100	270	44		perf PVC
3	30N/07W-14F71	157	AKK 964	yes	2006	Tillia	120	140	127		perf welded casing; previous well went dry
3	30N/07W-16A71	203	AGN 268	yes	2002	Tillia	170	203	135		perf PVC
3	30N/07W-16C71	80	none	n/a	?	unknown					
3	30N/07W-32L71	136	AGQ 695	yes	2004	Louie	131	136	103		screen
3	30N/07W-32L72	spring	none	no	?	unknown	0	0	flowing		irrigation use only; former drinking water supply
3	30N/08W-02F71	39	AHR 373	yes	2003	Aqua Pumps/Debler	33	39	7		5.5" screen
3	30N/08W-17N01	250	none	yes	1978	Stoican	50	230	202		perf PVC
3	30N/08W-20H71	85	none	yes	1991	Stoican	60	82	52		perf PVC
3	31N/07W-31L71	72	AFA 463	yes	1999	Tillia	63	68	52		
3	31N/07W-32R71	157	none	yes	1986	Louie's	157	157	115		open bottom
3	31N/07W-33G01	17	none	yes	1974	Stoican	14	17	9		2" sandpoint screen
3	31N/08W-28B71	unknown	ALB 660	no	1991	Louie's (original well)	49	49	20	96	deepened (construction info taken from original log)
3	31N/08W-31K71	202	ACC 095	yes	1996	Stoican	60	200	14		
4	30N/02W-31H71	340	none	yes	2001	Tillia/Louie's			185		1982 well ran dry; deepened from 243' to 340' in 2001
4	30N/02W-32Q71	256.5	none	yes	1986	Bekkevar	251	256.5	231	266	screen

TABLE 2. Rural Areas Groundwater Quality Study Results -- 2006-2008

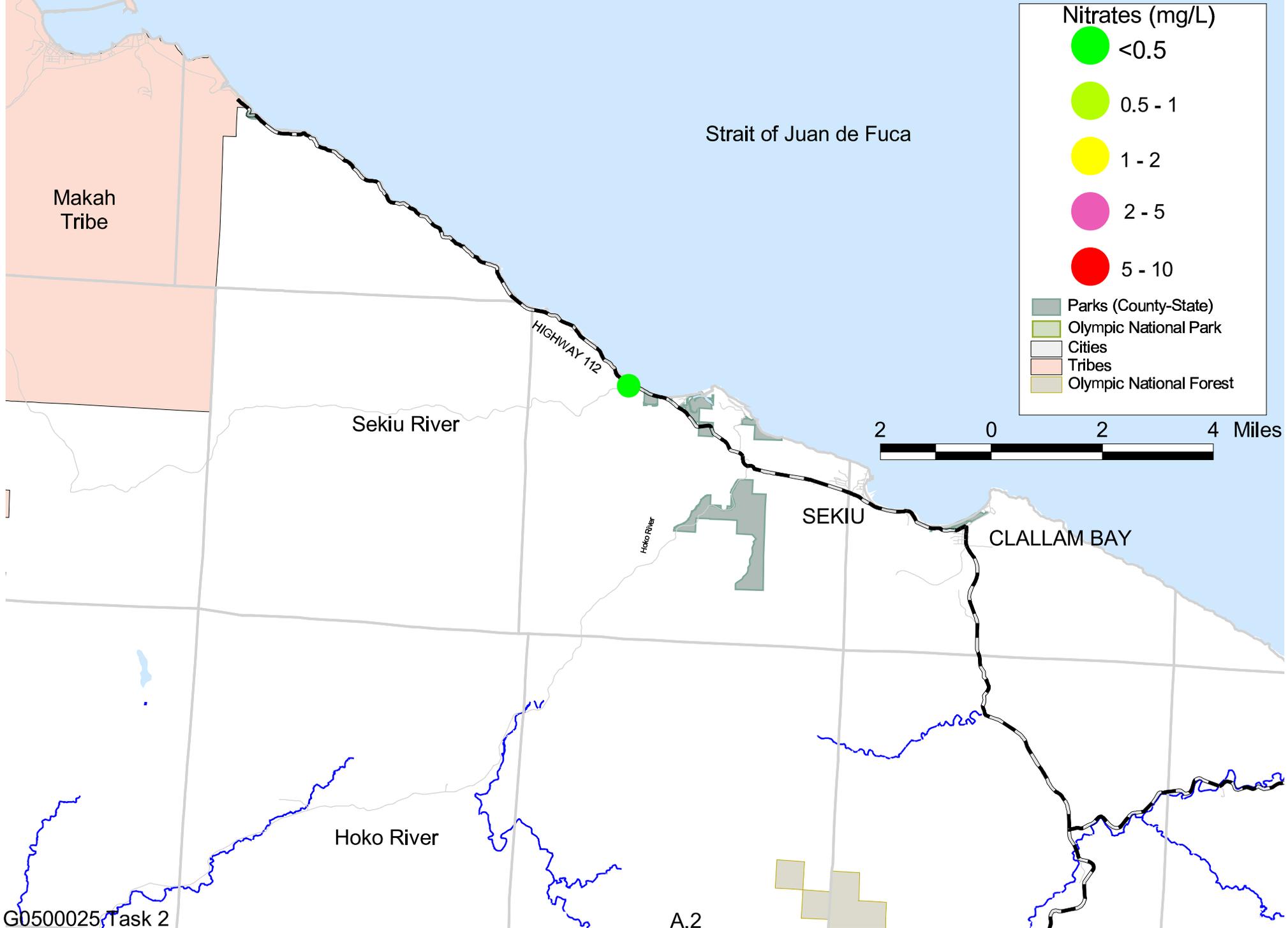
<i>Region</i>	Local ID	Well Depth ft	SWL ft BGS	Temp deg C	pH	Spec. Cond. uS/cm at 25°C	DO %	Purge time minutes	Purge rate gpm (est)	Sample Date	NO3 mg/L	Total Coliform +/- or # colonies	E. coli + or -
1	28N/13W-03B71	106	97	10.4	7.7	175	33.5	11	11	9/23/2008	0.03	negative	negative
1	28N/14W-20B71	45		10	6.6	99	83	11	10	6/5/2007	0.75	<1	negative
1	28N/14W-20Q71	75		10.3	6.6	118	96	21	9	6/5/2007	0.64	<1	negative
1	28N/15W-24R71	31		9.8	6.5	106	86	62	10	8/19/2008	0.6	negative	negative
1	29N/13W-16F71	45	39.3	10.3	6.4	81	91	12	8	6/5/2007	1.5	<1	negative
1	30N/12W-36B71	85	59.55	10	7.0	93	96	13	9	6/5/2007	0.52	<1	negative
2	32N/13W-08H71	64		12.6	6.4	246	54	76	3.3	8/5/2008	<0.5	positive	positive
3	30N/06W-08K71	340		10	7.6	202	41.2	39	8	8/20/2008	1.44	negative	negative
3	30N/06W-08P71	10 (spring)	0	8.6	6.8	348	63	24	9	3/20/2007	2.19	71	negative
3	30N/06W-17A71	122		9.2	7.9	262	57	24	8	1/23/2007	0.51	<1	negative
3	30N/07W-08P71	203	51.65	9.3	9.7	426	8	23	12	2/20/2007	<0.5	<1	negative
3	30N/07W-08P72	290						4	1	2/20/2007	0.53	<1	negative
3	30N/07W-09J71	228	195.88	8.8	7.9	227	15	30	8	1/23/2007	<0.5	<1	negative
3	30N/07W-10D71	174	134.33	9	7.8	216	85	22	12	2/6/2007	0.84	<1	negative
3	30N/07W-10E71	175		9.8	7.7	217	72	21	6	3/6/2007	0.74	<1	negative
3	30N/07W-10L71	365		9.3		269	13	21	10	2/6/2007	<0.5	<1	negative
3	30N/07W-11J71	66		10.5	8.3	294	8.6	15	12	2/20/2007	<0.5	<1	negative
3	30N/07W-13G01	278	59.51	8.2	8.8	303	3	23	12	3/6/2007	<0.5	<1	negative
3	30N/07W-14F71	157		7.9	8.0	287	83	12	10	3/20/2007	1.14	<1	negative
3	30N/07W-16A71	203		9.3	7.5	244	41	32	6	3/6/2007	<0.5	<1	negative
3	30N/07W-16C71	80		5.6	8.7	312	94	8	6	2/20/2007	<0.5	9	negative
3	30N/07W-32L71	136		8.7	7.7	279	15	19	15	3/20/2007	<0.5	<1	negative
3	30N/07W-32L72	spring	flowing	6.9	7.9	190	91	30	6	3/20/2007	<0.5	40	negative
3	30N/08W-02F71	39	5.83	10.7	7.6	298	10	14	12	3/6/2007	0.58	<1	negative
3	30N/08W-17N01	250		9.2	7.6	328	63	17	10	4/17/2007	0.92	<1	negative
3	30N/08W-20H71	85		9.8	7.0	155	4	19	10	3/20/2007	0.96	<1	negative
3	31N/07W-31L71	72	46.4					12	8	8/19/2008	0.77	negative	negative
3	31N/07W-32R71	157	88.8	9.1	7.3	640	95	20	10	2/6/2007	1.89	<1	negative
3	31N/07W-33G01	17		8.5	7.8	209	75	10	9	2/20/2007	1.66	<1	negative
3	31N/08W-28B71	unknown	R	12.8	7.7	497	79.6	17	15	9/22/2008	<0.01	positive	negative
3	31N/08W-31K71	202	13.45	10	9.2	573	26.5	30	8	8/19/2008	0.69	positive	negative
4	30N/02W-31H71	340		10.7	7.6	315	13.5	15	4	8/27/2008	0.69	positive	negative
4	30N/02W-32Q71	256.5		9.9	8.0	291	90.3	35	10	8/27/2008	1.32	negative	negative
count:		33	12	31	30	31	31	33	33		33	33	33
minimum:		0	(flowing)	5.6	6.4	81	3	4	1		0		
median:		129	56	9.8	7.7	262	63	20	9		0.6		
mean:		147	66	10	7.6	268	54	23	9		0.63		
maximum:		365	196	12.8	9.7	640	96	76	15		2.19		

SWL Static Water Level
 BGS Below Ground Surface
 R Recovering / Recently pumped
 Spec. Cond. Specific Conductance, in microsiemens per centimeter at 25 degrees Celcius
 DO Dissolved Oxygen
 NO3 Nitrate-as-Nitrogen

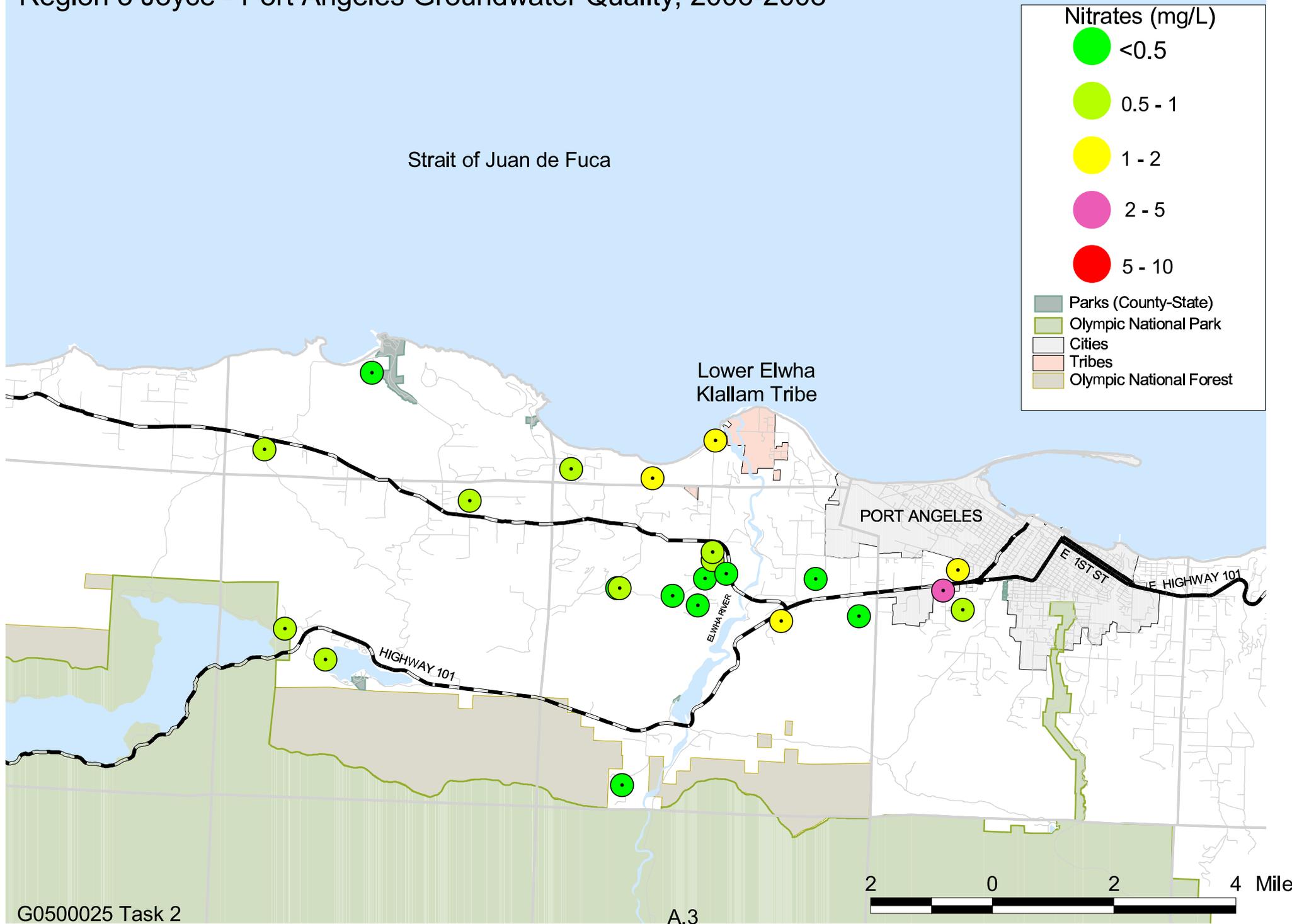
Region 1 LaPush - Beaver Groundwater Quality, 2006-2008



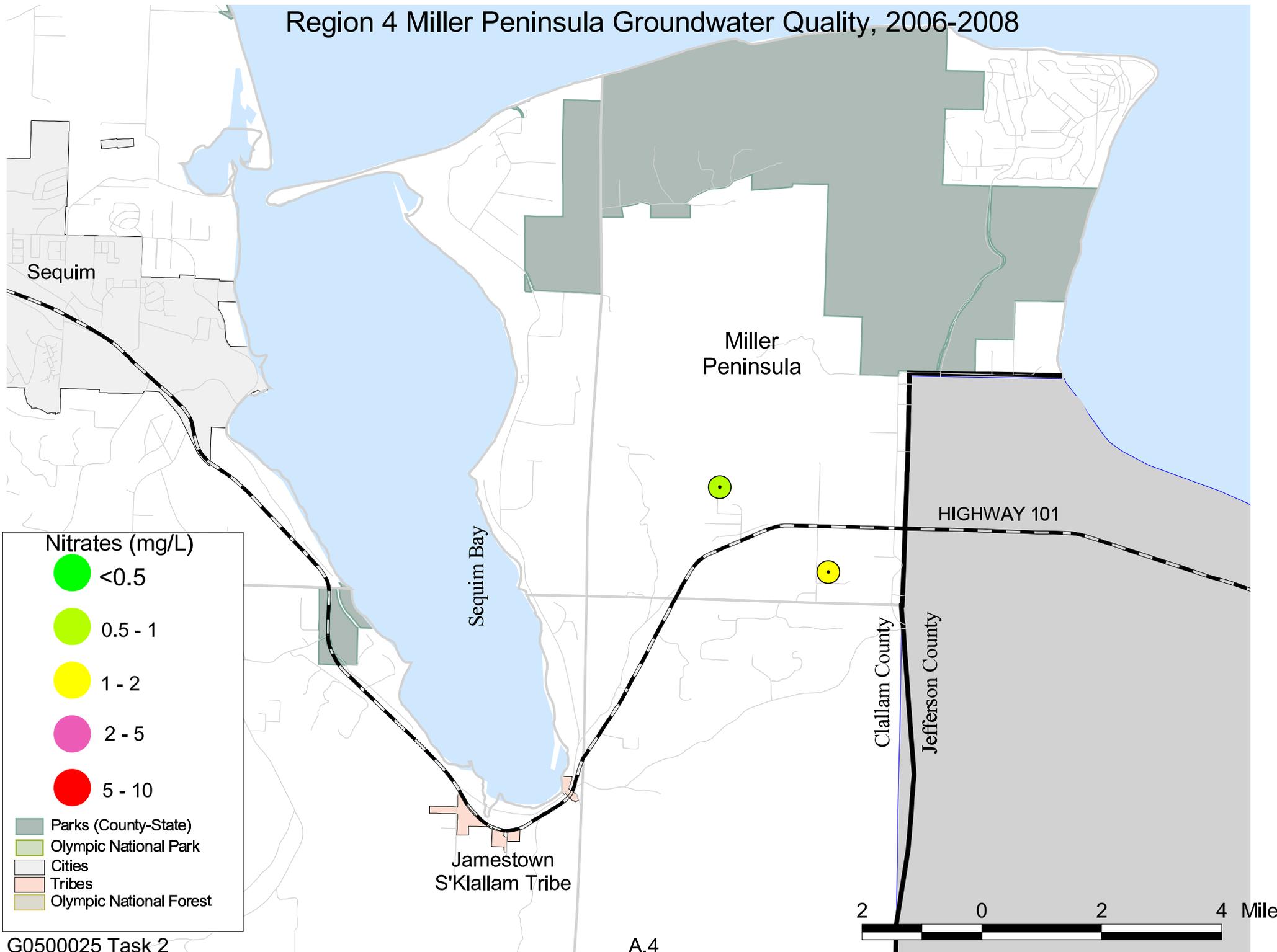
Region 2 Sekiu - Clallam Bay Groundwater Quality, 2006-2008



Region 3 Joyce - Port Angeles Groundwater Quality, 2006-2008



Region 4 Miller Peninsula Groundwater Quality, 2006-2008



Nitrate Data Quality Assessment

I. PRECISION

Measurement Quality Objective = RSD within 10%

A. Total Precision (replicate field samples)

1. Relative Percent Difference (RPD)

Dupe pairs	non-neg Diff	x200	C1 + C2	RPD
1.66 1.67	0.01	2	3.33	0.60
0.58 0.58	0	0	1.16	0.00
1.5 1.76	0.26	52	3.26	15.95

2. Relative Standard Deviation (RSD)

Pooling estimates of standard deviation for pairs (use when dupe pairs are of the same order of magnitude)

Dupe pair 1	non-neg Diff	D squared	Sum of D squareds	2m	Divided	Sp	RSD
1.66 1.67	0.01	0.0001	0.0677	4	0.016925	0.13009612	7.813580679
1.5 1.76	0.26	0.0676					7.981356952
Dupe pair 2	non-neg Diff	D squared	Sum of D squareds	2m	Divided	Sp	RSD
0.58 0.58	0.00	0	0.0001	2	0.00005	0.00707107	1.219149623
0.03 0.04	0.01	0.0001	Don't use--precision can't be accurately estimated when results are very near detection limit.				

Nitrate Data Quality Assessment

B. Analytical Precision (replicate lab analysis of samples)

	Duplicates		1. Relative Percent Difference	2a. Standard Deviation	
	Sample result	Rep result	RPD	s	RSD
Twiss 9/23/08	0.5	0.51	2	0.007071068	1.40021145
CCEH 8/20/08	1.55	1.63	5	0.056568542	3.55776997
CCEH 9/17/08	3.09	3.2	3.5	0.077781746	2.47318747

2b. Pooling estimates of standard deviation for pairs (use when dupe pairs are of the same order of magnitude)

Dupe pairs	non-neg Diff	D squared	Sum of D squareds	2m	Divided	Sp	RSD
1.55	0.08	0.0064	0.0185	4	0.004625	0.06800735	4.277191984
1.63							
3.09	0.11	0.0121					2.162395947
3.2							

II. ANALYTICAL BIAS

Measurement Quality Objective = within 5% of true value

	n	Blank	Lab Check Standard		% Recovery	Bias
		NO3+NO2	Value	Lab Result		
Twiss 9/23/08	6	<0.01	5.81	5.71	98.3	-1.7
CCEH 8/20/08	14	<0.5	7.14	7.24	101	1
CCEH 9/17/08	12	<0.5	7.14	7.35	103	3

III. ACCURACY

Measurement Quality Objective = 30% deviation from true value

	Precision	Bias	Accuracy = (Precision x 2) + Bias
	RSD		
Twiss 9/23/08	1.4	-1.7	1.1
CCEH 8/20/08	3.56	1	8.12
CCEH 9/17/08	2.47	3	7.94

IV. COMPLETENESS

Measurement Quality Objective = 90% of analyzed samples are valid

# analyzed	# valid	Completeness
33	33	100%