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Yelm Groundwater Baseline Sampling

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Yelm Groundwater Baseline Sampling

by
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Olympia, Washington 98504-7710

January 1998

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Summary

Twenty-three private water-supply wells were sampled bimonthly for one year to define nitrate concentrations in groundwater in a seven square mile area east of the city of Yelm. Twenty-two of the sampled wells tapped the principal aquifer, the Advance Outwash Aquifer that occurs at a depth of 70 to 100 feet below the ground surface. One sampled well tapped the uppermost aquifer that is little used for drinking water because it is considered susceptible to contamination from surface activities. Well samples were tested for nitrate+nitrite-N, chloride, total dissolved solids, ammonium and fecal coliform. Nitrate has migrated to the Advance Outwash Aquifer. Areas where mean nitrate+nitrite-N concentrations exceed 3 mg/L and 5 mg/L are identified. Concentrations are not at alarming levels but are high enough that additional nitrogen loading should be prevented. Potential nitrate sources upgradient of the study area are identified. Wells should be resampled in a few years to ensure that conditions have not deteriorated. Long-term monitoring is recommended at Crystal Springs, a natural spring located one mile north of Yelm. Water quality samples at Crystal Springs could be a useful indicator for changes in groundwater quality for a portion of the area north of Yelm.

Recommendations

1. Ecology should resample the same wells for nitrate in four to five years. Wells should be sampled bimonthly or more frequently for one year. The data should be evaluated relative to the baseline results of this study to determine if there is a trend in nitrate concentrations.

2. A sampling program should be designed and implemented at Crystal Springs as part of the monitoring for the wastewater reuse project. The discharge at Crystal Springs appears to be a convenient sampling point that could indicate changes in groundwater quality for a portion of the groundwater between the city of Yelm and Crystal Springs.

3. Potential sources of nitrate upgradient of the areas of elevated nitrate concentrations include:

   - onsite sewage systems
   - the poultry farm south of Bald Hill Road and west of the intersection of Bald Hill Road and Harris Road
   - the poultry farm north of Bald Hill Road and north of the intersection of Bald Hill Road and 110th Avenue
   - the abandoned poultry farm on Bald Hill Road and southeast of the intersection of Bald Hill Road and Harris Road
   - the livestock auction yard north of Highway 507

   The Ecology Southwest Regional Office (SWRO) should follow up with site inspections and provide technical assistance to the poultry farms.

4. If better resolution of the nitrogen source locations is desired by the SWRO, Ecology should establish a water-level monitoring program to define the groundwater flow direction more accurately including seasonal variability. This program would require identifying additional wells for water level measurements, surveying wellhead elevations to 0.1 feet, and monitoring water levels monthly for at least one year.

Acknowledgments

I thank the many people who helped with this project.

◊ Dave Garland, Water Quality Program hydrogeologist, conceived the need for the project and reviewed the Quality Assurance Project Plan and the draft report.

◊ Kathy Cupps, Water Quality Program SWRO, reviewed the Quality Assurance Project Plan and draft report.

◊ Melanie Kimsey and Bob Duffy, Water Quality Program SWRO, reviewed the draft report.

◊ Pam Covey, Manchester Environmental Laboratory, monitored sample flow and testing.

◊ Manchester Environmental Laboratory chemists Becky Bogaczyk, Nancy Jensen, Debbie Lacroix and Casey Maggart conducted testing and provided quality assurance reviews.

◊ Ken Garmann, City of Yelm, provided well information and reviewed the draft report.

◊ Joan LeTourneau formatted and edited the report.

◊ The well owners allowed us to sample their wells; without their help this project would not have been possible.

Introduction

The City of Yelm is proposing to treat its wastewater to a high level and "reuse" the water for irrigation at schools, parks and a proposed golf course; for recharge to groundwater via infiltration ponds; and for constructed wetlands. The susceptibility of groundwater in the Yelm vicinity to contamination is well established. In 1994, in response to elevated nitrate concentrations in groundwater, the City of Yelm constructed a Septic Tank Effluent Pump system, which pumps the primary treated effluent from septic systems in the city to a central treatment plant (Skillings and Lewis, 1995). Because nitrate contamination had been previously identified in groundwater east of Yelm (Tayne, 1996), the Ecology Water Quality Program requested that the Environmental Investigations and Laboratory Services Program conduct sampling to help define the extent of nitrate contamination before the water reuse project starts. This report describes the methods and findings of this baseline assessment.

Site Description

Location

Yelm is located in southwestern Thurston County, Washington about 20 miles southeast of Olympia. The city is situated on a northwest-southeast trending, flat-lying, glacial outwash plain called the Yelm Prairie. The study area is located east of Yelm and occupies about seven square miles (Figure 1). Within the study area, the City of Yelm proposes to reuse treated wastewater on fields at two elementary schools, a park, and a constructed wetland (Skillings-Connolly, 1995). However, most of the treated wastewater will be applied to a future golf course, a part of the Thurston Highland development in the upland about 2.5 miles southwest of Yelm, which is not in the study area.

Regional Geology and Hydrogeology

Geology provides the framework within which groundwater moves. The vicinity geology is characterized by a thick sequence of unconsolidated glacial deposits overlying sedimentary bedrock (Mundorff, Weigle and Holmberg, 1955). Multiple glacial advances and retreats laid down the unconsolidated deposits. Most of the deposits in the Yelm vicinity are a product of the most recent glaciation, the Vashon. Regionally Dion, Turney, and Jones (1994) identified eight principal geologic units in northern Thurston County (listed in order of increasing age): alluvium, Vashon recessional outwash and end moraine, Vashon Till, Vashon advance outwash, Kitsap Formation, "penultimate" glacial deposits, undifferentiated unconsolidated deposits, and bedrock.

The principal aquifers in the region occur as saturated layers of sand and sandy gravel in unconsolidated deposits. These layers readily transmit water and are sandwiched between silty layers of relatively low permeability. As a result, the study area hydrogeology is characterized by multiple water-bearing zones with depth. Dion, Turney and Jones (1994) identified the following three principal regional aquifers:

- alluvial and recessional outwash deposits
- advance outwash deposits
- "penultimate" glaciation deposits

The study area geology and hydrogeology are discussed in Results I.

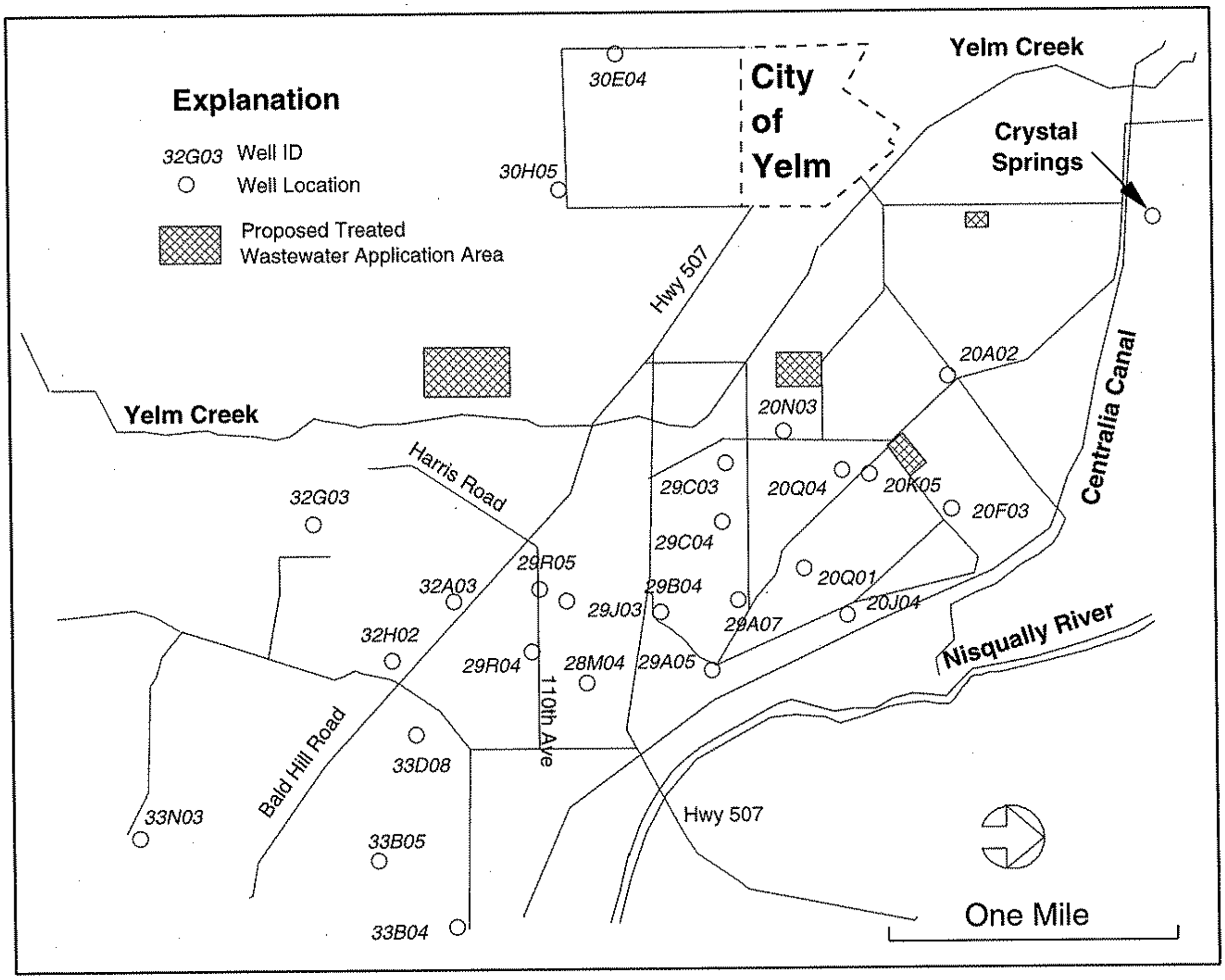

Figure 1. Yelm Groundwater Baseline Sampling Well Locations.

Methods

Monitoring Network

A groundwater-monitoring network was established using existing private water-supply wells. Wells were inventoried from the following sources: US Geological Survey Groundwater Information System, US Geological Survey Water Resource Division files, well logs on file at the Ecology Southwest Regional Office, and Thurston County Environmental Health well information.

Twenty-three wells were identified and selected for sampling. The locations of sampled wells are shown in Figure 1. Well construction data for each of the sampled wells are listed in Appendix A, Table A-1. The depth of sampled wells ranged from 21 to 119 feet with a mean depth of about 90 feet. Wells were sampled for nitrate+nitrite-N, ammonium, chloride, total dissolved solids, and fecal coliform bacteria. Sampling procedures are described in Appendix B. Wells were sampled bimonthly (every other month) for one year from April 1996 through February 1997. Static water levels were measured at 16 wells. The wellhead elevations were estimated from 1:24,000 topographic maps with 20-foot contour intervals.

Hydrogeologic Characterization

The stratigraphy of the study area was defined using drillers' logs for 55 wells with verified locations. Elevations of the tops and bottoms of hydrogeolgic units were determined based on lithologies described on the drill logs and are shown in Appendix A, Table A-2. Because conditions are inferred by extrapolating between well locations, actual conditions may vary from those portrayed. Also, the density of wells varies spatially and drillers' logs vary in quality, therefore the hydrogeology of some areas is better defined than others. Lithology data were managed and hydrogeolgic profiles were prepared using ROCKWARE UTILITIES™ software.

Results I. Study Area Hydrogeology

General

The hydrogeology of the study area is complex. Five hydrogeologic units, three aquifers and two aquitards, are identified beneath the study area to a depth of 150 feet. The aquifers consist of sand and sandy gravel which readily transmit water and are designated as the Recessional Outwash Aquifer, Advance Outwash Aquifer and the Deep Aquifer.

Aquitards generally have a substantial silt or clay component or are "cemented" and do not transmit water as readily as the aquifers. They act to hydraulically separate aquifers, although in most cases the aquitards provide only a partial barrier to flow between water-bearing zones. For this report the aquitards are designated the Upper and Lower Aquitards. The subsurface relationships of the hydrogeologic units are shown in hydrogeologic profiles Figures 2 and 3. The occurrence and properties of the hydrogeologic units are described below in order of increasing depth.

Recessional Outwash Aquifer

The Recessional Outwash Aquifer is the uppermost aquifer in the study area. It represents the saturated portion of the Vashon recessional outwash deposits mapped by Dion, Turney, and Jones (1994). Recessional outwash was deposited by glacier meltwater as the Vashon glacier retreated and consists of loose mixtures of sand and gravel. The deposits are nearly continuous beneath the study area and range up to 25 feet thick. One well (T17N/R2E-20N03) that tapped the Recessional Outwash Aquifer was sampled for this project. The aquifer is recharged primarily by infiltrated precipitation. Generally, the groundwater flow direction is probably northward toward the Nisqually River, however localized flow patterns will develop as a result of variations in infiltration and recharge.

Upper Aquitard

The Upper Aquitard acts as a partial hydraulic barrier between the Recessional Outwash Aquifer and the underlying Advance Outwash Aquifer. Drillers refer to this unit as "clay and gravel", "hardpan", or "cemented gravel". The Upper Aquitard is probably the same as the Vashon till as defined by Mundorff, Weigle, and Holmberg (1955) and Dion, Turney, and Jones (1994). Vashon till was deposited directly and overridden by the advancing glacial ice. Typically Vashon till consists of a compacted, concrete-like mixture of clay, silt, sand and gravel that transmits water poorly. The unit ranges in thickness from 20 to 30 feet and underlies much of the study area but may be absent locally.

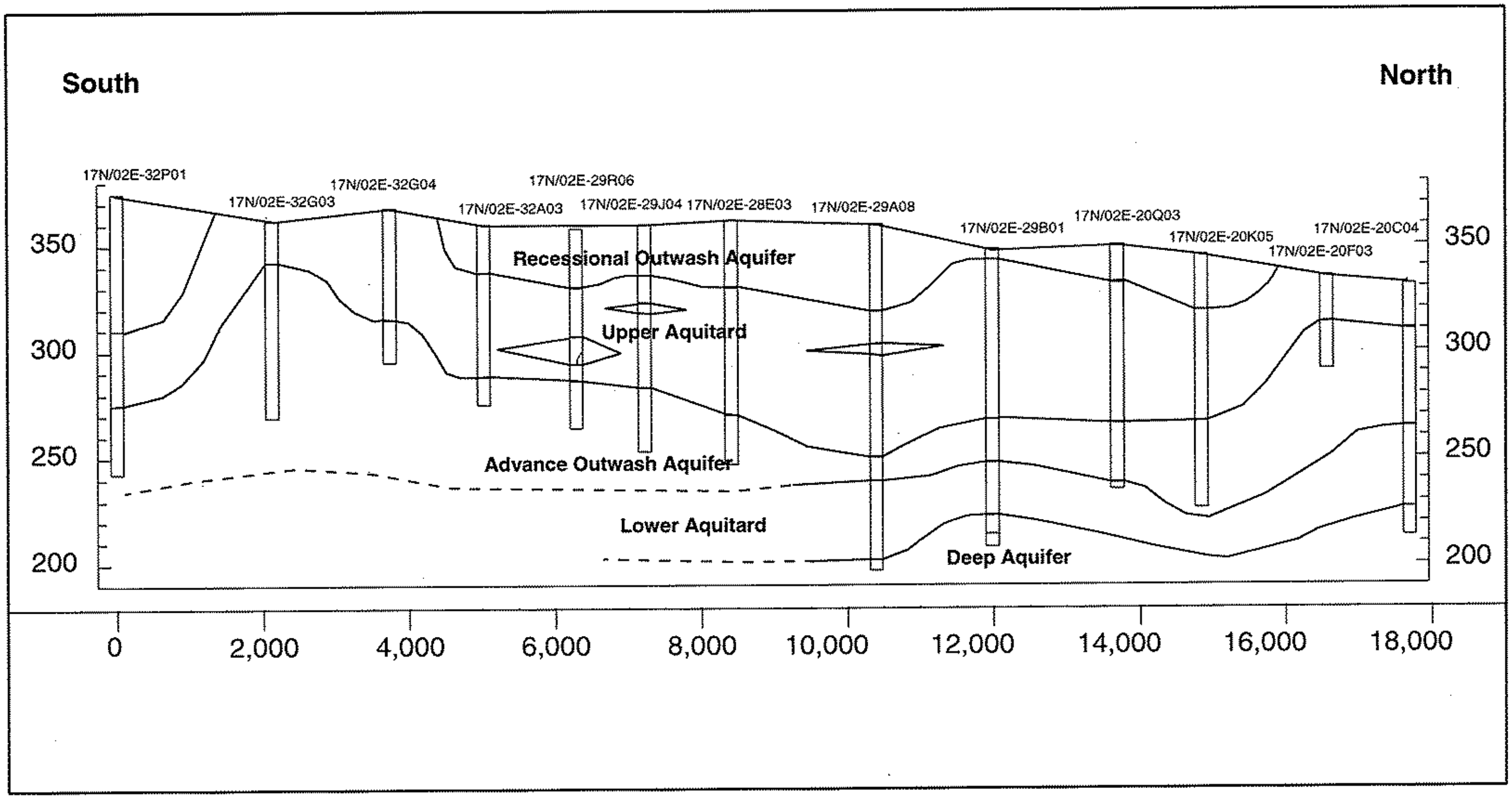

Figure 2. South-North Hydrogeologic Profile in the Vicinity of Yelm, Washington.

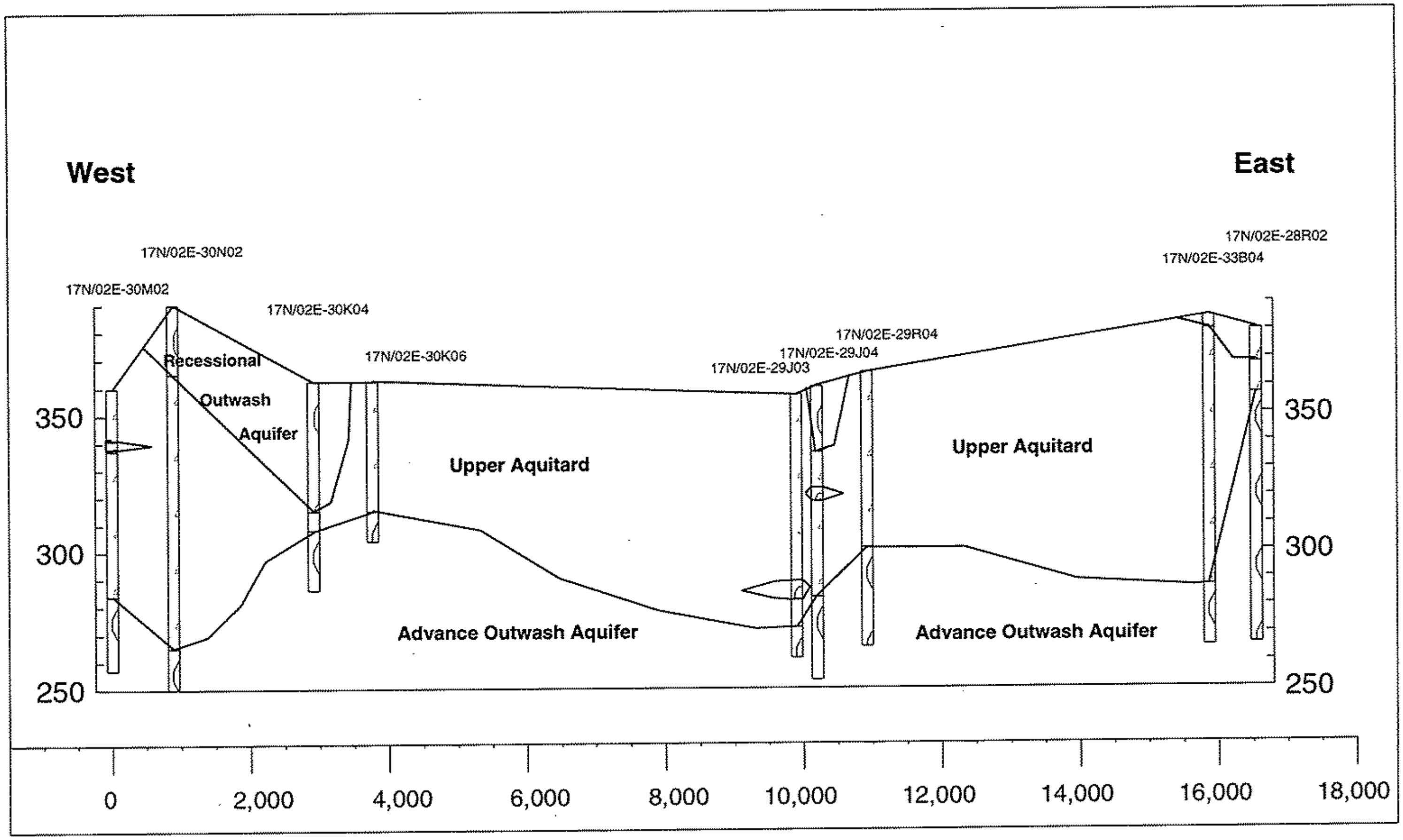

Figure 3. West-East Hydrogeologic Profile in the Vicinity of Yelm.

Discontinuous, water-bearing lenses of sand and sandy gravel occur within the till which can provide enough water for a domestic well. These lenses have limited lateral extent and typically are less than five feet thick. No wells sampled for this project were completed in these discontinuous lenses.

Advance Outwash Aquifer

The Advance Outwash Aquifer is the principal aquifer in terms of use in the Yelm area. Twenty-two of the 23 wells sampled for this project obtain water from this aquifer. This aquifer continuously underlies the study area and consists of sand and gravel deposited by glacial meltwater ahead of the advancing glacier. The deposits typically range from 10 to 50 feet thick. The top of the aquifer usually occurs at depth of about 70 to 100 feet below the ground surface.

The aquifer is recharged primarily from infiltrated precipitation and leakage from the overlying Recessional Outwash Aquifer. Figure 4 shows water level fluctuations in five wells completed in the Advance Outwash Aquifer over the study period. The seasonal water-level fluctuation ranged from about six to 13 feet. Water levels were highest in the late winter and spring and lowest in late summer and fall.

Figure 5 shows the groundwater-flow pattern for the Advance Outwash Aquifer. The map was constructed from water-level elevations measured in 16 wells in April 1996. The groundwater-flow pattern is strongly influenced by the Nisqually River. In the southern portion of the study area groundwater flows northwestward but swings westerly as it approaches the river.

Lower Aquitard

The properties and the distribution of the Lower Aquitard are not well defined. Only five of the wells used to define stratigraphy penetrate the entire thickness of the Lower Aquitard. The Lower Aquitard separates the Advance Outwash Aquifer from the Deep Aquifer. The Lower Aquitard was identified only in the north-central portion of the study area. Its thickness is variable ranging from less than 5 feet to greater than 60 feet. The aquitard consists of hardpacked silty or clayey sandy gravel and may be equivalent to the Kitsap Formation. However, there is disagreement about the presence and distribution of the Kitsap Formation in the Yelm area. Noble and Wallace (1966) did not identify the Kitsap Formation in well logs near Yelm but Dion, Turney and Jones (1994) indicate that the unit continuously underlies the study area. Also, because the Kitsap Formation represents lake, swamp and floodplain deposits it should consist predominately of silt and clay.

Deep Aquifer

Little is known about the occurrence and distribution of the Deep Aquifer in the study area; only five of the 55 well logs used for stratigraphy reached the Deep Aquifer. The Deep Aquifer consists mostly of sand and gravel. The Deep Aquifer may be equivalent to the outwash deposits of an older glacial advance, called the "penultimate" glaciation (Dion, Turney and Jones, 1994). No wells tapping the Deep Aquifer were sampled for this project.

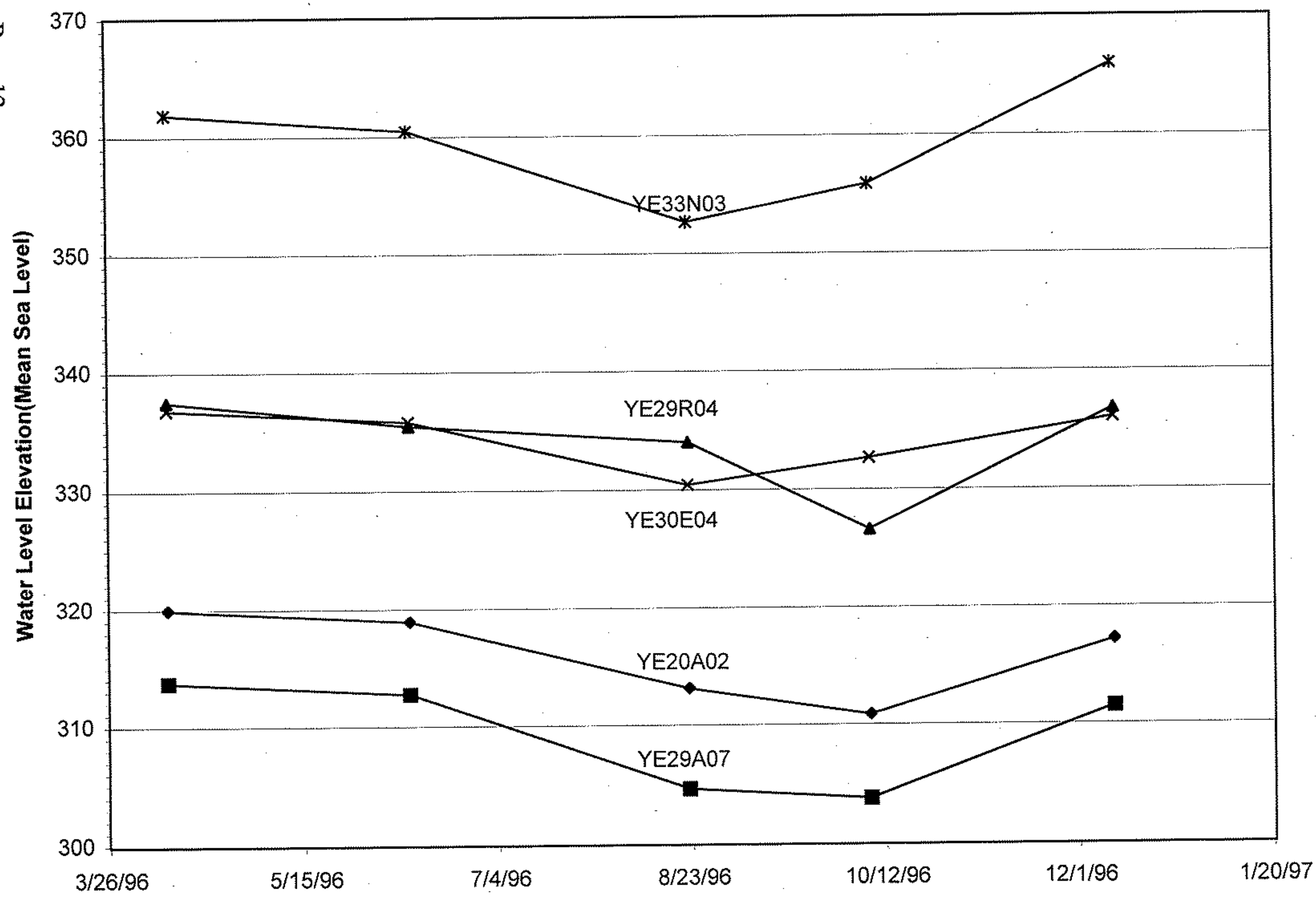

Figure 4. Selected Well Hydrographs, Yelm Groundwater Baseline Sampling.

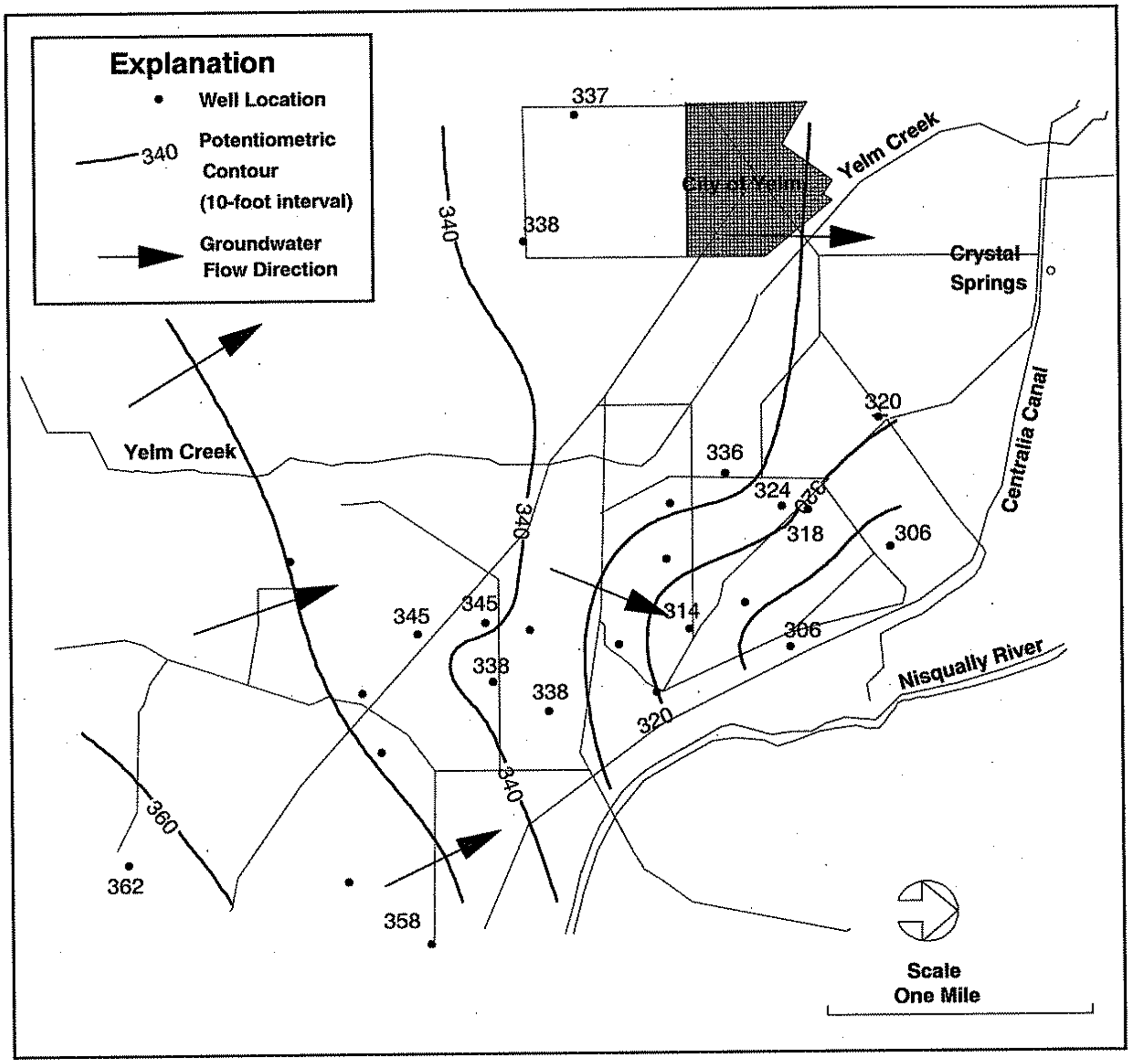

Figure 5. Potentiometric Map, Advance Outwash Aquifer, April 1996.

Hydraulic Conductivity

Hydraulic conductivity is a measure of the ease that water moves through an aquifer. Under most circumstances, it is one of the most important factors that affects the rate that groundwater moves. Typical hydraulic conductivities for coarse glacial sediments such as the deposits that occur in Yelm range from 2.8 to 2,800 feet/day (Fetter, 1980).

For this study we estimated hydraulic conductivity from 76 well-yield tests using the method described by Bradbury and Rothschild (1985). This method is an iterative solution to the Theis equation with modifications for partial penetration and well loss. Well construction information and test data for the hydraulic conductivity estimates are listed in Appendix A, Table A-3. The hydraulic conductivity results are summarized in Table 1. The results show that hydraulic conductivity varies substantially vertically and horizontally. For each aquifer the geometric mean is considered the best estimate of central tendency for hydraulic conductivity results (Freeze, 1975). The geometric means for each aquifer are listed in Table 1.

Table 1. Summary of Hydraulic Conductivity Results.
(Units = feet/day)

Aquifer Name	Minimum	Maximum	Geometric Mean	Number of Tests/Wells
Recessional Outwash	4,800	66,000	18,000	2/1
Lenses in Vashon Till	47	6,800	370	16/15
Advance Outwash	10	12,000	87	42/42
Deep	22	380	72	16/11

Groundwater Velocity

Groundwater velocity can be estimated using Darcy's Law:

$$v = - K\,(dh/dL)/n_e.$$

where,
v = the average linear groundwater velocity (feet/day)
K = hydraulic conductivity (feet/day)
dh/dL = hydraulic gradient (dimensionless)
n_e = effective porosity (dimensionless)

From Darcy's Law the average groundwater velocity for the Advance Outwash Aquifer is expected to range between 0.2 and 200 feet/day. This is based on:

- a hydraulic gradient of 0.004 (from Figure 4, 50 feet/12,300feet)
- an effective porosity of 0.25, and
- the hydraulic conductivities listed in Table 5.

The best estimate for the average groundwater velocity of the Advance Outwash Aquifer is about one to two feet/day using the geometric mean of the hydraulic conductivity (87 feet/day).

Wert (1989) reported a dye test conducted in the 1960s by Milt Johnson, retired water master for the City of Yelm, that had some remarkable results. Two gallons of dye were placed in a city well and dye was observed in Crystal Springs, about 6600 feet north of the well location, less than 12 hours later. This corresponds to a groundwater flow velocity of 13,200 feet/day. This velocity is substantially greater than the average velocity of one to two feet/day estimated using Darcy's Law.

Assuming that results of the dye test are described accurately, a possible explanation for the difference in the velocities obtained from the dye test and from the Darcy's Law calculation is that there is a preferred groundwater flowpath that connects the city well to Crystal Springs. Considering the meltwater origin of the deposits in Yelm, this pathway could be a buried stream channel that might consist of coarse gravel with little or no sandy matrix material. Such a deposit would have very high hydraulic conductivity. The lateral extent of this zone is not known but based on the hydraulic conductivity results from well-yield tests, it appears to have limited extent.

Results II. Water Quality

Quality Assurance

Quality assurance results are shown and summarized in Appendix C. Accuracy and precision of laboratory results were estimated using matrix spikes, laboratory duplicates and calibration standards. Blind field duplicates were used to estimate overall sampling and laboratory precision. Based on the quality assurance sample, all water quality data are considered acceptable for use.

Nitrate + Nitrite-N

All water quality results for this project are listed in Appendix D, Table D-1. Nitrite+nitrate-N results are summarized in Table 2. Nitrite+nitrate-N concentrations for all wells over the study period ranged from a minimum of 0.13 mg/L to a maximum of 10.1 mg/L. The mean concentration for all wells was 3.2 mg/L.

The Drinking Water Standard (Maximum Contaminant Level, MCL) for nitrate is 10 mg/L for public water-supply systems (Chapter 246-290,-291 WAC). Only one well (YE28R04) had a concentration exceeding 10 mg/L (10.1 mg/L) and this occurred for one sampling event. The mean concentration over the study period for well YE28R04 was 8.6 mg/L.

The distribution of mean nitrate+nitrite-N concentrations is shown in Figure 6. In general, upgradient concentrations are less than about one mg/L and concentrations increase downgradient. The observed elevated nitrate concentrations in the downgradient direction confirm that nitrogen loading is occurring between the upgradient and downgradient wells. Hachured areas on Figure 6 approximate where mean concentrations exceed 3 mg/L and 5 mg/L. Nearly half of the Advance Outwash Aquifer within the study area has nitrate+nitrite-N concentrations exceeding 3 mg/L and about 10% of the aquifer concentrations exceed 5 mg/L.

Figure 7 shows nitrate+nitrite-N concentrations for six wells over the study period. With the exception of well YE20R04 the data show little seasonal variability. At well YE20R04 the concentrations were highest in late winter/early spring (at the beginning and end of the study) and lowest in the fall.

Table 2. Nitrate+Nitrite-N Results Summary, April 1996 through February 1997.							
Site ID	**Mean**	**Minimum**	**Maximum**	**Difference**	**Depth Top**	**Depth Bottom**	**Aquifer**
YE20A02	4.73	3.49	6.30	2.81	55	55	RO/AO
YE20F03	2.97	2.76	3.16	0.40	115.3	115.3	AO
YE20K05	5.34	5.00	6.44	1.44	119	119	AO
YE20N03	3.5	2.56	4.48	1.92	21	21	RO
YE20Q01	5.98	4.24	8.15	3.91	70	90	AO
YE20Q04	5.95	4.89	7.65	2.76	58	58	AO
YE28M04	0.47	0.43	0.50	0.07	96	96	AO
YE29A05	0.37	0.28	0.70	0.41	106	106	AO
YE29A07	6.22	4.94	7.34	2.40	101	101	AO
YE29B04	2.86	1.74	4.47	2.73	85	85	AO
YE29C04	6.16	4.57	9.79	5.22	100	100	RO/AO
YE29J03	0.76	0.69	0.86	0.17	96	96	AO
YE29R04	8.63	6.77	10.10	3.33	100	100	AO
YE29R05	3.41	3.14	3.61	0.47	85	85	AO
YE30E04	0.47	0.41	0.54	0.13	97	97	AO
YE30H05	2.00	1.10	2.58	1.48	42	49	AO
YE32A03	0.53	0.50	0.57	0.08	80	80	AO
YE32G03	0.15	0.13	0.19	0.05	83	93	AO
YE32H02	1.02	0.94	1.20	0.26	80	80	AO
YE33B04	5.21	4.11	6.14	2.03	118	118	AO
YE33B05	2.50	2.30	2.63	0.33	118	118	AO
YE33D08	3.24	2.44	3.95	1.51	105	105	AO
YE33N03	0.62	0.49	0.70	0.22	109	109	AO
Mean=	3.18			1.48	89	90	
Minimum=		0.13					
Maximum=			10.10				
RO= Recessional Outwash Aquifer							
AO=Advance Outwash Aquifer							

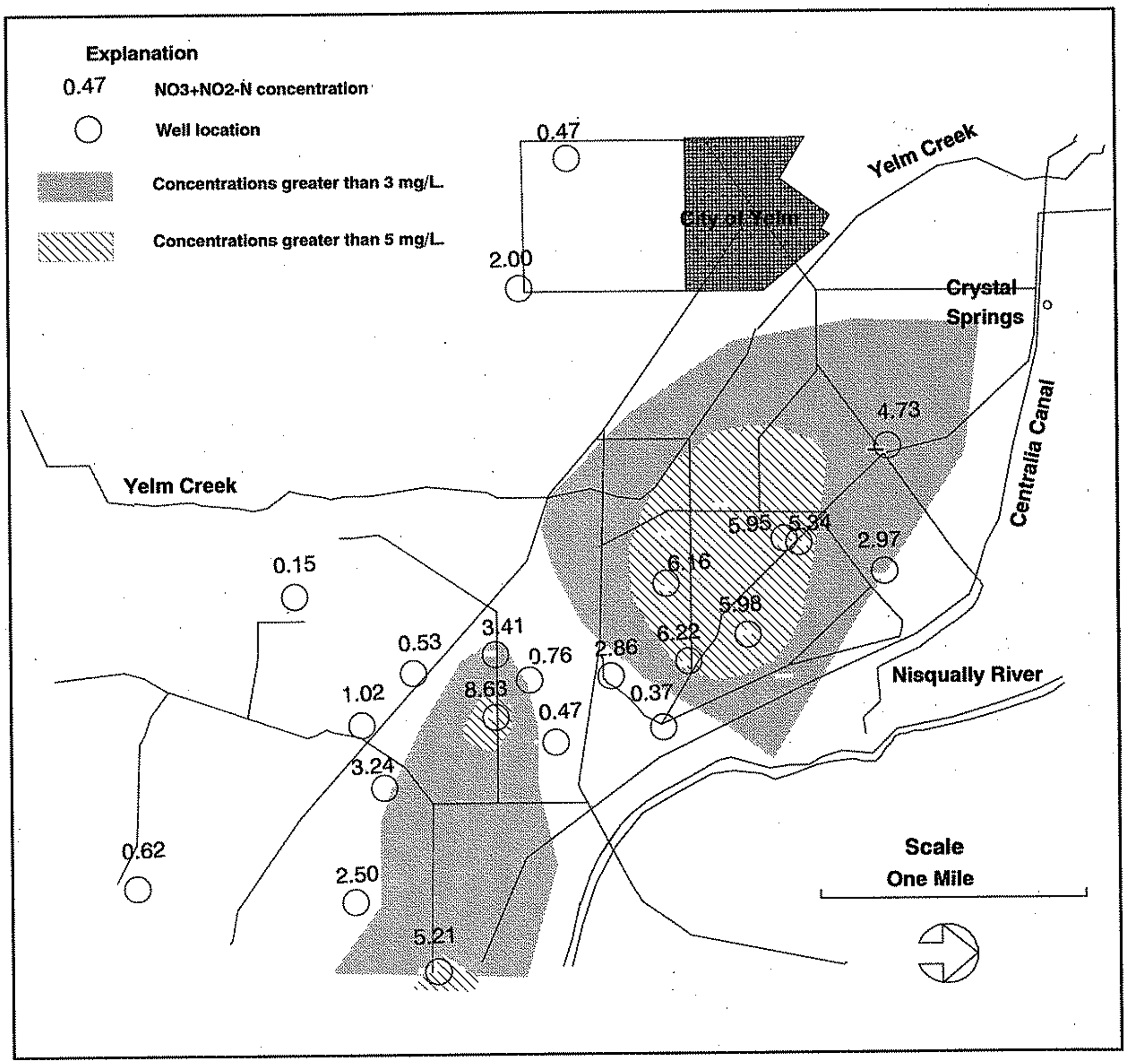

Figure 6. Mean Nitrate+Nitrite-N Concentrations for the Advance Outwash Aquifer.

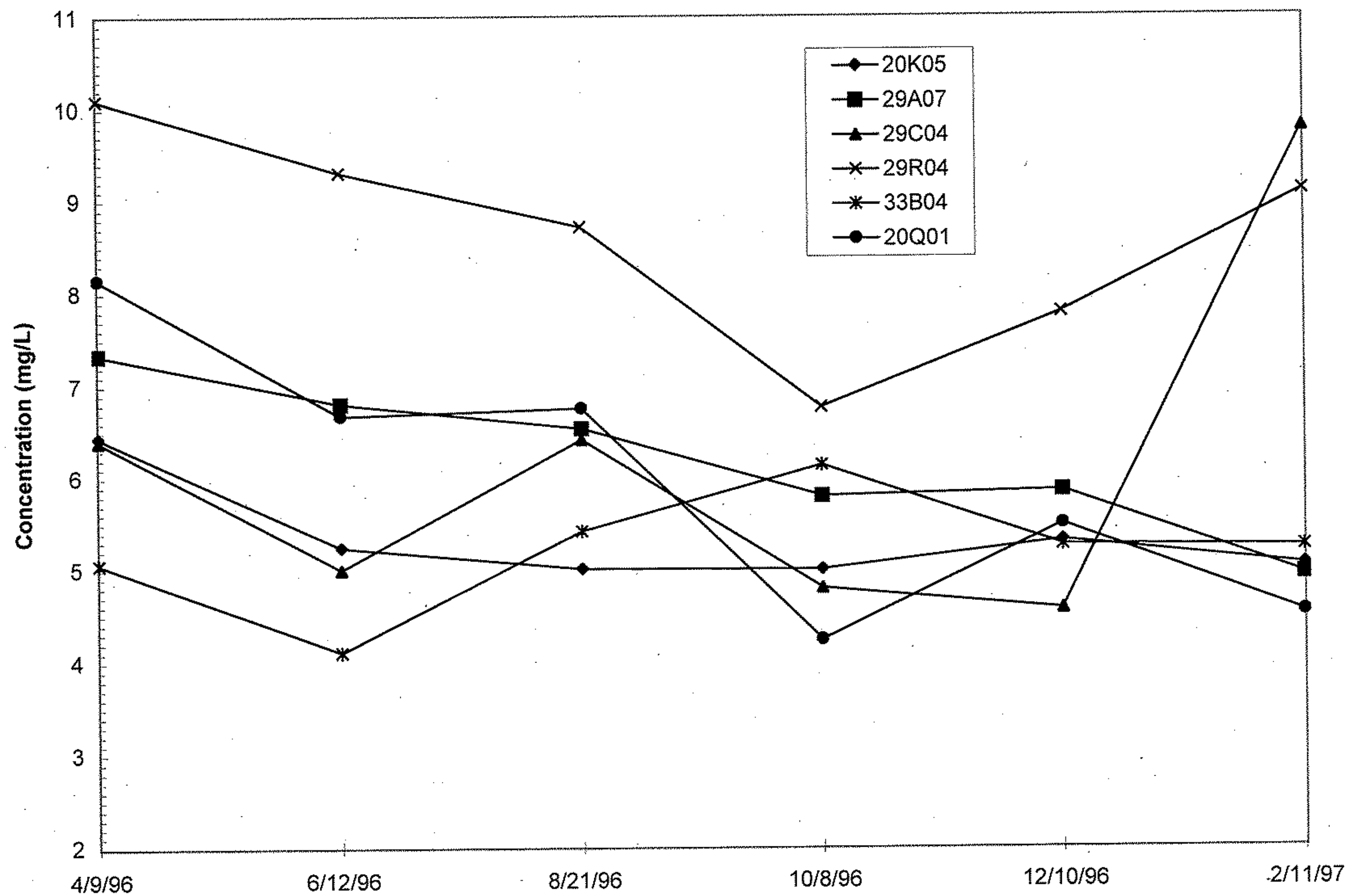

Figure 7. Nitrate+Nitrite-N at Selected Wells, Yelm Groundwater Baseline Sampling.

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) concentrations ranged from 67 to 158 mg/L with a mean of 110 mg/L. For groundwater these represent fairly low concentrations and are probably a function of rapid groundwater movement in the Yelm area and the proximity to recharge sources. The Drinking Water Standard for TDS is a Secondary MCL and is 500 mg/L (Chapter 246-290 and –291WAC). A Secondary MCL is not health based but instead is based on aesthetics such as taste, odor or staining.

Chloride

Chloride concentrations ranged from 1.2 to 17.3 mg/L with a mean of 4.9 mg/L. Chloride is considered a good tracer in groundwater because it is readily soluble in water and does not adsorb to soil particles. It is naturally occurring but is also present in human and animal wastes. The Secondary Drinking Water Standard for chloride is 250 mg/L (Chapter 246-290 and –291WAC).

Ammonium-N

Ammonium-N was detected in two wells for one sampling event for each well. Both detections, 0.014 and 0.015 mg/L, were only slightly above the method detection limit, 0.01 mg/L. Ammonium is an indicator of animal and human waste loading. Because ammonium does not readily move through groundwater, its presence in groundwater usually indicates proximity to a source area.

Fecal Coliform Bacteria

Fecal coliform bacteria were not detected in any samples during the study period. The presence of fecal coliform bacteria in groundwater usually indicates proximity to the source area.

Discussion

Groundwater quality in the study area is generally good. The susceptibility of the Recessional Outwash Aquifer to contamination is widely recognized by local well drillers and the public. Only one active well was found that obtained water from this aquifer. This well was used for irrigation and not drinking water. Most new wells in the area are completed in the Advance Outwash Aquifer or deeper aquifers. The nitrate concentrations in the Recessional Outwash Aquifer are largely unknown but because the aquifer is so shallow they are probably high locally. The one well sampled for this study that tapped the Recessional Outwash Aquifer had a mean nitrate+nitrite-N concentration of 3.5 mg/L.

Nitrate has migrated to the Advance Outwash Aquifer that occurs at a depth of 70 to 100 feet below the ground surface. Areas where nitrate+nitrite-N concentrations exceed 3 mg/L and 5 mg/L in the Advance Outwash Aquifer are shown in Figure 6. Using the potentiometric map (Figure 5) to define flow direction it is possible to identify the general area, upgradient of the elevated nitrate, where the nitrogen sources are located. Potential nitrogen sources within this area include:

- onsite sewage systems
- the poultry farm south of Bald Hill Road and west of the intersection of Bald Hill Road and Harris Road
- the poultry farm north of Bald Hill Road and north of the intersection of Bald Hill Road and 110th Avenue
- the abandoned poultry farm on Bald Hill Road and southeast of the intersection of Bald Hill Road and Harris Road,
- the livestock auction yard north of Highway 507

The presence of a preferred groundwater flowpath in the area north of Yelm is significant from a water quality perspective. A zone of hydraulically connected groundwater flows toward the preferred flowpath and eventually discharges at Crystal Springs. Water quality samples at Crystal Springs could be a convenient and cost-effective means to indicate changes in groundwater quality from this zone. However, because the areal extent drained by the preferred flow zone is not known, possible correlations of changes in groundwater quality with source activities are limited.

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Appendices

APPENDIX A

Table A-1. Well Construction Data for Sampled Wells.

Table A-2. Elevation of the Top of Hydrogeologic Units.

Table A-3. Yelm Wells Specific Capacity Tests and Hydraulic Conductivity Results.

Table A-4. Water-Level Elevations, April 1996.

Table A-1. Well Construction Data for Sampled Yelm Wells.

Local ID	State Plane X	State Plane Y	Altitude MSL (Feet)	Date Drilled	Open Interval	Static Water Level	Water-Bearing Zone	Remarks
T17N/R2E-20A02	1478588	596152	340	12/23/92	55	30	AO	Unconfined
T17N/R2E-20F03	1480866	595967	335	04/24/89	115.3	32	AO	Unconfined
T17N/R2E-20J02	1482642	593977	340	10/1/89	53-58	36	TILL	Water level only.
T17N/R2E-20K05	1480245	594357	345	03/10/83	119	44	AO	
T17N/R2E-20N03	1479470	592765	343	1960's	21	13	RO	Unconfined
T17N/R2E-20Q01	1481838	593172	340	11/25/78	90	40	AO	
T17N/R2E-20Q04	1480202	593991	350	09/25/73	58	39	AO	
T17N/R2E-28M04	1483648	589043	360	07/06/93	96	59	AO	
T17N/R2E-29A05	1483465	591308	350	06/30/95	106	56	AO	
T17N/R2E-29A07	1482347	591980	350	04/23/85	101	40	AO	
T17N/R2E-29B04	1482532	590351	350	6/1/05	85	---	AO	Depth reported.
T17N/R2E-29C03	1479974	591704	348	07/19/84	40-80	31	AO	Sampled once.
T17N/R2E-29C04	1480929	591605	348	9/17/79	100	38	AO	
T17N/R2E-29J03	1482502	588640	357	08/06/86	96	36	AO	
T17N/R2E-29R04	1483135	587912	365	04/23/94	100	38	AO	
T17N/R2E-29R05	1482006	587996	362	01/11/95	85	25.8	AO	
T17N/R2E-30E04	1472870	589934	362	04/15/92	97	29	AO	
T17N/R2E-30H05	1475196	588855	362	06/22/87	49	27	AO	
T17N/R2E-32A03	1482263	586412	360	3/28/75	80	42	AO	
T17N/R2E-32G03	1480739	583955	362	09/02/92	93	32	AO	
T17N/R2E-32H02	1483167	585260	360	04/20/84	80	28	AO	
T17N/R2E-33B04	1487842	586405	385	10/04/94	118	59	AO	
T17N/R2E-33B05	1486512	584862	390	06/10/86	118	48	AO	
T17N/R2E-33D08	1484463	585684	370	12/14/88	105	43	AO	
T17N/R2E-33N03	1486079	580520	430	05/19/92	109	75	AO	

RO= Recessional Outwash Aquifer

AO= Advance Outwash Aquifer

Table A-2. Elevation of the Top of Hydrogeologic Units.

Well ID	Aquifer	X	Y	RO	TILL	Inter-TILL	TILL	AO	L.AQTRD	DEEP	D.AQTRD	BOTTOM
17N/02E-19N01	AO	1473978	593307.8	345	334	-	-	310	283	-	-	282
17N/02E-20A02	AO	1478588	596151.6	-	-	-	-	340	-	-	-	285
17N/02E-20C04	DEEP	1480660	597072.3		331	-	-	310	264	226	-	213
17N/02E-20F03	AO	1480866	595966.6		335	-	-	313	-	-	-	291
17N/02E-20J02	TILL	1482642	593977.4	340	301	289	-	-	-	-	-	282
17N/02E-20J04	DEEP	1482642	593977.4	340	300	289	282	246	190	173	-	145
17N/02E-20J05	AO	1482792	593611.3	340	324	263	259	254	-	-	-	223
17N/02E-20K05	AO	1480245	594357.3	345	319	-	-	267	-	-	-	226
17N/02E-20L05	AO	1482565	593433.1		355	315	295	264	-	-	-	
17N/02E-20N03	RO	1479470	592765.1	343	-	-	-	-	-	-	-	322
17N/02E-20P03	AO	1479471	592271.4	345	332	-	-	304	-	-	-	247
17N/02E-20Q01	AO	1481838	593172.4	340	333	298	295	248	-	-	-	237
17N/02E-20Q03	AO	1480693	593295.1	350	332	-	-	266	238	-	-	235
17N/02E-20Q04	AO	1480202	593990.9	-	350	-	-	294	-	-	-	288
17N/02E-28E03	AO	1483620	589389.1	362	330	-	-	270	-	-	-	247
17N/02E-28M04	AO	1483648	589043.4	360	341	-	-	282	-	-	-	264
17N/02E-28R02	AO	1488184	586996.3	380	-	-	368	357	-	-	-	266
17N/02E-29A05	AO	1483465	591308.5	350	316	-	-	278	242	-	-	230
17N/02E-29A06	AO	1482806	590831.8	-	360	-	-	265	-	-	-	252
17N/02E-29A07	AO	1482347	591980.5	-	350	-	-	260	-	-	-	249
17N/02E-29A08	DEEP	1483185	591328	360	319	303	298	250	239	202		197
17N/02E-29B01	DEEP	1481718	591938.6	348	343	-	-	268	248	223	214	208
17N/02E-29B02	DEEP	1482450	590467.4	350	336	315	245	235	-	-	-	212
17N/02E-29B05	AO	1481178	591967.2	348	334	-	-	318	295	-	-	288
17N/02E-29C04	AO	1480929	591604.9	-	-	-	-	348	-	-	-	248
17N/02E-29C02	AO	1479788	592048.6	348	339	-	-	272	-	-	-	265
17N/02E-29C03	AO	1479974	591703.8	-	348	-	-	308	-	-	-	260
17N/02E-29HO1D1	DEEP	1483714	590870.2	360	330	-	-	270	266	-	-	202
17N/02E-29J03	AO	1482502	588640.4	-	357	289	282	272	-	-	-	261
17N/02E-29J04	AO	1482785	588548.6	360	336	323	318	283	-	-	-	253
17N/02E-29R04	AO	1483135	587911.6	-	365	-	-	301	-	-	-	265
17N/02E-29R05	AO	1482006	587995.9	362	362	-	-	284	277	-	-	278
17N/02E-29R06	AO	1482495	587659.3	358	330	307	294	286	-	-	-	264

Table A-2. Elevation of the Top of Hydrogeologic Units.

Well ID	Aquifer	X	Y	RO	TILL	Inter-TILL	TILL	AO	L.AQTRD	DEEP	D.AQTRD	BOTTOM
17N/02E-30E04	AO	1472870	589934.2	-	362	307	298	272	265	-	-	262
17N/02E-30H05	AO	1475196	588855.3	-	362	-	-	325	-	-	-	313
17N/02E-30K04	AO	1475593	588323.8	362	315	-	-	308	-	-	-	286
17N/02E-30K06	AO	1476373	588665.8	-	362	-	-	315	-	-	-	304
17N/02E-30N02	AO	1473567	588228.9	390	365	-	-	265	-	-	-	250
17N/02E-30M02	AO	1472977	588892.6	-	360	341	337	284	-	-	-	257
17N/02E-31G03	DEEP	1475312	586188.2	-	455	-	-	420	325	317	-	275
17N/02E-32A03	AO	1482263	586411.6	360	337	-	-	288	-	-	-	275
17N/02E-32G02	AO	1480374	584000.4	-	360	-	-	337	-	-	-	288
17N/02E-32G03	AO	1480739	583955.1	-	362	-	-	342	-	-	-	269
17N/02E-32G04	AO	1481673	585267.3	-	368	-	-	315	-	-	-	295
17N/02E-32H02	AO	1483167	585260.2	-	360	-	-	292	-	-	-	280
17N/02E-32J01D1	AO	1483545	583446.8	374	358	346	329	314	-	-	-	274
17N/02E-32P01	AO	1479373	582330.3	375	310	-	-	275	-	-	-	243
17N/02E-33B04	AO	1487842	586405	385	380	-	-	287	-	-	-	265
17N/02E-33B05	AO	1486512	584861.8	390	383	333	327	280	-	-	-	272
17N/02E-33D08	AO	1484463	585684.4	370	364	319	308	292	265	-	-	262
17N/02E-33G01	AO	1486479	584966.8	390	378	311	304	280	270	-	-	267
17N/02E-33K05	AO	1487453	583414.6	371	343	-	-	316	301	-	-	291
17N/02E-33L03	AO	1485566	583276.9	-	368	-	-	323	-	-	-	308
17N/02E-33N03	AO	1486079	580519.8	-	430	-	-	343	321	-	-	313
17N/02E-33N06	AO	1486294	580316.9	-	440	-	-	362	348	-	-	344
RO= Recessional Outwash Aquifer												
AO= Advanced Outwash Aquifer												
DEEP=Deep Aquifer												
L.AQTRD= Lower Aquitard.												

Appendix A-3. Well-Yield Tests and Hydraulic Conductivity Results.

Well ID	Well Dia. (In.)	Static DTW (Feet)	Test DTW (Feet)	Test Duration (Hours)	Q (GPM)	Aquifer Thickness (Feet)	Open Interval (Feet)	Storage Coeff.	Well Loss	Hydraulic Conductivity (ft/day)	Open Interval Depth	Zone
17N/2E-19	8	22	30	18	30	14	0.67	0.001	1	255	93	AO
17N/2E-19C	8	20	40	1	58	10	10	0.001	1	58.2	48-58	TILL
17N/2E-19C	6	30	40	4	20	5	0.5	0.001	1	169	60	TILL
17N/2E-19H	6	60	100	1	60	6	0.5	0.001	1	118	140	DEEP
17N/2E-19H05	6	19	20	2	37	11	5	0.25	1	886	29-34	TILL
17N/2E-19J01	6	19	32	1	40	41	0.5	0.25	1	431	60	TILL
17N/2E-19J02	6	23	31	1	12	22	0.5	0.001	1	168	45	TILL
17N/2E-19J07	12	18	168	7	240	15	15	0.001	1	22.4	233-243,	DEEP
17N/2E-19N01	12	25.5	25.62	1	540	27	10	0.25	1	DNC	50-60	AO
17N/2E-19N01	12	25.5	25.62	4	540	27	10	0.25	1	DNC		AO
17N/2E-19N01	12	27.2	27.36	4	550	27	10	0.25	1	DNC	50-60	AO
17N/2E-19N02	12	25.02	30.22	1	1250	31	10.65	0.25	1	DNC	52-61	AO
17N/2E-19N02	12	25.02	30.22	4	1250	31	10.65	0.25	1	DNC	52-61	AO
17N/2E-19Q01	6	6	11	24	15	5	0.5	0.25	1	222	33	TILL
17N/2E-19Q01	6	6	14	1	24	5	0.5	0.25	1	191	33	TILL
17N/2E-20B	6	40	90	1	60	19	0.5	0.001	1	127	114	AO
17N/2E-20B	6	58	86	1	20	10	0.5	0.001	1	59.9	120	AO
17N/2E-20C	6	26	56	1.5	10	1.5	0.5	0.001	1	43.2	70.5	AO
17N/2E-20C	6	26	26.5	1	20	11.5	0.5	0.001	1	3740	53.5	TILL
17N/2E-20C04	6	60	63	1	3	13	0.5	0.001	1	91.7	118	AO
17N/2E-20D	6	18	35	1	15	10	0.5	0.001	1	74.3	64	AO
17N/2E-20D	6	96	107	1	4	13	0.5	0.001	1	32.9	114	AO
17N/2E-20G	6	60	85	1	15	56	0.5	0.001	1	94.7	116	AO
17N/2E-20G	8	20	46	1	12	37	0.67	0.001	1	41.9	65	AO
17N/2E-20G	6	52	81	1	15	12	0.5	0.001	1	45.7	103	AO
17N/2E-20G	6	35	70	1	10	57	0.5	0.001	1	45.3	104	AO
17N/2E-20J02	6	36	41	1	12	7	5	0.001	1	77.8	53-58	TILL
17N/2E-20J04	6	43	53	1	20	28	5	0.001	1	43.4	190-195	DEEP
17N/2E-20J05	6	51	69	1	15	31	0.5	0.001	1	106	117	AO
17N/2E-20K05	6	44	56	1	20	41	0.5	0.001	1	236	119	AO
17N/2E-20L05	6	22	80	1	7	31	0.5	0.001	1	15.3	91	AO

Appendix A-3. Well-Yield Tests and Hydraulic Conductivity Results.

Well ID	Well Dia. (In.)	Static DTW (Feet)	Test DTW (Feet)	Test Duration (Hours)	Q (GPM)	Aquifer Thickness (Feet)	Open Interval (Feet)	Storage Coeff.	Well Loss	Hydraulic Conductivity (ft/day)	Open Interval Depth	Zone
17N/2E-20N	6	23	25	1	30	10	0.5	0.001	1	1330	40	TILL
17N/2E-20N03	8	13	15	24	110	3	0.67	0.25	1	4800	21	RO
17N/2E-20N03	8	13	13.17	24	110	8	0.67	0.25	1	65900	21	RO
17N/2E-20Q01	6	40	65	1	15	11	11	0.001	1	10	70-90	AO
17N/2E-20Q04	6	39	47	1	20	4	0.5	0.001	1	212	58	AO
17N/2E-21L01	6	0	68	1	10	7	0.5	0.001	1	10.9	79	AO
17N/2E-28D	6	41	56	1	30	97	0.5	0.25	1	376	138	DEEP
17N/2E-28D	6	40	49	1	8	7	0.5	0.25	1	58.3	63	TILL
17N/2E-28E02	6	80	110	1	40	25	0.5	0.001	1	157	161	DEEP
17N/2E-28E03	6	65	110	1	10	23	0.5	0.001	1	25	115	AO
17N/2E-28E04	6	30	65	1	20	17	5	0.001	1	12.9	67-72	AO
17N/2E-28F	6	0	15	2	40	20	0.5	0.001	1	291	110	AO
17N/2E-28J	8	13	73	1	450	24	14.5	0.001	1	86.7	154.5-16	DEEP
17N/2E-28J	8	13	77	3	450	24	14.5	0.001	1	86.2	154.5-16	DEEP
17N/2E-28J	8	13	80	24	450	24	14.5	0.001	1	91.6	154.5-16	DEEP
17N/2E-28M02	6	45	57	1	15	14	0.5	0.001	1	118	77	AO
17N/2E-28M04	6	59	75	1	12	18	0.5	0.001	1	77.4	96	AO
17N/2E-28M05	6	27	51	1	50	15	5	0.001	1	51	148-153	DEEP
17N/2E-28M05	6	27	53	2	50	15	5	0.001	1	48.3	148-153	DEEP
17N/2E-28M05	6	27	53.5	3	50	15	5	0.001	1	48.2	148-153	DEEP
17N/2E-28M05	6	27	53.55	4	50	15	5	0.001	1	48.7	148-153	DEEP
17N/2E-28M06	6	43	80	1	15	27	0.5	0.001	1	48.8	118	AO
17N/2E-28N	6	35	60	3	40	4	0.5	0.001	1	140	160	DEEP
17N/2E-28Q	8	52	104	4	105	9	5	0.001	1	58.9	133	AO
17N/2E-28R01	8	49	49.5	1	60	11	5	0.001	1	3830	76-81	AO
17N/2E-28R01	8	49	49.5	1	60	11	0.67	0.001	1	8250	76	AO
17N/2E-29A06	6	59	74	1	10	13	0.5	0.001	1	60.8	108	AO
17N/2E-29B02	6	37	97	1	15	23	0.5	0.001	1	28.2	138	DEEP
17N/2E-29B05	6	15	40	1	11	23	0.5	0.001	1	49.8	50	AO
17N/2E-29C02	6	28	70	1	10	7	0.5	0.001	1	17.9	80	AO
17N/2E-29C03	8	31	45	1	30	48	40	0.001	1	9.6	40-80	AO

Appendix A-3. Well-Yield Tests and Hydraulic Conductivity Results.

Well ID	Well Dia. (In.)	Static DTW (Feet)	Test DTW (Feet)	Test Duration (Hours)	Q (GPM)	Aquifer Thickness (Feet)	Open Interval (Feet)	Storage Coeff.	Well Loss	Hydraulic Conductivity (ft/day)	Open Interval Depth	Zone
17N/2E-29C04	6	38	71	1	15	62	0.5	0.25	1	73.6	100	AO
17N/2E-29H01	8	26	33	3	40	4	0.67	0.001	1	438	94	AO
17N/2E-29J	6	55	85	1	20	7	0.5	0.001	1	51.6	100	AO
17N/2E-29J01	6	30	60	1	20	6	0.5	0.001	1	50.9	96	AO
17N/2E-29J04	6	26	69	1	30	41	0.5	0.001	1	98.6	107	AO
17N/2E-29Q	6	17	45	1	15	12	0.5	0.001	1	47.4	58	TILL
17N/2E-29R01	6	12	67	2	8	12	0.5	0.001	1	12.8	76	AO
17N/2E-30F03	6	80	101	1	40	6	0.5	0.001	1	151	138	DEEP
17N/2E-30H02	8	40	96	2	30	8	0.67	0.001	1	30.5	136	DEEP
17N/2E-30R01	6	98	104	1	15	2	0.5	0.001	1	300	118	AO
17N/2E-31H03	6	55	75	1	20	6	0.5	0.001	1	77.4	99	AO
17N/2E-31H04	6	36	36.5	1	20	5	0.5	0.001	1	3600	60	TILL
17N/2E-32K01	6	90	90.5	1	60	5	0.5	0.001	1	11600	105	AO
17N/2E-33A02	6	55	65	1	30	4	0.5	0.001	1	256	127	AO
17N/2E-33N01	6	54	70	1	8	12	0.5	0.001	1	44.2	80	AO
17N/2E-34F02	6	43	48	1	20	4	0.5	0.25	1	257	58	TILL
17N/2E-34G02	6	30	30.5	1	30	3	0.5	0.001	1	6770	50	TILL
17N/2E-34H02	6	28	30	1	16	5	0.5	0.001	1	676	40	TILL
17N/2E-34N01	8	43	59	1	45	11	0.67	0.001	1	171	97	AO

DNC= Did not converge, no solution.

Table A-4. Water-Level Elevations, April 1996					
			Measuring Point Elevation (MSL, Feet)	Depth to Water (Feet)	Water-Level Elevation (MSL,Feet)
Well ID	State Plane X	State Plane Y			
YE20A02	1478588	596152	340	20.07	319.93
YE20F03	1480866	595967	335	28.83	306.17
YE20K05	1480245	594357	345	26.63	318.37
YE20N03	1479470	592765	343	7.48	335.52
YE20Q04	1480202	593991	350	26.03	323.97
YE28M04	1483648	589043	360	22.44	337.56
YE29A07	1482347	591980	350	36.27	313.73
YE29R05	1482006	587996	362	16.87	345.13
YE29R04	1483135	587912	365	27.5	337.5
YE30E04	1472870	589934	362	25.18	336.82
YE30H05	1475196	588855	362	24.42	337.58
YE32A03	1482263	586412	360	14.79	345.21
YE33B04	1487842	586405	385	27.37	357.63
YE33N03	1486079	580520	430	68.1	361.9
YE20J02	1482642	593977	340	33.88	306.12

APPENDIX B

Sampling and Testing Procedures

Samples were obtained using standard groundwater sampling procedures for the parameters to be tested.

Water levels were measured in each accessible well prior to sampling using a commercial electric probe. Measurements were recorded to 0.01 feet and were accurate to 0.03 feet. Well volumes were calculated using the height of water in the well casing above the bottom of the well.

Wells were purged a minimum of three well volumes and until specific conductance, pH, temperature measurements stabilized (changes of 10% or less between well volumes). Meters and precision for field parameters are listed in Table B-1. Samples were placed in bottles obtained from Manchester Environmental Laboratory. Bottle materials and preservatives for the target analytes are listed in Table B-2.

Table B-1. Field parameters, meters, and measurement precision.

Parameters	Meter	Precision
Specific Conductance	Beckman Conductivity Bridge	10 micromhos/cm
pH	Orion Model 9107	0.1 Std Unit
Temperature	Orion Model 9107	0.1 °C

Table B-2. Bottles, holding times and preservatives for Yelm target analytes.

Parameter	Bottle	Holding Time	Preservative
Nitrate+Nitrite-N	125 mL clear, w/m polyethylene	28 days	Sulfuric acid to pH<2, Cool to 4°C
Chloride	1000 mL polyethylene	28 days	Cool to 4°C
Fecal Coliform	250 mL sterile glass	30 hours	Cool to 4°C
Total Dissolved Solids	1000 mL polyethylene	28 days	Cool to 4°C

All samples were immediately placed in coolers with ice and transported to the Ecology Headquarters building in Lacey at the end of each day of sampling. Samples were left in the walk-in cooler until picked up by the laboratory courier to Ecology/EPA Manchester Environmental Laboratory in Manchester, Washington.

Samples were tested for the target parameters at the Ecology/EPA Manchester Environmental Laboratory The target parameters, test methods and method detection limits are listed in Table B-3.

Table B-3. Target parameters, test methods and method detection limits.

Target Parameter	Test Method EPA Method/Standard Methods	Method Detection Limit (mg/L)
Nitrate+Nitrite-N	EPA 353.2/4500 NO3 F	0.01
Chloride	EPA 330.0/4110B	0.1
Fecal Coliform Bacteria	Membrane Filter 9222D	1CFU/100mL
Total Dissolved Solids	EPA 160.1/2540C	1

CFU= Colony forming unit.

APPENDIX C
Quality Assurance

Field

Field quality assurance samples consisted of one duplicate sample per ten well samples. Duplicate samples for this project are defined as two sequential samples obtained from the same well using identical sampling procedures. The duplicate sample results are used to estimate combined sampling and analytical precision. The relative percent difference (RPD) of the mean, the ratio of the difference and mean of duplicate results expressed as a percentage, is used to describe the precision of duplicate results. Low RPD's indicate high precision and high RPD's indicate poor precision. RPDs for nitrite+nitrate-N, total dissolved solids, and chloride calculated for each of the duplicate samples are shown in Table C-1. The precision for field duplicates was very good with RPDs ranging from 0 to 8% for nitrate+nitrite-N, 0 to 3% for total dissolved solids, and 0.1 to 1.7% for chloride

Laboratory

Copies of quality assurance reviews by Manchester Laboratory for each sampling event are shown in Appendix C. All analyses were performed within established EPA holding times. All initial and continuing calibration verification standards and blanks were within USEPA Contract Laboratory Program control limits Laboratory quality control tests are done on each set of 20 or fewer samples and consisted of duplicate blanks, duplicate samples, a spiked sample, and a check (control) standard. Manchester Laboratory's quality control samples and procedures are discussed in Quality Assurance Manual, Manchester Environmental Laboratory (1988). All spike recoveries were within the acceptance limit of ± 25%. Laboratory duplicate results were within the ± 20% acceptance window. Procedural blanks showed no analytical significant levels of analytes. Laboratory control sample analyses were within their acceptance windows of ± 20%.

Table C-1. Yelm Ground-Water Quality Assessment, Quality Assurance Results.							
		NO2/NO3-N		Total Diss. Solids		Chloride	
Site ID	Date	Value	RPD	Value	RPD	Value	RPD
YE32H02	4/8/96	1.18		94		3.11	
YE32H02	4/8/96	1.23	4.1	94	0.0	3.13	0.2
YE29C03	4/16/96	4.36		106		5.44	
YE29C03	4/16/96	4.32	0.9	107	0.2	5.43	0.0
YE32H02	6/10/96	0.949		99		3.48	
YE32H02	6/10/96	1	5.2	103	1.0	3.32	1.2
YE29R05	8/20/96	3.12		112		3.77	
YE29R05	8/20/96	3.23	3.5	119	1.5	3.63	0.9
YE29C04	8/21/96	6.5		120		7.36	
YE29C04	8/21/96	6.33	2.7	113	1.5	7.33	0.1
YE20F03	8/22/96	3.15		104		4.42	
YE20F03	8/22/96	2.93	7.2	109	1.2	4.3	0.7
YE29R05	10/7/96	3.13		120		3.85	
YE29R05	10/7/96	3.16	1.0	127	1.4	3.88	0.2
YE20Q04	10/8/96	5.09		121		6.95	
YE20Q04	10/8/96	4.69	8.2	122	0.2	6.89	0.2
YE29A07	10/8/96	5.77		132		8.02	
YE29A07	10/8/96	5.84	1.2	128	0.8	8.01	0.0
YE32H02	12/9/96	1.13		99		3.1	
YE32H02	12/9/96	1.08	4.5	97	0.5	3.2	0.8
YE29A07	12/10/96	5.86		108		6.41	
YE29A07	12/10/96	5.86	0.0	106	0.5	6.51	0.4
YE20F03	12/11/96	2.87		103		4.5	
YE20F03	12/11/96	2.95	2.7	106	0.7	4.42	0.4
YE32A03	2/10/97	0.564		82		1.73	
YE32A03	2/10/97	0.576	2.1	72	3.2	1.72	0.1
YE20A02	2/11/97	4.6		111		5.56	
YE20A02	2/11/97	4.4	4.4	106	1.2	5.2	1.7
YE29A07	2/11/97	4.84		118		6.29	
YE29A07	2/11/97	5.03	3.9	119	0.2	6.19	0.4

RPD = Relative percent difference of the mean, the ratio of the difference and mean of duplicate results expressed as a percentage.

Washington State Department of Ecology
Manchester Laboratory

April 30, 1996

TO: Denis Erickson

FROM: Becky Bogaczyk, Chemist

SUBJECT: General Chemistry Quality Assurance memo for Yelm Groundwater, week 16

SUMMARY

The data generated by the analysis of these samples can be used noting the qualifications discussed in this memo. All analyses requested were evaluated by established regulatory quality assurance guidelines

SAMPLE INFORMATION

Samples for Yelm Groundwater week 16 project were received by Manchester Laboratory on 04/17/96 in good condition.

HOLDING TIMES

All analyses were performed within established EPA holding times.

ANALYSIS PERFORMANCE

Instrument Calibration

Where applicable, instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. All initial and continuing calibration verification standards were within USEPA Contract Laboratory Program (CLP) control limits. A correlation coefficient of 0.995 or greater was met as stated in CLP calibration requirements.

Procedural Blanks

The procedural blanks associated with these samples showed no analytical significant levels of analytes.

Spiked Sample Analysis

Spike samples were performed where applicable with all spike recoveries within acceptance limits of ± 25%.

Precision Data

Spike sample results, where applicable, and duplicate sample results were used to evaluate precision on this sample set. Relative Percent Difference (RPD) for all parameters was within the 20% acceptance window for all duplicate analysis. Laboratory duplication is performed at a frequency of at least 10%.

Laboratory Control Sample (LCS) Analyses

LCS analyses were within the windows established for each parameter.

Other Quality Assurance Measures and Issues

Please call Becky Bogaczyk at SCAN (360) 871-8830 to further discuss this project.

cc: Bill Kammin
    Project File

Data in Access

Washington State Department of Ecology
Manchester Laboratory

July 18, 1996

TO: Denis Erickson

FROM: Nancy Jensen, Microbiologist NJ

SUBJECT: General Chemistry Quality Assurance memo for Yelm Groundwater-24..

SUMMARY

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

SAMPLE INFORMATION

These samples were received by the Manchester Laboratory on 06/11/96 in good condition.

HOLDING TIMES

Analysis of all parameters was performed within all applicable EPA holding times.

ANALYSIS PERFORMANCE

Instrument Calibration

Where applicable, instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. A correlation coefficient of 0.995 or greater was met as stated in CLP calibration requirements.

Spiked Sample Analysis

All spiked samples were within acceptable limits.

Procedural Blanks

All procedural blanks were within acceptable limits.

Precision Data

Spike sample results and duplicate sample results were used to evaluate precision on this sample set. Relative Percent Difference (RPD) for all analytes were within the 20% acceptance window for duplicate analysis. Fecal coliforms RPD acceptance window is 40%. Laboratory duplication is done at a frequency of at least 10%.

Laboratory Control Sample (LCS) Analyses

LCS analyses were within the established windows.

Other Quality Assurance Measures and Issues

Please call Becky Bogaczyk at SCAN (360) 871-8830 to further discuss this project.

cc: Project File

Data in Access

Washington State Department of Ecology
Manchester Laboratory

September 18, 1996

TO: Denis Erickson

FROM: Becky Bogaczyk, Chemist

SUBJECT: General Chemistry Quality Assurance memo for Yelm Groundwater, week 34

SUMMARY

The data generated by the analysis of these samples can be used noting the qualifications discussed in this memo. All analyses requested were evaluated by established regulatory quality assurance guidelines.

SAMPLE INFORMATION

Samples for Yelm Groundwater week 34 project were received at Manchester Laboratory on 08/21-23/96 in good condition.

HOLDING TIMES

All analyses were performed within established EPA holding times.

ANALYSIS PERFORMANCE

Instrument Calibration

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. All initial and continuing calibration verification standards were within USEPA Contract Laboratory Program (CLP) control limits. A correlation coefficient of 0.995 or greater was met as stated in CLP calibration requirements.

Procedural Blanks

The procedural blanks associated with these samples showed no analytical significant levels of analytes.

Spiked Sample Analysis

Spike samples were performed with all spike recoveries within acceptance limits of ± 25%.

Precision Data

Results from duplicate analysis were used to evaluate precision. Duplicate analyses of all parameters were within acceptable limits.

Laboratory Control Sample (LCS) Analysis

All laboratory controls were within acceptance windows.

Other Quality Assurance Measures and Issues

All nutrient samples with a "U" qualifier have a result less than the detection limit of 0.01 mg/L.

All fecal samples with a "U" qualifier have a result less than the detection limit of 1/100 mL.

Call Nancy Jensen at (360) 871-8810 if you have any questions.

cc: Bill Kammin
Project File.

Washington State Department of Ecology
Manchester Laboratory

Data in Access Database

November 5, 1996

TO: Denis Erickson

FROM: Debbie Lacroix, Chemist DL

SUBJECT: General Chemistry Quality Assurance memo for the Yelm Groundwater Project

SUMMARY

The data generated by the analysis of these samples can be used without qualifications.

SAMPLE INFORMATION

Samples 96418070-95 from the Yelm Groundwater Project were received by the Manchester Laboratory on 10/8 and 10/9-96 in good condition.

HOLDING TIMES

All analyses were performed within applicable EPA holding times.

ANALYSIS PERFORMANCE

Instrument Calibration

Where applicable, instrument calibration was performed before each analysis and verified by initial and verification standards and blanks. All initial and continuing calibration verification standards were within the relevant EPA control limits. A correlation of 0.995 or greater was met as stated in CLP calibration requirements. All balances are calibrated yearly with calibration verification performed monthly.

Procedural Blanks

All procedural blanks were within acceptable limits.

Spiked Sample Analysis

All spikes were within the acceptance windows of ±25%.

Precision Data

The results of the duplicate analysis of samples were used to evaluate the precision on this sample set. The Relative Percent Differences (RPD) were within their acceptance windows of +/- 20 %.

Laboratory Control Sample (LCS) Analyses

LCS analyses were within their acceptance windows of +/- 20 %.

Please call Debbie Lacroix at SCAN 871-8812 with any questions or concerns about this project.

cc: Project File

Data in
Data Base

Washington State Department of Ecology
Manchester Laboratory

January 16,1997

TO: Denis Erickson

FROM: Casey Maggart, Chemist

SUBJECT: General Chemistry Quality Assurance memo for Yelm Groundwater

SUMMARY

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo. All analyses requested were evaluated using USEPA Contract Laboratory Program (CLP) quality assurance requirements.

Sample Information

These samples from the Yelm Groundwater project were received by the Manchester Laboratory on 12/10/96 through 12/12/96 in good condition.

Holding Times

Analysis of all parameters was performed within USEPA established holding times.

ANALYSIS PERFORMANCE

Instrument Calibration

Where applicable, instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. A correlation coefficient of 0.995 or greater was met as stated in CLP calibration requirements. The turbidimeter is calibrated bi-annually as stated in the manufacturer's recommendations. All balances are calibrated yearly with calibration verification occurring monthly. Oven temperatures are recorded before and after analyses to insure control.

Procedural Blanks

The procedural blanks associated with these samples showed no analytically significant levels of analytes.

Spiked Sample Analysis

Spike sample analyses were performed on the nutrients on this data set. All spike recoveries were within the CLP acceptance limits of +/- 25%.

Precision Data

The Relative Percent Difference (RPD) for all parameters were within their acceptance windows except for TDS sample 508230 which was qualified with a "J". The sample is qualified as an estimate because the replicate falls outside of the acceptance windows.

Laboratory Control Sample Analyses

LCS analyses were within the windows established for each parameter.

Other Quality Assurance Measures and Issues

All nutrient samples with a "U" qualifier have a result less than the detection limit of 0.01 mg/L.

All Fecal samples with a "U" qualifier have a result less than the detection limit of 1.0/100mL.

Please call Casey Maggart at SCAN 871-8824 to further discuss this project.

cc: Bill Kammin

Entered in Database

Washington State Department of Ecology
Manchester Laboratory

March 12, 1997

TO: Denis Erickson

FROM: Becky Bogaczyk, Chemist

SUBJECT: General Chemistry Quality Assurance memo for Yelm Groundwater, week 07

SUMMARY

The data generated by the analysis of these samples can be used noting the qualifications discussed in this memo. All analyses requested were evaluated by established regulatory quality assurance guidelines

SAMPLE INFORMATION

Samples for Yelm Groundwater week 07 project were received by Manchester Laboratory on 02/11/97 in good condition.

HOLDING TIMES

All analyses were performed within established EPA holding times.

ANALYSIS PERFORMANCE

Instrument Calibration

Where applicable, instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. All initial and continuing calibration verification standards were within control limits. A correlation coefficient of 0.995 or greater was met .

Procedural Blanks

The procedural blanks associated with these samples showed no significant analytical levels of analytes.

Spiked Sample Analysis

Spike samples were performed where applicable with all spike recoveries within acceptance limits of ± 25%.

Precision Data

Spike sample results, where applicable, and duplicate sample results were used to evaluate precision on this sample set. Relative Percent Difference (RPD) for all parameters was within the 20% acceptance window for all duplicate analysis. Laboratory duplication is performed at a frequency of at least 10%.

Laboratory Control Sample (LCS) Analyses

LCS analyses were within the windows established for each parameter.

Other Quality Assurance Measures and Issues

The "U" qualification indicates the analyte was not detected at or above the reported result.

Please call Becky Bogaczyk at (360) 871-8830 to further discuss this project.

cc: Project File

APPENDIX D

Table D-1. Yelm Groundwater Quality Results, April 1996 through February 1997.

Table D-1. Yelm Groundwater Quality Results, April 1996 through February 1997.

Site ID	Date	Nitrate+ Nitrite-N (mg/L)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Ammonium-N (mg/L)	Fecal Coliforms (CFU/100mL)
YE20A02	4/10/96	6.3	111	5.68	0.01 U	1 U
YE20A02	6/11/96	4.75	104	5.15	0.01 U	1 U
YE20A02	8/22/96	4.23	104	5.03	0.01 U	1 U
YE20A02	10/8/96	3.49	103	5.01	0.01 U	1 U
YE20A02	12/10/96	5.02	98	5.75	0.01 U	1 U
YE20A02	2/11/97	4.5	108.5	5.38	0.01 U	1 U
YE20F03	4/10/96	3.16	101	4.12	0.01 U	1 U
YE20F03	6/11/96	3.04	105	4.27	0.01 U	1 U
YE20F03	8/22/96	3.04	106.5	4.36	0.01 U	1 U
YE20F03	10/8/96	2.76	113	4.46	0.01 U	1 U
YE20F03	12/11/96	2.91	104.5	4.46	0.01 U	1 U
YE20F03	2/11/97	2.88	121	4.58	0.01 U	1 U
YE20K05	4/9/96	6.44	129	6.33	0.01 U	1 U
YE20K05	6/12/96	5.24	103	6.05	0.01 U	1 U
YE20K05	8/21/96	5.01	126	6.18	0.01 U	1 U
YE20K05	10/8/96	5	124	7.0	0.01 U	1 U
YE20K05	12/10/96	5.31	111	7.63	0.01 U	1 U
YE20K05	2/11/97	5.04	118	6.52	0.01 U	1 U
YE20N03	4/9/96	3.19	93	4.59	0.01 U	1 U
YE20N03	6/11/96	2.56	78	4.52	0.01 U	1 U
YE20N03	8/22/96	4.34	104	6.11	0.01 U	1 U
YE20N03	10/8/96	3.89	111	6.06	0.01 U	1 U
YE20N03	12/19/96	2.72	98	4.71	0.01 U	1 U
YE20N03	2/11/97	4.48	112	5.58	0.01 U	1 U
YE20Q01	4/9/96	8.15	142	7.11	0.01 U	1 U
YE20Q01	6/11/96	6.68	117	6.75	0.01 U	1 U
YE20Q01	8/21/96	6.76	126	7.0	0.01 U	1 U
YE20Q01	10/8/96	4.24	131	7.18	0.01 U	1 U
YE20Q01	12/10/96	5.49	107	5.96	0.01 U	1 U
YE20Q01	2/11/97	4.53	123	6.11	0.01 U	1 U
YE20Q04	4/9/96	7.65	144	6.82	0.01 U	1 U
YE20Q04	6/12/96	5.95	116	6.31	0.01 U	1 U
YE20Q04	8/21/96	5.07	121	6.2	0.01 U	1 U
YE20Q04	10/8/96	4.89	121.5	6.92	0.01 U	1 U
YE20Q04	12/10/96	5.86	112	6.9	0.01 U	1 U
YE20Q04	2/11/97	6.27	127	6.82	0.01 U	1 U
YE28M04	4/10/96	0.427	86	1.25	0.01 U	1 U
YE28M04	6/11/96	0.477	70	1.44	0.01 U	1 U
YE28M04	8/21/96	0.463	78	1.41	0.01 U	1 U
YE28M04	10/7/96	0.437	96.5	1.3	0.01 U	1 U
YE28M04	12/10/96	0.498	78	1.4	0.01 U	1 U
YE28M04	2/10/97	0.494	72	1.37	0.01 U	1 U
YE29A05	4/9/96	0.301	90	1.36	0.01 U	1 U
YE29A05	6/11/96	0.353	70	1.49	0.01 U	1 U
YE29A05	8/21/96	0.332	81	1.61	0.01 U	1 U
YE29A05	10/8/96	0.281	87	1.65	0.01 U	1 U
YE29A05	12/10/96	0.695	73	1.85	0.01 U	1 U
YE29A05	2/11/97	0.281	84	1.51	0.01 U	1 U
YE29A07	4/9/96	7.34	136	8.01	0.01 U	1 U
YE29A07	6/11/96	6.81	120	7.45	0.01 U	1 U
YE29A07	8/21/96	6.54	128	7.59	0.01 U	1 U
YE29A07	10/8/96	5.805	130	8.015	0.01 U	1 U
YE29A07	12/10/96	5.86	107	6.46	0.01 U	1 U
YE29A07	2/11/97	4.935	118.5	6.24	0.01 U	1 U

Table D-1. Yelm Groundwater Quality Results, April 1996 through February 1997.

Site ID	Date	Nitrate+ Nitrite-N (mg/L)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Ammonium-N (mg/L)	Fecal Coliforms (CFU/100mL)
YE29B04	4/10/96	4.47	100	5.3	0.01 U	1 U
YE29B04	6/11/96	2.44	78	3.19	0.01 U	1 U
YE29B04	8/21/96	2.7	79	3.1	0.01 U	1 U
YE29B04	10/8/96	2.43	97	2.91	0.01 U	1 U
YE29B04	12/10/96	1.74	69	2.35	0.01 U	1 U
YE29B04	2/11/97	3.37	102	4.07	0.01 U	1 U
YE29C03	4/16/96	4.34	106.5	5.435	0.01 U	1 U
YE29C04	4/9/96	6.4	122	6.95	0.01 U	1 U
YE29C04	6/11/96	5	98	6.54	0.01 U	1 U
YE29C04	8/21/96	6.415	116.5	7.345	0.01 U	1 U
YE29C04	10/8/96	4.8	129	10.2	0.01 U	1 U
YE29C04	12/10/96	4.57	110	7.32	0.01 U	1 U
YE29C04	2/11/97	9.79	157	8.61	0.01 U	1 U
YE29J03	4/10/96	0.811	87	1.54	0.01 U	1 U
YE29J03	6/11/96	0.752	77	1.64	0.01 U	1 U
YE29J03	8/20/96	0.687	95	1.61	0.01 U	1 U
YE29J03	10/7/96	0.692	97	1.55	0.01 U	1 U
YE29J03	12/9/96	0.765	80	1.66	0.01 U	1 U
YE29J03	2/10/97	0.858	82	1.64	0.01 U	1 U
YE29R04	4/10/96	10.1	148	12.1	0.01 U	1 U
YE29R04	6/11/96	9.31	132	11.7	0.01 U	1 U
YE29R04	8/20/96	8.72	158	9.53	0.01 U	1 U
YE29R04	10/7/96	6.77	146	8.99	0.01 U	1 U
YE29R04	12/9/96	7.79	142	12.7	0.01 U	1 U
YE29R04	2/10/97	9.1	134	10.8	0.01 U	1 U
YE29R05	4/8/96	3.61	105	3.8	0.01 U	1 U
YE29R05	6/10/96	3.61	108	3.99	0.01 U	1 U
YE29R05	8/20/96	3.175	115.5	3.7	0.01 U	1 U
YE29R05	10/7/96	3.145	123.5	3.865	0.01 U	1 U
YE29R05	12/9/96	3.42	106	3.94	0.01 U	1 U
YE29R05	2/10/97	3.51	103	4.22	0.01 U	1 U
YE30E04	4/10/96	0.527	114	3.15	0.01 U	1 U
YE30E04	6/10/96	0.476	114	3.32	0.01 U	1 U
YE30E04	8/21/96	0.418	114	3.28	0.01 U	1 U
YE30E04	10/8/96	0.412	114	3.24	0.01 U	1 U
YE30E04	12/11/96	0.478	116	3.32	0.01 U	1 U
YE30E04	2/11/97	0.538	130	3.44	0.01 U	1 U
YE30H05	4/10/96	1.37	67	4.14	0.01 U	1 U
YE30H05	6/10/96	1.1	69	3.55	0.01 U	1 U
YE30H05	8/21/96	2.4	94	6.11	0.01 U	1 U
YE30H05	10/8/96	2.17	98.5	6.39	0.01 U	1 U
YE30H05	12/10/96	2.58	82	5.58	0.01 U	1 U
YE30H05	2/11/97	2.37	99	6.03	0.01 U	1 U
YE32A03	4/8/96	0.529	80	1.61	0.01 U	1 U
YE32A03	6/10/96	0.53	81	1.76	0.01 U	1 U
YE32A03	8/20/96	0.524	89	1.72	0.01 U	1 U
YE32A03	10/7/96	0.495	92	1.64	0.01 U	1 U
YE32A03	12/9/96	0.533	80	1.75	0.01 U	1 U
YE32A03	2/10/97	0.57	77	1.725	0.01 U	1 U
YE32G03	4/8/96	0.134	118	3.05	0.01 U	1 U
YE32G03	6/10/96	0.15	115	3.22	0.01 U	1 U
YE32G03	8/20/96	0.132	122	3.7	0.01 U	1 U
YE32G03	10/7/96	0.139	143	3.1	0.01 U	1 U
YE32G03	12/9/96	0.131	118	3.24	0.01 U	1 U

Table D-1. Yelm Groundwater Quality Results, April 1996 through February 1997.

Site ID	Date	Nitrate+ Nitrite-N (mg/L)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Ammonium-N (mg/L)	Fecal Coliforms (CFU/100mL)
YE32G03	2/10/97	0.185	118	3.26	0.01 U	1 U
YE32H02	4/8/96	1.205	94	3.12	0.01 U	1 U
YE32H02	6/10/96	0.9745	101	3.4	0.01 U	1 U
YE32H02	8/20/96	0.962	104	3.07	0.01 U	1 U
YE32H02	10/7/96	0.936	107	3.09	0.01 U	1 U
YE32H02	12/9/96	1.105	98	3.15	0.01 U	1 U
YE32H02	2/10/97	0.937	89	3.03	0.01 U	1 U
YE33B04	4/8/96	5.06	99	6.99	0.01 U	1 U
YE33B04	6/10/96	4.11	101	5.38	0.01 U	1 U
YE33B04	8/20/96	5.42	142	17.3	0.01 U	1 U
YE33B04	10/7/96	6.14	157.5	16.2	0.01 U	1 U
YE33B04	12/9/96	5.26	102	5.71	0.014	1 U
YE33B04	2/10/97	5.24	99	6.72	0.01 U	1 U
YE33B05	4/8/96	2.58	119	3.79	0.01 U	1 U
YE33B05	6/10/96	2.55	120	3.98	0.01 U	1 U
YE33B05	8/20/96	2.41	126	3.97	0.01 U	1 U
YE33B05	10/7/96	2.3	131	3.98	0.01 U	1 U
YE33B05	12/9/96	2.52	123	4.12	0.01 U	1 U
YE33B05	2/10/97	2.63	122	4.23	0.01 U	1 U
YE33D08	4/8/96	3.25	111	4.92	0.01 U	1 U
YE33D08	6/11/96	3.95	107	6.87	0.01 U	1 U
YE33D08	8/20/96	3.41	121	6.2	0.01 U	1 U
YE33D08	10/7/96	2.84	123	5.64	0.015	1 U
YE33D08	12/9/96	2.44	120	4.9	0.01 U	1 U
YE33D08	2/10/97	3.55	105	6.36	0.01 U	1 U
YE33N03	4/8/96	0.678	142	3.6	0.01 U	1 U
YE33N03	6/10/96	0.647	141	3.74	0.01 U	1 U
YE33N03	8/20/96	0.662	149	3.77	0.01 U	1 U
YE33N03	10/7/96	0.519	154	3.81	0.01 U	1 U
YE33N03	12/9/96	0.486	150	3.88	0.01 U	1 U
YE33N03	2/10/97	0.701	138	3.89	0.01 U	1 U
	Mean=	**3.19**	**110**	**4.92**		**1 U**
	Min=	**0.13**	**67**	**1.25**	**0.01 U**	**1 U**
	Max=	**10.1**	**158**	**17.3**	**0.015**	**1 U**

U= Analyte not detected above listed value.