Report of Examination Routing Slip

File No. G2-29794 · Y:// Tammy / herzog G2-29794doc

Letter No./Fee Exam 2 Fee $5.80

	Initial	Date
Author	TH	3/11/03
Hydrogeologist	Dave	4/4/03 (see attached)
Reviewers	Deb	4/7/03
	Jill	4/11/03
Proofed		5/12/03
Signed by Author		
Section Supervisors Approval and Sig.		
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Herzog
6-2-2004

WASHINGTON STATE DEPARTMENT OF ECOLOGY

DEPARTMENT OF ECOLOGY
MEMORANDUM

April 22, 2003

TO: Pending Applications for WRIA 13

FROM: Tammy Hall, L.H.G.

SUBJECT: TECHNICAL EVALUATION OF NEW APPLICATIONS IN THURSTON COUNTY

General Hydrogeology

The presented geologic/ hydrogeologic information was compiled from the following references:

- Sinclair, Kirk and Pitz, Charles, 1999, *Estimated Baseflow Characteristics of Selected Washington Rivers and Streams*: Washington Department of Ecology Water Supply Bulletin No. 60.
- Drost, B.W., Turney, G.L., Dion, N.P., and Jones, M.A., 1999, *Conceptual Model and Numerical Simulation of the Ground-Water-Flow System in the Unconsolidated Sediments of Thurston County, Washington*: US Geological Survey Water Resources Investigations Report 99-4165.
- Drost, B.W., Turney, G.L., Dion, N.P., and Jones, M.A., 1998, *Hydrology and Quality of Ground Water in Northern Thurston County, Washington*: US Geological Survey Water-Resources Investigations Report 92-4109 (revised).

Geologic History

The landscape of the Thurston County area is largely the result of erosion and deposition that has taken place during the past 15,000 years. For the most part, the land surface is a low-lying glacial drift plain that ranges in altitude from 200 to 400 feet above sea level. The plain is generally of low relief and terminates in steep bluffs on the shores of Puget Sound. The following information is taken largely from Drost and others (1998).

Continental glaciation in the Thurston County area began approximately 15,000 years ago when continental glaciers advanced into Thurston County. It is estimated that continental glaciation occurred at least twice during this glacial period. During the most recent glacial event, referred to as the Vashon Stade of the Frasier Glaciation, a huge continental ice sheet that formed in British Columbia moved slowly southward, blanketing the entire Puget Sound basin. As the Vashon glacier advanced southward, streams that once drained northward were blocked, including the Nisqually and Deschutes Rivers, and a large lake formed in front of the ice sheet. Eventually, as the lake filled, drainages were established westward and southwestward into the Chehalis River Valley. As the climate warmed, approximately

13,500 years ago, the glacier began retreating northward and drainage to the north through the Puget Lowland was eventually reestablished. The southern part of Thurston County, near Tenino, is generally regarded as the southern-most extent of continental glaciation in western Washington. This most recent glaciation left behind two general types of deposits, outwash (moderately to well sorted sands and gravels) and till (unsorted sand, gravel, and boulders in a silt and clay matrix).

As a result of these geologic events, northern Thurston County is underlain by unconsolidated deposits that are both glacial and non-glacial in origin. The aquifers and confining beds described are referred to as "geohydrologic" units because they were identified using a combination of geologic (primarily grain size and sorting) and hydrologic (hydraulic conductivity and hydraulic continuity) properties. Although glacial aquifers may be composed predominately of sand and (or) gravel, they also contain relatively thin and discontinuous lenses of clay or silt. In addition, confining layers composed predominately of silt and (or) clay, may also contain local lenses of coarse sand or gravel. As a result, the occurrence and movement of groundwater may be influenced locally. Underlying these unconsolidated deposits, which can be as much as 1,800 feet, is bedrock, the oldest geologic unit in Thurston County.

Alluvial and deltaic sand and gravel of Holocene age are the youngest geologic deposits found in Thurston County. This sand and alluvium is of limited extend and generally exists along valley bottoms of the principal streams. Because of lithologic similarities, Vashon recessional outwash and Holocene alluvium are generally referred to as a single geohydrologic unit (Qvr). This unit is the most widely exposed at the surface in Thurston County. Recessional outwash, deposited by streams emanating from the melting and receding glacier, consists of poorly to moderately well-sorted sand and gravel. Locally, perched groundwater may exist in this unit because of the low vertical permeability of the underlying glacial till. This unit is generally between 10 and 50 feet in thickness, but locally may be as thick as 150 feet.

The Vashon till, and possibly some older tills, make up geohydrologic unit Qvt. The unit Qvt generally underlies Qvr and is considered a poor source of water. The unit is broadly distributed and exposed at land surface over the four peninsulas in Thurston County. Although considered a confining bed, the upper part of the unit is less compacted and can contain thin layers of relatively clean sand which support some low producing wells. Qvt is generally between 25 and 50 feet in thickness but locally may be as thick as 150 feet.

The Vashon advance outwash, represented as geohydrologic unit Qva, is an important aquifer in northern Thurston County. In the extreme northern Thurston County the unit is relatively thin, and therefore has not been developed extensively. Where it is present, Qva is generally between 15 and 35 feet thick, but locally may exceed 150 feet in thickness. The top of the Qva generally occurs between 50 and 200 feet above sea level. In the vicinity of McAllister Springs, the thick coarse grained sediments have been divided arbitrarily into Qvr, Qva, and Qc. The portion of this assemblage designated as Qva was selected to be more-or-less laterally continuous with the Qva identified to the west and south.

The Kitsap Formation and other poorly permeable materials occurring beneath the Qva are represented as geohydrologic unit Qf. Although unit Qf confines groundwater in the coarse-grained glacial deposits both above and below it, thin lenses of sand and gravel can yield relatively small quantities of water suitable for domestic use. Qf is effective in retarding the downward percolation of groundwater into the underlying geohydrologic unit Qc and in causing vertical head gradients between the Qva and Qc aquifer units. Where present, Qf is generally between 15 and 75 feet thick.

The coarse-grained Salmon Springs (?) Drift, penultimate deposits, and other deposits are described as geohydrologic unit Qc. The Qc unit is one of the most widely used aquifers in Northern Thurston County. Groundwater in this unit generally occurs under confined conditions. Unit Qc is one of the most widely used aquifers in northern Thurston County. In some locations, such as near McAllister Springs, where the overlying Qf is absent, Qc merges with Qva to form a single thick and productive aquifer. The top of

the unit is commonly between 50 and 150 feet above sea level feet above sea level. Where the entire thickness of Qc has been penetrated, it is generally about 30 feet thick.

The unconsolidated and undifferentiated sediments beneath Qc are designated as geohydrologic unit TQu. These deposits are primarily thought to be older than Salmon Springs Drift but may also contain some younger materials. This unit is heterogeneous and wells utilizing water from this unit tap several different water-bearing layers that are irregularly distributed both laterally and vertically. Groundwater occurs generally under confined conditions.

Bedrock (Tb) underlies the Qc and is described as a poorly permeable base of unconsolidated sediments consisting mostly of claystones, sandstones, and some basalt.

Horizontal flow directions of groundwater within aquifers Qva and Qc is generally from areas of higher head to areas of lower head. Groundwater in Qva generally moves toward marine water bodies and to surface drainage channels. Local mounds of the potentiometric surface occur beneath each of the major peninsulas. The configuration of the potentiometric surface for Qc is similar to that of Qva. Beneath the upland areas on the peninsulas, water levels in Qva are generally higher than Qc, indicating that water flows vertically downward, passing through Qf, where it is present and discharging to either salt water or to surface water drainages.

Seawater Intrusion in Thurston County

The following information regarding seawater intrusion was compiled using the following sources:

1. Walters, Kenneth L., 1971, *Reconnaissance of Sea-Water Intrusion Along Coastal Washington, 1966-68*: US Geologic Survey, Water Supply Bulletin No. 32.

2. Dion, N.P and Sumioka, S.S., 1984, *Seawater Intrusion into Coastal Aquifers in Washington, 1978*: US Geologic Survey Water-Supply Bulletin 56.

Seawater contains about 19,000 milligrams per liter (mg/l) chloride, whereas uncontaminated groundwater in most coastal areas of Washington contains less than 10 mg/l of chloride (Walters 1970). For seawater intrusion to occur, two basic situations must exist. First, the water bearing materials that underlie an area must be in hydraulic continuity with the sea. Second, there must be a reduction of hydraulic head of the fresh water relative to the seawater. When the fresh water hydraulic gradient in a coastal aquifer is seaward, as it is under natural conditions, fresh groundwater moves seaward under a condition of equilibrium with the salt water. Under natural conditions, the hydraulic gradient is land ward only during high tide and only near the shoreline. When the hydraulic gradient is reversed, or even decreased, by pumping nearshore wells, the front of the salt water moves landward.

In a nearshore aquifer, fresh water "floats" on the heavier salty water. Some mixing will occur in a narrow zone of diffusion at the salt water/fresh water interface. When fresh water overrides seawater in an aquifer, about 40 feet of fresh water will occur below sea level for each foot of fresh water that occurs above sea level. Because the water table for the fresh groundwater increases in altitude landward from the shore, the interface between the fresh water and salt water has a slope inland approximately 40 times the slope of the water table. This condition assumes a "natural" state, that is, under hydrostatic balance, in an unconfined aquifer of uniform composition. It may not apply in areas of appreciable groundwater movement or in confined aquifer conditions. When an aquifer is not under hydrostatic balance, or under dynamic conditions (ie. pumping conditions), the underlying salt water will rise 40 feet for every foot that the water table is depressed.

Most aquifers are more permeable to water moving laterally through them than to water moving in a vertical direction. This is especially the case for glacial deposits which are largely deposited by either melting ice (ablation till) or streams draining glacial plains (advance or recessional outwash).

One obvious way to minimize SWI when drilling water wells near-shore is to locate the well as far inland as possible. Pumping rates should be kept at a minimum, so a pronounced cone of depression that draws up salt water does not develop. If either of these is not possible, drilling to a deeper aquifer that is not in hydraulic continuity with the seawater may also provide a possible solution.

Ecology contends that is much easier to prevent SWI than to mitigate it. Water wells with greater than 100 mg/l of chloride are at a medium to high risk of experiencing SWI. Water wells with over 200 mg/l concentration of chloride are considered at a high risk. The Maximum Contaminant Level (MCL) allowed according Federal standards for chloride is 250 mg/l.

There is considerable evidence of seawater intrusion along the inlets and channels of northern Thurston County. Even though the median chloride concentration of 133 groundwater samples collected in 1978 was only 3.4 mg/L, 17 of the samples had chloride concentrations in excess of 100 mg/l.

The salinity pattern observed in the groundwater of Thurston County suggest that, even on narrow peninsulas, there are several tongues of intrusion in small areas, or several strata of intrusion. In addition, most occurrences of intrusion are in wells that tap aquifers generally less than 55 feet below sea level. Pumping of additional wells, or increased pumping of existing wells, could cause a coalescing of the contaminated areas, with the result that several wells could start producing water with little or no forewarning.

As with all other factors, SWI potential for a proposed withdrawal should be taken on a site specific basis.

Hydrologic Scenarios in Thurston County

In general, hydrologic conditions for all pending applications fall in one of two basic hydrologic scenarios, groundwater either discharges to marine water or to surface water.

Chapter 173-513 WAC closes several streams in Thurston County to appropriation and lists flow restrictions on others. Essentially, for applications located within the watersheds for the listed closed streams, denials are likely unless any potential impairment withdrawals will have on streams can be mitigated. For areas where restricted streams may be affected, minimum flows must be met.

The effect of pumping groundwater on surface water can be explained in rather simple terms, pumping groundwater creates a capture zone, or an area where groundwater flow is directed toward an area of pumping. Research has shown that capture zone areas can affect stream flow in both local and regional flow systems over time. Pumping of water from wells has the potential to decrease flow in creeks and rivers by decreasing the amount of baseflow provided by groundwater to gaining streams and by increasing the seepage from a losing stream as aquifer recharge.

Applications where groundwater clearly discharges to marine water can likely be approved, of course, depending on the situation (ie. potential impairment of senior water users, the potential for seawater intrusion, etc). Withdrawals, in this case, would intercept groundwater that would otherwise discharge to salt water.

Johnson Point Applications

G2-28148 Capital Development.

On May 10, 1991, Capital Development Company filed an application to withdraw public ground water from one well. The amount requested was 700 gallons per minute (gpm) for irrigation of 110 acres and multiple domestic supply.

Public notice was published in "The Olympian" of Olympia, Washington on May 28 and June 4, 1991 and on December 11 and December 18, 1992. In response to the public notice Ecology received two letters of concern.

Preliminary Permit to Drill and Test

A preliminary permit was issued on July 8, 1991 at the request of Capital Development Company. This preliminary permit allowed the installation of three production wells and three observation wells to monitor the aquifer testing. This application (No. G2-28148) was amended on November 18, 1992 to increase the withdrawal rate to 700 gpm. The preliminary permit was extended to July 8, 1993, so necessary testing could be completed.

After drilling and testing of the wells was completed, it was determined that Well No.1 was completed in a different aquifer than Well Nos. 2 and 3. Ground Water Application No. G2-28862 was subsequently submitted for Well Nos. 2 and 3. Well No. 1 is sited approximately ½ mile southwest of Woodland Creek and less than 2 ½ miles upstream of here Woodland Creek empties into Henderson Inlet.

The results of the drilling and testing of all three wells installed under this preliminary permit are summarized in *Report of Hydrologic Services, Identifications and Development of Ground Water Resources at Woodland Green Development, Lacey, Washington* (GeoEngineers, 1993). Information on the subject well is as follows:

System Description

Well No. 1 (PW-1)

Depth:	132 feet
Casing Diameter:	8 inch
Static Water Level (SWL):	8.57 feet below ground surface (bgs)
Well Yield:	180 gpm
Surface Elevation at Well Site:	68 feet above msl
Driller:	Holt Drilling Co.
Constructed:	February 1993

PW-1 would be equipped with a submersible pump capable of discharging 180 gpm to an associated underground irrigation system design. This system would be computerized, and equipped with water sensors to detect when and where watering is needed. Watering would likely take place between the hours of 10 p.m. and 5 a.m.

Aquifer Characteristics

Subsurface conditions encountered during the drilling of PW-1 consisted of fine to medium sand with interbedded lenses of silt to depths of approximately 90 to 100 feet bgs. Fine gravel with coarse sand was encountered below the sand unit. Shallow groundwater was encountered at a depth of approximately 8 feet bgs.

Well PW-1 is completed in what has been interpreted as a semi-confined aquifer found at an elevation ranging between approximately 50 and 100 feet below msl. The aquifer material consists of sand with some gravel and silt and/or clay lenses. This aquifer appears to be partially separated from the overlying unconfined aquifer by several relatively thin lenses of silt and clay. Static water levels (SWL) of wells completed in this aquifer appear to be approximately 50 to 60 feet above msl. Based on information in Drost (1998), this well appears to be drawing water from the Qc hydrologic unit.

Aquifer Test Evaluation

Well PW-1 was pumped at a rate of 180 gpm for 1430 minutes during a constant rate test. The SWL prior to starting the test was measured at 8.57 feet bgs, and the water level dropped to a depth of 69.1 feet bgs by the end of the test The time-drawdown data indicate that steady-state conditions were achieved approximately 100 minutes into the constant rate test (GeoEngineers, 1993).

Based on water-level measurements taken during the test in the production well and five observation wells, it is estimated that a discharge rate of 180 gpm would result in an area of drawdown around this well of about 200 feet (GeoEngineers, 1993). The nearest observation well measured is approximately 400 feet southwest of the production well. The nearest water supply wells are located over 1,000 feet north and southeast of this production well.

Consideration of Letters of Concern

In response to the public notice, Ecology received two letters expressing concern that there could be adverse impacts to their existing water supply wells as a result of the proposed withdrawals associated with this project.

Paul Shoblom submitted a letter of concern regarding potential interference from the proposed withdrawal. The Shoblom well operates under Ground Water Permit No. G2-28742 issued on February 8, 1993 for 200 gpm and an annual quantity of 10.5 ac-ft. This well was drilled in 1987 and is completed at a depth of 392 feet bgs (242 feet below msl), approximately the same elevation as Capital Development's PW-2 and PW-3 and utilizing the same aquifer.

A letter was also submitted by Avanell Wheaton expressing concern about potential adverse impact from the proposed withdrawal. A water well report for the Wheaton well is not on file with Ecology. Sue Wheaton stated that her well is approximately 100 feet deep, indicating that her well is completed in the same shallow semi-confined aquifer that PW-1 taps.

Affects to Surface Water

In GeoEngineers (1993), the relationship between PW-1 and Woodland Creek was evaluated. Based on the interpretation provided in the report, GeoEngineers determined that a hydraulic connection likely existed between PW-1 and the wetland areas found on the project site. These wetland areas arelikely a source area for small streams that contribute some water to Woodland Creek.

In Sinclair and Pitz (*Estimated Baseflow Characteristics of Selected Washington Rivers and Streams*: Washington Department of Ecology Water Supply Bulletin No. 60., 1999), streamflow information collected on the Deschutes River suggested that most of the river flow is due to baseflow contribution, especially during the summer months. Baseflow is the portion of streamflow contributed by groundwater. A comparison of annual data for the Deschutes River for the period of time evaluated indicates a divergence between baseflow contribution and total streamflow, suggesting that groundwater contribution has decreased. This decrease in groundwater contribution may be due to increased groundwater pumping, decreased groundwater recharge, or increased surface runoff. All three of these factors may be the result of an overall increase in impervious area (development).

A similar analysis for Woodland Creek indicates even a stronger dependence of groundwater contribution to stream baseflow (Sinclair and Pitz, 1999)Therefore, a decrease in groundwater contribution (baseflow) would directly result in a reduction of streamflow in Woodland Creek.
In Drost (1999), a conceptual model of the groundwater system is presented which identifies two components of subsurface flow, those which discharge directly to Puget Sound and those that discharge

to surface water bodies. This model was constructed as a tool to increase the understanding of the groundwater flow system and provides an indication of how the groundwater flow system behaves.

A conceptual analysis using the information provided in Drost (1999) and Drost (1998) indicates that pumping of the Capitol Development Well No. 1 would likely capture groundwater that would otherwise discharge to Woodland Creek and its associated wetlands. Flow and volume of groundwater discharging from these surface waters would likely be reduced and senior water right holders would be impaired.

Minimum instream flows were established in 1988 through Chapter 173-513 WAC, the Instream Resources Protection Program (IRPP) for the Deschutes River Basin Water Resource Inventory Area (WRIA) 13. This IRPP also closes Woodland Creek and its tributaries to withdrawals. Flows established in this WAC are considered an appropriation and senior to all permits approved after 1988 and subsequent water right applications. Ecology must deny any proposed groundwater withdrawals that have the potential to impair flows in Woodland Creek.

G2-28862 Capital Development

On June 7, 1993, Capital Development Company filed an application to withdraw public ground water from two wells. The amount requested was 1,200 gallons per minute (gpm) for irrigation of 381 acres. The project site is located in the Deschutes River Watershed in Water Resources Inventory Area (WRIA) 13.

Public notice was published in "The Olympian" of Olympia, Washington on June 15 and 22, 1993. In response to the public notice Ecology received two letters of concern.

Preliminary Permit to Drill and Test

A preliminary permit was issued on July 8, 1991 at the request of Capital Development Company. This preliminary permit allowed the installation of three production wells and three observation wells to monitor the aquifer testing. The preliminary permit was issued in response to Ground Water Application No. G2-28148, which requested water to be pumped from up to three wells. After drilling and testing was completed, it was determined that Well No.1 was completed in a different aquifer than Wells Nos. 2 and 3. Therefore, this application (G2-28862) was submitted for Well Nos. 2 and 3. Well No. 1 is addressed in Application No. G2-28148.

Wells Nos. 2 and 3 are located about 350 feet apart and less than 2 ½ miles upstream from the point where Woodland Creek empties into Henderson Inlet, slightly more than ½ mile northeast of the creek. The wells are sited in a sand and gravel aquifer that extends from approximately 230 to 260 feet below ground surface (bgs) to the completed depth of the wells. Utilizing information in Drost (1998), the wells appear to be completed within the TQu hydrologic unit. This aquifer is overlain by semi-confining layer approximately 160 feet in thickness.

The results of the drilling and testing of all three wells installed as a result of this preliminary permit is summarized in *Report of Hydrologic Services, Identifications and Development of Ground Water Resources at Woodland Green Development, Lacey, Washington* (GeoEngineers, 1993). Information on the subject wells is as follows:

System Description

	Well No. 2 (PW-2)	Well No. 3 (PW-3)
Well Depth:	340 feet	312 feet
Casing Diameter:	8 inch	8 inch
Static Water Level (SWL):	66 feet	55 feet

Well Yield:	470 gpm	430 gpm
Surface elevation at well-site:	122 feet above msl	110 feet above msl
Driller:	Holt Testing	Holt Testing
Date Constructed:	Feb/April 1993	June/Aug 1993

Water pumped from these wells would discharge to an underground irrigation system. This system would be computerized, and equipped with water sensors to detect when and where watering is needed. Watering would take place between the hours of 10p.m. and 6a.m.

Aquifer Characteristics

Groundwater in the vicinity of the subject site appears to occur in three (3) aquifers. Delineation of these aquifers is approximate, based on regional information produced by the US Geological Survey and data collected from wells drilled as part of this project.

An unsaturated zone, or water table aquifer, occurs near the surface of the site. This shallow aquifer, likely within the Qvr hydrologic unit, is comprised of stratified sand and gravel deposits that are interbedded with relatively low-permeability zones of silt and clay. The thickness of the saturated zone is influenced by the surface relief and the relief of the underlying (older) deposits and by horizontal and vertical variations in permeability. These permeability variations are related to zones or lenses of soil containing variable amounts of silt and/or clay. Groundwater occurs generally within 10 feet of the surface.

The middle aquifer is located near the southeast portion of the project site at an elevation ranging between approximately 50 and 100 feet below msl. This middle aquifer, likely within the Qc hydrologic unit, does not appear to be continuous across the project site. Consisting primarily of sand with some gravel and silt or and/or clay lenses, this aquifer appears to be at least partially separated from the overlying unconfined aquifer by several relatively thin lenses of silt and clay. SWLs of wells completed in this aquifer appear to be approximately 50 to 60 feet above msl.

The deeper aquifer appears to be located beneath the site at an elevation of greater than approximately 150 feet below msl and consists of sand and gravel with some minor silt and/or clay lenses. Well logs for PW-2 and PW-3 penetrated approximately 160 feet of lacustrine silt and clay before encountering this lower aquifer. SWLs for wells completed in this aquifer appear to be approximately 50 to 60 feet above msl. Utilizing information in Drost (1998), it is likely that this aquifer is located within the TQu hydrologic unit.

Aquifer Test Evaluation

PW-2

A constant rate aquifer test was conducted on PW-2 of April 1 and 2, 1993. PW-2 was pumped at a rate of 470 gpm for 24 hours. The water level prior to starting the test was measured at 65.66 feet, and dropped to 204.16 feet at the end of the test, resulting in 138 feet of drawdown. The time-drawdown data reviewed indicate that steady-state conditions were achieved about 900 minutes (15 hours) into the constant rate test.

Based on water level measurements taken during the test for this production well, one observation well (OW-2), and one domestic well (PS-1 Shoblom), it is estimated that a discharge rate of 470 gpm will result in an area of drawdown around this well of about 1,200 feet (GeoEngineers, 1993).

PW-3

A constant rate aquifer test was conducted on PW-3 on July 22 and 23, 1993. PW-3 was pumped at 430 gpm approximately 13 hours (785 minutes). The pre-pumping SWL was measured at 55.02 feet, and had dropped to 248.35 feet at the end of the test, resulting in 195.33 feet of drawdown. The time-drawdown data reviewed indicate that steady-state conditions were achieved about 5 hours (300 minutes) into the constant rate test.

Based on water level measurements taken during the test for this production well, PW-2, OW-2, and PS-1, it is estimated that a discharge rate of 430 gpm will result in an area of drawdown of approximately 1,400 feet (GeoEngineers, 1993).

Consideration of Letters of Concern

Public notice appeared in "The Olympian" of Olympia, Washington on June 15 and 22, 1993. In response to the public notice, Ecology received two letters expressing concern that there could be adverse impacts to their existing water supply wells as a result of the proposed withdrawals associated with this project.

Paul Shoblom submitted a letter of concern regarding potential interference from the proposed withdrawal. The Shoblom well operates under Groundwater Permit No. G2-28742 issued on February 8, 1993 for 200 gpm and an annual quantity of 10.5 ac-ft. That well was drilled in 1987 and is completed at a depth of 392 feet bgs (242 feet below msl), approximately the same elevation as Capital Development's PW-2 and PW-3 and utilizing the same aquifer.

A letter was also submitted by Avanell Wheaton expressing concern about potential adverse impact from the proposed withdrawal. A water well report for the Wheaton well is not on file with Ecology. Sue Wheaton stated that her well is approximately 100 feet deep, indicating that her well is completed in the same shallow semi-confined aquifer that Capital Development's PW-1 taps.

Affects to Surface Water

The elevation of Woodland Creek at the nearest point to the withdrawal site is approximately 50 feet above msl. A cross section provided in Drost, et al. (1998) which runs within ¼ mile from the site, suggests that at the well site location the TQu may be separated from the creek by Qf, Qvt, Qvr, Qc, and Qva. However, additional information within Drost (1998) suggests that these units may not be continuous across the project area or if present, the units may not very thick.

In Sinclair and Pitz (*Estimated Baseflow Characteristics of Selected Washington Rivers and Streams*: Washington Department of Ecology Water Supply Bulletin No. 60.1999), streamflow information collected on the Deschutes River suggested that most of the river flow is due to baseflow contribution, especially during the summer months. Baseflow is the portion of streamflow contributed by groundwater. A comparison of annual data for the Deschutes River for the period of time evaluated indicates a divergence between baseflow contribution and total streamflow, suggesting that groundwater contribution has decreased. This decrease in groundwater contribution may be due to increased groundwater pumping, decreased groundwater recharge, or increased surface runoff. All three of these factors may be the result of an overall increase in impervious area (development).

A similar analysis for Woodland Creek indicates even a stronger dependence of groundwater contribution to stream baseflow (Sinclair and Pitz, 1999). Therefore, a decrease in groundwater contribution (baseflow) would directly result in a reduction of streamflow in Woodland Creek
In Drost (1999), a conceptual model of the groundwater system is presented which identifies two components of subsurface flow, those which discharge directly to Puget Sound and those that discharge to surface water bodies. This model was constructed as a tool to increase the understanding of the groundwater flow system and provides an indication of how the groundwater flow system behaves.

A conceptual analysis using the information provided in Drost (1999) and Drost (1998) indicates that pumping of the Capitol Development's PW-2 and PW-3 would likely capture groundwater that would otherwise discharge to Woodland Creek and its associated wetlands. Flow and volume of groundwater discharging from these surface waters would likely be reduced and senior water right holders would be impaired.

Minimum instream flows were established in 1988 through Chapter 173-513 WAC, the Instream Resources Protection Program (IRPP) for the Deschutes River Basin Water Resource Inventory Area (WRIA) 13. This IRPP also closes Woodland Creek and its tributaries to withdrawals. Flows established in this WAC are considered an appropriation and senior to all permits approved after 1988 and subsequent water right applications. Ecology must deny any proposed groundwater withdrawals that have the potential to impair flows in Woodland Creek.

G2-29250 Prairie Ridge Water Company:

This application was filed on July 24, 1995 by Robert R. Drohman of Drohman Developing. The application requested a groundwater withdrawal from one well for 125 gallons per minute (gpm) at an annual quantity of 80 acre-feet (ac-ft) of water per year for multiple domestic supply for an unspecified number of single family residencies. This project site known as "Prairie Ridge Development" is located approximately two miles north of Lacey on Marvin Road.

Currently, the development serves water to approximately 84 residences under Groundwater Certificate No.G2-25621 and Groundwater Permit No. G2-27105, which allow service to 99 single family residences at full build-out. Groundwater Certificate No. G2-25621 was issued in March 1981and applies to Prairie Ridge Well #1. Groundwater Permit No. G2-27105, issued in June 1987, corresponds to Prairie Ridge Well #2, and is supplemental to Groundwater Certificate No. G2-25621. The combined instantaneous withdrawal from both wells is 225 gpm at an annual quantity of 50 ac-ft of water per year. The developer has recently applied for a 5-year extension to put all allocated water to full beneficial use by December 31, 2006. Both wells 1 and 2 serve Prairie Ridge Divisions I, II, III, and IV. The developer intended this application to apply to a new well (Prairie Ridge Well No. 3) and to serve additional residences in the remaining undeveloped area of Division IV.

Prairie Ridge Well Nos. 1 and 2 utilize water withdrawn from an aquifer approximately 130 feet below the surface (170 to 130 feet above msl), interpreted by Drost and others as being hydrologic unit Qva. Static water level (swl) for both wells ranges from 133 feet below the surface for Well 1 to 140 feet below the surface for Well 2. Prairie Ridge Well No. 3, if installed, would likely tap the same aquifer.

Subsurface conditions encountered during the drilling of Well 1 consisted of alternating layers of cemented gravel and sand to depths of approximately 170 feet below the surface. Well 2 reports cemented gravel to a depth of 130 feet before encountering a water-bearing zone at a depth of 130 feet.

To evaluate the potential of impairment to flows in Woodland Creek that this withdrawal would have, a scenario was run using USGS Thurston County groundwater model. The well was located within the Qva aquifer of equivalent depth as wells 1 & 2 and screened across the entire thickness of the aquifer. The withdrawal rate was calculated using the proposed annual quantity and back-calculating for a constant rate of pumping. Running the scenario for 1000 days resulted in a net loss of water to Woodland Creek.

The relationship between the proposed withdrawal and Woodland Creek, the results of the evaluation indicated that pumping will almost certainly capture groundwater that would otherwise discharge to Woodland Creek and its associated wetlands. Flow and volume of groundwater discharging from these surface waters would likely be reduced and senior water right holders would be impaired. Mitigation of these potential impacts will be necessary in order for Ecology to approve the application.

G2-29374 ARP Water System:

This application was filed April 10, 1996. The applicant requested water for multiple domestic supply for 6 connections and irrigation of 3.5 acres. The location of the proposed withdrawal is on the western side of Johnson Point Peninsula, less than ¼ mile from Henderson Inlet.

A well log provided by the applicant indicates that the well is 90 feet in depth and 6 inches in diameter. The water bearing unit is a gravel and sand layer approximately 19 feet in thickness that occurs from 69 to 90 feet bgs. The static water level is recorded at 65 feet bgs after drilling.

The Thurston County groundwater model (Drost and others, 1999) does not show adequate detail to conduct an analysis of this application. However, a cross section provided in Drost and others (1998), utilizes two wells that are located within the same quarter section as the ARP water system well. These two wells appear to be deeper than the ARP well, and, based on the cross section appear to be drawing water from the Qc aquifer. Based on information on the well log, the ARP well may be drawing water from a permeable gravel and sand lens at the base of the Qf unit.

Ecology's well log data base reports a total of 146 water supply wells within one mile of the ARP water system well. Most wells are less than 100 feet deep. Ten wells are located within the same quarter-section as the ARP well and range in depth from 67 feet to 167 feet. The five shallower wells (less than 100 feet deep), are likely drawing water from permeable zones located at the base of the Qf unit. The deeper wells are likely drawing water from the Qc aquifer.

Dion and Sumioka (1978) list a well with chloride concentrations above the 100 mg/l threshold level within ¼ mile of the location of the ARP well. This well is 116 feet deep, compared to the ARP well which is 90 feet deep. The well was sampled in 1967 and 1978 for chloride and reported concentrations of 105 and 110 mg/l, respectively. This well appears to be cross-gradient from the ARP well.

Groundwater at this location is discharging to marine water. Using a USGS quad map, it appears the surface elevation at the location of the ARP well is approximately 100 feet above msl, making the static water level of the well approximately 35 feet above msl. Given the close proximity of the well to salt water, and that the elevation of the water table is near sea level, there is risk of SWI risk at this location if withdrawals are not managed properly. It would be applicable to request the applicant to submit chloride data as part of the conditions of the permit.

G2-29414 Manke Lumber Co.

This application was filed September 9, 1996. The applicant requests water for multiple domestic supply for 335 homes at a withdrawal rate of 750 gpm. The proposed withdrawal is located mid Johnson Point Peninsula, approximately 3 miles north of Lacey. This proposed withdrawal is located east of applications G2-29250 Prairie Ridge and G2-29557 Washington Water Service.

The information utilized in evaluating this application consisted of the following reference materials:

- Economic and Engineering Services, Inc., August 1995, *City of Lacey Wellhead Protection Plan.*
- Robinson and Noble, Inc., September 1984,*Test/Production Drilling at Hawks Prairie for the Glacier Park Company.*
- Robinson, Roberts & Associates, Inc. June 1971,*Exploration for a Ground-Water Supply for Jones Beach State Park.*

The Manke property slopes northeasterly towards Nisqually Reach, surface elevations ranging from 240 to 140 feet above msl. The surface elevation at the proposed well site is approximately 220 feet above msl. The Manke property is also located directly south of Tolmie State Park. The applicant indicates that a well

has not yet been installed but the target aquifer is within the "pre Vashon" age deposits, likely within the TQu unit. The target depth is approximately 600 feet below ground surface, approximately 400 feet below msl.

The TQu unit is likely glacial outwash in origin and aquifers within the unit are generally coarse-grained and interbedded with fine-grained deposits. The lateral extent of the individual aquifers is uncertain due to the relatively few wells that tap these deposits. Groundwater found in the TQu is typically confined by overlying and underlying silt and/or clay layers. Recharge to the aquifer is presumed to be by direct vertical leakage, probably over a widespread area.

A cross section provided by Robinson & Noble in the Glacier Park report transects the Manke property and provides an interpretation of the subsurface in the vicinity of the proposed withdrawal. The Glacier Park well taps the target aquifer and is located less than one mile from the project site. Aside from the Glacier Park well, the nearest well tapping this aquifer is a municipal well owned by the City of Lacey located within one mile of the proposed withdrawal.

Information gathered from wells tapping aquifers in the TQu indicates that static water levels are generally between 100 feet to 50 feet above msl and become closer to sea level as you approach marine water. Based on results of specific capacity tests performed in 50 wells throughout northern Thurston County assessed by the US Geological Survey, hydraulic conductivity values range from about 4 to 2,700 ft/day, with a median value of 34 ft/day.

The applicant opted not to obtain a preliminary permit to drill a test well, but rather chose to rely on the information gathered from the drilling of the Glacier Park well, since the proposed withdrawal is located approximately ½ mile from the Glacier Park well and conditions are expected to be similar. The Glacier Park well has a completed depth of 590 feet bgs, fully penetrating the aquifer, and is screened from 539 to 590 feet bgs (approximately 294 to 345 feet below msl) across the entire aquifer thickness. The static water level of the Glacier Park well is approximately 200 feet bgs, approximately 50 feet above msl. Pump tests conducted indicated a specific capacity of 25.8 gpm per foot of drawdown on the Glacier Park well. Data gathered from the 24-hour pump test indicated that drawdown would be expected from this well for approximately 100 days before equilibrium would be reached. Aquifer transmissivity indicated a near-well T of approximately 55,000 gpd/ft and a more distant T value of 32,000 gpd/ft. The water level at the conclusion of the pump test was approximately 232.5 ft below the top of the casing, or slightly above msl. The testing also indicated that Glacier Park well was capable of producing 1000 gpm but withdrawal was limited to 800 gpm to avoid excessive velocity through the screened portion of the well.

To the north of the proposed withdrawal site and drawing water from a shallower water-bearing zone, is the Tolmie State Park well. This well penetrates an extensive thickness of glaciolacustrine clay that is interpreted by Robinson and Noble to be a channel fill cut through regional geologic layers. The Tolmie State Park well has a completed depth of 334 feet bgs, or approximately 239 below msl.

Some well interference from pumping at the Manke property may occur at the Glacier Park well, but this interference is expected to be minimal. Groundwater from this aquifer at the location of the proposed withdrawal is discharging to marine water.

Dion and Sumioka (1978) do not identify any high chloride wells near the proposed withdrawal. Groundwater at this location is discharging to marine water. Given the distance of this well to marine water (one mile) and that the well is under confining pressure, I consider SWI risk at this location to be low.

A search of Ecology's well log data base identified 27 water wells within one mile of this proposed withdrawal. The wells range from 42 to 596 feet deep, most of them being within the 100 to 200 foot depth range and likely draw water from the shallower aquifers, primarily the Qva.

G2-29557 Washington Water Service

This application was filed December 3, 1997. The applicant requested water for multiple domestic supply for 150 connections from multiple wells. The requested instantaneous amount is 110 gpm and an annual quantity of 60 ac-ft per year. The location of this proposed withdrawal is located between Marvin and Hawks Prairie roads, approximately 2 miles north of Lacey.

The location of this withdrawal and the proposed place of use appear to overlap with G2-29250 Prairie Ridge application.

Surface elevations at the proposed well site range from 260 to 300 feet above msl. Information on the application indicates that the proposed depth of the wells is 150 feet. Utilizing information by Drost and others (1998) the water producing unit at that depth is the Qc.

Ecology records indicate at least 54 water wells are located within a one mile radius of the proposed place of withdrawal. These wells range in depth from approximately 50 feet to 646 feet below ground surface. All wells draw water from similar glacial type deposits. Thirty-two wells are between 100 and 200 feet deep and also likely draw water from the Qc.

Utilizing the USGS Thurston County groundwater model, a scenario was run to simulate potential impacts resulting from withdrawal from the proposed wells. Each well was located within the Qva aquifer. The withdrawal rate was calculated using the proposed annual quantity and back-calculating for a constant rate of pumping, and dividing the quantity in half. The pumping rate chosen was 19 gpm for each well. Running the scenario for 1000 days resulted in a net loss of water to Woodland Creek.

Although the exact quantities are only estimates, the relationship between the proposed withdrawal and Woodland Creek, the results of the evaluation indicated that pumping will almost certainly capture groundwater that would otherwise discharge to Woodland Creek and its associated wetlands. Flow and volume of groundwater discharging from these surface waters would likely be reduced and senior water right holders would be impaired. Mitigation of these potential impacts will be necessary in order for Ecology to approve the application.

G2-29697 American Water Resources

On May 18, 1998, Virgil Fox, representing American Water Resources, filed an application to withdraw public groundwater from one well. The amount requested was 30 gallons per minute (gpm) and an annual quantity of 3 acre-feet (ac-ft) per year for multiple domestic use for 6 connections. The project name is "Woods Estate" and is located on Dickenson Point Peninsula near Boston Harbor, within one-half mile of Dana Passage of Puget Sound.

The project name is "Woods Estate" and is located on Dickenson Point Peninsula near Boston Harbor, within one-half mile of Budd Inlet and Dana Passage of Puget Sound. The Dickenson Point Peninsula is roughly 6 miles long and 4 miles wide. The Dickenson Point Peninsula forms roughly the western half of the Henderson Inlet subbasin, a portion of the Deschutes River Watershed, in WRIA 13. The eastern half of the peninsula is drained primarily by Woodward Creek and several small streams that discharge to Budd Inlet, to the east. The western portion of the peninsula is drained primarily by Woodland Creek which empties into Henderson Inlet. Henderson and Budd Inlets are two of the five inlets that form the terminus of Puget Sound.

The Woods Estate Water System is a Class B water system that serves a total of 6 connections on 6 developed lots. Four lots are approximately 5-acres in size and two lots are approximately 2 ½ acres in size. The well is 8-inches in diameter with a completed depth of 50 feet.

A well log provided by the applicant indicates that a well was drilled in 1997. A USGS quad map estimates the surface elevation at the project site to be approximately 100 feet above mean sea level (msl). Information recorded on the well log indicates the well was tested at 15 gpm with approximately 40 feet of drawdown after

2 hours of pumping. The well is screened from 40 to 50 feet bgs, across the entire thickness of the water producing zone. The water bearing unit is described as a sand unit situated between clay units that lie both above and below it. The static water level was recorded at 8 feet below ground surface (bgs), or approximately 92 feet above msl, indicating confined aquifer conditions.

A well log provided by the applicant indicates that a well was drilled in 1997 and is approximately 50 feet in depth and 8 inches in diameter. A USGS quad map estimates the surface elevation at the project site to be approximately 100 feet above mean sea level (msl). Information recorded on the well log indicates the well was tested at 15 gpm with approximately 40 feet of drawdown after 2 hours of pumping. The well is screened from 40 to 50 feet bgs, across the entire thickness of the water producing zone. The water bearing unit is described as a sand unit situated between clay units that lie both above and below it. The static water level was recorded at 8 feet below ground surface (bgs), or approximately 92 feet above msl, indicating confined aquifer conditions.

Although the pump test was run at only 15 gpm, this well is currently producing 32 gpm; therefore this well should easily produce the requested amount of 30 gpm.

Drost and others (1998) utilized a well approximately 2,000 feet from the Woods Estate well in their study. Comparing information on this well with the estimated elevations of the water table and the water bearing zone in the Woods Estate well, the Woods Estate well is likely drawing water from a permeable zone within the Qvt.

The Woods Estate well intercepts water that likely flows downward to deeper units which ultimately discharge to marine water. Because this well is located more than ½ mile from marine water and the elevations of the water table and the water producing zone are considerably above sea level, this well does not appear to be a high risk area for seawater intrusion.

The subject well is completed in an aquifer approximately 40 feet above msl. The Woods Estate well intercepts water that would otherwise flow vertically downward to other aquifers and ultimately discharge to Puget Sound. As such, withdrawals from this well are not expected to affect surface waters in the WRIA.

G2-29861 Mance and Sons Residential Development, Inc.

On June 14, 1999, John Mance, on behalf of Mance & Son Residential Development, Inc., filed an application to withdraw public ground water from one well. The amount requested was 100 gallons per minute (gpm) and 20 acre-feet (ac-ft) for multiple domestic supply for 12 connections. The name of the project is "North Pointe".

North Pointe is located directly east of Tolmie State Park. The property slopes northeasterly towards Nisqually Reach, surface elevations ranging from 165 to 120 feet above msl. The surface elevation at the well site is approximately 140 feet above msl. The well was drilled in December 2000, has a completed depth of 173 feet bgs, and is screened from 147 to 173 feet bgs. The well log indicates intercepting a water bearing zone at an approximate depth of 92 feet bgs that extends to the total completed depth of the well. Utilizing information in Drost (1998) this well is likely drawing water from the Qc geohydrologic unit. Groundwater at this location is discharging to marine water.

The North Pointe well is completed in an aquifer approximately 20 feet below msl. The North Pointe well intercepts water that would otherwise discharge to the Nisqually Reach of Puget Sound, therefore groundwater withdrawals are not expected to affect flow in surface waters in the Deschutes River watershed.

The Thurston County Conservancy Board approved a transfer of 3.5 ac-ft of water to the North Pointe well. Currently, this well is operating under permit No. G2-27912 which authorizes the withdrawal of 100 gpm from 2 wells, the second well identified as Deerfield Park Well 2.

Dion and Sumioka (1978) do not identify any high chloride wells near the proposed withdrawal. Although the elevation of the aquifer is near sea level, the withdrawal location is approximately ¾ mile from marine water. At this distance from marine water, the risk of seawater intrusion at this location is minimal.

G2-29951 Miller Land and Homes

On October 18, 2000, Eric Weber in behalf of Miller Land and Homes, filed an application for multiple domestic supply from two wells for 172 gpm and 45.2 ac-ft per year. This proposed development, Pleasant Glade, occupies approximately 171 acres in the Woodland Creek watershed. Based on zoning restrictions, the development would have a maximum of 101 lots. Both proposed well locations lie within 1/3 mile of Woodland Creek. The wells would be drilled to a depth of approximately 160 feet and be drilled to target the Qc geohydrologic unit.

The elevation of Woodland Creek at the nearest point to the withdrawal site is approximately 35 to 40 feet above msl. A cross section provided in Drost (1998) that transects the site suggests the well site locations within the Qc may be separated from the creek by Qf, Qvt, and Qvr. However, additional information within Drost (1998) suggests that these units may not be continuous across the project area or if they are present, they may not very thick.

In Sinclair and Pitz (*Estimated Baseflow Characteristics of Selected Washington Rivers and Streams*: Washington Department of Ecology Water Supply Bulletin No. 60.1999), streamflow information collected on the Deschutes River suggested that most of the river flow is due to baseflow contribution, especially during the summer months. Baseflow is the portion of streamflow contributed by groundwater. A comparison of annual data for the Deschutes River for the period of time evaluated indicates a divergence between baseflow contribution and total streamflow, suggesting that groundwater contribution has decreased. This decrease in groundwater contribution may be due to increased groundwater pumping, decreased groundwater recharge, or increased surface runoff. All three of these factors may be the result of an overall increase in impervious area (development).

A similar analysis for Woodland Creek indicates even a stronger dependence of groundwater contribution to stream baseflow (Sinclair and Pitz, 1999). Therefore, a decrease in groundwater contribution (baseflow) would directly result in a reduction of streamflow in Woodland Creek
In Drost (1999), a conceptual model of the groundwater system is presented which identifies two components of subsurface flow, those which discharge directly to Puget Sound and those that discharge to surface water bodies. This model was constructed as a tool to increase the understanding of the groundwater flow system and provides an indication of how the groundwater flow system behaves.

A conceptual analysis using the information provided in Drost (1999) and Drost (1998) indicates that withdrawals at the proposed locations would likely capture groundwater that would otherwise discharge to Woodland Creek and its associated wetlands. Flow and volume of groundwater discharging from these surface waters would likely be reduced and senior water right holders would be impaired.

Minimum instream flows were established in 1988 through Chapter 173-513 WAC, the Instream Resources Protection Program (IRPP) for the Deschutes River Basin Water Resource Inventory Area (WRIA) 13. This IRPP also closes Woodland Creek and its tributaries to withdrawals. Flows established in this WAC are considered an appropriation and senior to all permits approved after 1988 and subsequent water right applications. Ecology must deny any proposed groundwater withdrawals that have the potential to impair flows in Woodland Creek.

G2-29953 Miller Land and Homes

On October 10, 2000, Eric Weber in behalf of Miller Land and Homes, filed an application for multiple domestic supply from two wells for 244 gpm and 74 ac-ft per year. This proposed development would occupy approximately 279 acres on 3 tax parcels and have up to 166 lots. The wells are expected to be approximately 240 feet deep and target the Qc geohydrologic unit.

The project area is located on Johnson Point Peninsula, approximately Henderson Inlet to the west and the Nisqually Reach to the east. The 279-acre proposed development is on property that looks north eastward to the Nisqually Reach, within ¾ mile from marine water. The subject site is immediately south of application No. 2-29861 (Mance and Sons Residential Development) and targets the same geohydrologic unit, the Qc. A well at the proposed location targeting the Qc will intercept water that would otherwise discharge to the Nisqually Reach of Puget Sound. Therefore groundwater withdrawals from the proposed locations are not expected to affect flow in surface waters in the Deschutes River watershed.

Dion and Sumioka (1978) do not identify any high chloride wells near the proposed withdrawal. Although the elevation of the aquifer is near sea level, the withdrawal location is approximately ¾ mile from marine water. At this distance from marine water, the risk of seawater intrusion at this location is minimal.

G2-30061 Kimberly Baxter:

This application was filed July 12, 2000. This application was filed for single domestic use, stockwater, and irrigation of 3 acres at an instantaneous amount of 50 gpm. The location of the proposed withdrawal is on Dickinson Point Peninsula near Boston Harbor, within one mile of Budd Inlet.

A well log provided by the applicant indicates the well was drilled in 1995 and is approximately 340 feet deep. Information on the well log identifies the water bearing unit as a sand and gravel layer at a depth of 350 feet bgs. The well log records static water level at 155 feet bgs. The well was tested at 50 gpm.

Ecology's well log data base indicates approximately 76 water wells within one mile radius of the Baxter well. At least 67 wells draw water either from permeable layers within the Qf unit or in the Qc aquifer. Interpretation provided by Drost and others (1998) indicates that the Baxter well is likely drawing water from the older TQu unit. Using a USGS quad map, the surface elevation at the location of the Baxter well is approximately 140 feet above msl. The water bearing zone appears to occur at a depth of approximately 350 feet bgs, or 210 feet below msl. Comparing this depth interval to the measured static water level in the well after drilling (155 feet bgs, 15 feet above msl) indicates this well is under pressure or confined conditions.

Dion and Sumioka (1978) do not identify any high chloride wells near the proposed withdrawal. Groundwater at this location is discharging to marine water. Given the distance of this well to marine water (one mile) and that the well is under confining pressure, I consider SWI risk at this location to be low.

<u>Mud Bay –Cooper Point Applications</u>

G2-27426 City of Olympia

On November 11, 1988, the City of Olympia filed an application to withdraw public groundwater from a well at a rate of 1,500 gallons per minute (gpm) and 2,500 acre feet (ac-ft) of water per year for municipal supply. The application was assigned number G2-27426. In accordance with Chapter 173-591 WAC Reservation of Future Public Water Supply for Thurston County, this application was given a priority date of August 13, 1986. A request to drill and test the above referenced well was submitted with the application. The project location is in the Deschutes Water Resources Inventory Area (WRIA) 13. The well is sited in the Allison Springs Aquifer.

<u>Preliminary Permit to Drill and Test</u>

A preliminary permit was issued to the City of Olympia to install and test a new municipal water supply well (Well 13) on November 14, 1988. This preliminary permit also allowed installation of monitoring wells to be used during the well testing. The well construction, testing, and monitoring were summarized in *Drilling and Testing of Olympia Well 13* by JMM Consulting Engineers dated March 1989.

On June 12, 1995 the City of Olympia requested a temporary permit for use of Well 13 to lessen reliance of water use from McAllister Springs because of water quality concerns at the springs. Ecology issued a temporary permit to use Well 13 on July 28, 1995 and has extended the temporary use permit year by year, to date.

Well Description

Following are the construction details of Well 13:

Well Depth:	200 feet
Elevation:	147 feet above msl
Casing Diameter:	16 inch
Screen Diameter:	14 inch
Yield:	1,000 gpm
Screened interval:	171 feet to 185 feet, 24 to 38 feet below msl
Static Water Level (SWL):	115 feet bgs, 32 feet above msl
Construction Completed:	January 13, 1989
Driller:	Burt Well Drilling

Aquifer Characteristics

The Allison Springs Aquifer is interpreted to be confined on a regional scale and is recharged from the upland area to the east (Robinson & Noble, Inc., December 1989, *City of Olympia, Construction and Testing of Production Well 19 at Allison Springs*). A review of water level data indicates that the direction of groundwater flow is westerly towards Eld Inlet. The springs represent a local breach of the confining layer, but drain only a small portion of the aquifer underflow. Allison Springs discharges directly to Eld Inlet and is located on property owned by the City of Olympia.

During the drilling of Well 13, two distinct aquifers were found (JMM, 1989). The upper aquifer extends from 96 feet to 114 feet below ground surface (bgs) (51 feet to 33 feet above mean sea level (msl)). This upper aquifer is likely located in the Qva hydrologic unit (Drost, 1998). Olympia's well 13 is cased off from the upper aquifer, and completed within the lower aquifer. The lower aquifer, or Allison Springs Aquifer, extends from 147 feet to 191 feet bgs (sea level to 44 feet below msl). Based on interpretation using Drost (1998), this well is likely drawing water from the Qc hydrologic unit.

Mud Bay Observation Well

An observation well, installed near Mud Bay, was used to monitor the impacts that groundwater withdrawals by City of Olympia Wells 12 and 13 may have on area wells. Several flowing artesian wells, ranging in depth from 90 to 110 feet bgs (80 to 100 feet below msl) are utilized for domestic and commercial purposes along Mud Bay near the site of the observation well.

The Mud Bay Observation Well has a total depth of 105 ft with an artesian pressure of approximately 12 feet measured using a standpipe manometer (5.2 pounds per square inch, psi) (JMM, 1989). Subsurface materials encountered during drilling consisted of clays and silty clays from near ground surface to a depth of over 100 feet. These clays are plastic, and range in character from soft to firm and are interbedded with thin seams of sand and gravelly sand.

Based on the information gained during drilling of the observation well, it appears that the Allison Springs Aquifer does not extend to the developed area along Mud Bay. Instead, this aquifer is truncated near the base of the slope in the Allison Springs area. The flowing wells along Mud Bay appear to be tapping thin aquifers approximately 40 to 60 feet below the bottom of the Allison Springs Aquifer (JMM, 1989).

Utilizing information provided in Drost (1998), these wells are likely drawing water from zones within the TQu hydrologic unit.

January 1989 Pump Test Results

A 24-hour long pump test of Well 13 was performed January 12 and13, 1989. The test was conducted in two parts, a step-test followed by constant rate test. The step test consisted of three one-half hour steps at approximate pumping rates of 500 gpm, 725 gpm, and 1,050 gpm. The 1,050 gpm step was continued for the constant rate portion of the test. Average flow rate for the entire testing period was 1,033 gpm. Maximum drawdown was 31.5 feet (150 feet below the top of the casing). Two hours following the conclusion of the test, the water level in the well recovered to the pre-pumping water level(JMM, 1989).

Specific capacities during the step portion of the test ranged from approximately 53 gpm per foot of drawdown (gpm /ft) at the end of the first step to 35 gpm/ft at the end of the third step. Drawdown appeared to decrease after approximately 200 minutes of pumping, and stabilized after 700 minutes. The decrease in drawdown rate appears to be the result of an increase in "apparent transmissivity" and is likely the result of leakage from underlying and/or overlying aquifers. The transmissivity of the aquifer was estimated to be 65,000 gpd/ft. An increase in "apparent transmissivity" to 170,000 gpd/ft was evident later in the recovery period can be attributed to leakage (JMM, 1989).

Water levels in six surrounding wells were measured throughout the pumping and recovery periods. Responses in observation wells during the test were inconclusive, with at least two of the wells showing tidal influences. Several monitoring wells appeared to indicate leaky aquifer conditions(JMM, 1989).

Although there was no practical way to measure the discharge from Allison Springs during the pump test, visual observations were made. While pumping Well 13 a noticeable decrease in the rate of discharge from Allison Springs was observed (JMM, 1989). Allison Springs discharges directly to Puget Sound. The City of Olympia owns the property on which Allison Springs is located.

Based on the results of the pump test, Well 13 should be capable of a sustained yield of approximately 1,000 gpm(JMM, 1989).

September 1994 Pump Test

In August 1994, a domestic well jointly used by Mud Bay Pottery and Blue Heron Bakery reportedly suffered a loss of head. This well normally flows to a cistern from which the water supply is pumped. The well owners approached the City of Olympia, believing that the head loss was caused by pumping from the Allison Springs Aquifer. In response to this request, additional well testing was conducted September 1996 and is summarized in *City of Olympia, Allison Springs Wellfield Test* by Robinson and Noble, Inc., dated September 1994.

A well test was designed to address possible impacts at Allison Springs and the Pottery Shop Well. Well 13 was pumped at an average rate of 650 gpm continuously for several days prior to, and for the duration of the testing period. The well test, itself, consisted of pumping Well 19 at 1,250 gpm for 24 hours. Monitoring of the aquifer response was performed at both pumping wells (wells 13 and 19) and four observation wells (Robinson & Noble, 1994).

Well 19 is the primary production well for the Allison Springs wellfield. The current production rate of the well is approximately 1,200 gpm. Noticeable responses at the Pottery Shop Well and Allison Springs were reported only when Well 19 was pumping. This is likely due to the fact that Well 19 is completed in a more productive portion of the aquifer than Well 13. Well 19 is also located closer to discharge area for Allison Springs (Robinson & Noble, 1994).

The test results indicated a clear interference at Allison Springs and the observation wells as a result of pumping from the Allison Springs Wellfield. However, the imposed drawdown at the Pottery Shop Well does not reduce the production capacity of that well, but only causes a reduction of water level, causing

the well to no longer be free flowing. The interference was sufficient to warrant installation of a pump in the Pottery Shop Well (Robinson & Noble, 1994).

Seawater Intrusion

While the aquifer is below sea level, the water level in Well 13 is above sea level, making the aquifer confined. Confined aquifers generally are not susceptible to seawater intrusion. However, to further evaluate area conditions with regard to seawater intrusion, Ecology's Environmental Information Management (EIM) system and the Southwest Regional Office (SWRO) Ground Water Data Base were consulted to determine if elevated chloride conditions occurred near the Allison Springs Wellfield. As such, these sources contained no elevated chloride results, suggesting seawater intrusion in the project area is not an issue.

Available data from wells in the area shows chloride concentrations are relatively low. Based on the available information, it does not appear that this area is at risk of seawater intrusion.

Recommendations

The general direction of groundwater in the Allison Springs Aquifer is westerly towards Eld Inlet, and Olympia's Well 13 is pumping groundwater that discharges to Puget Sound. As such, well operations would not be expected to affect flow in any regulated surface waters within the Deschutes River Basin. Although pumping of Well 13 does cause a reduction in the amount of discharge from Allison Springs, these springs are located on property owned by the City of Olympia and discharge directly to Eld Inlet.

Pumping high rates of water from the Allison Springs Wellfield does impact some free flowing artesian domestic wells, specifically, the Pottery Shop Well. The yield of the well is not reduced by this interference, however, it did necessitate the installation of a pump. Both Wells 13 and 19 have been in use since 1995, pumping rates of 900 and 1200 gpm, respectively, reportedly with no adverse effects.

G2-27941 City of Olympia

On December 8, 1990, the City of Olympia filed an application to withdraw public groundwater from a well at the instantaneous rate of 1,500 gallons per minute (gpm) for municipal supply at 1,600 acre-feet (ac-ft) per year for municipal supply.

Wells 13 and 19 comprise the City of Olympia Allison Springs Wellfield. Both Wells 13 and 19 are located off of Delphi Road, in the Allison Springs Subarea in west of Olympia. The City of Olympia also operates Well 13 at the site, a second municipal water supply well (application No. G2-27426) located 500 feet east of Well 19. A third municipal water supply well, Well 12, is also located at the site, but is not being utilized. The City has not filed an application with regard to Well 12

Preliminary Permit to Drill and Test

In response to a request by the City of Olympia, a temporary permit was issued January 24, 1991to allow the construction and testing of a new municipal water supply well (Well 19). This temporary permit expired January 31, 1992, however, this well was not drilled.

A preliminary permit was subsequently issued July 20, 1993 to drill and test Well 19 and on August 27, 1993, drilling began. The well construction, testing, and monitoring were summarized in *City of Olympia, Construction and Testing of Production Well 19 at Allison Springs* (Robinson & Noble, Inc., December 1989).

On June 12, 1995 the City of Olympia requested a temporary permit for use of Wells 13 and 19 to lessen reliance of water use from McAllister Springs because of water quality concerns at the springs. Ecology issued a temporary permit to use Wells 13 and 19 on July 28, 1995 and has extended the temporary use permit year by year, to date.

Well Description

Following are the construction details of Well 19:

Well Depth:	160 ft
Casing Diameter:	16 inch
Screen Diameter:	14 inch
Yield:	1,200 gpm
Screening:	129 ft to 159.7 ft bgs
Elevation:	120 ft above msl
Static Water Level:	87.30 ft bgs, 32.7 ft above msl
Construction Completed:	September 24, 1993
Driller:	Hokkaido Drilling and Development Co.

Aquifer Characteristics

The following information was gathered from the following resource materials:

- *Drilling and Testing of Olympia Well* 13, James M. Montgomery Consulting Engineers, Inc., 1989. (JMM)
- *City of Olympia, Construction and Testing of Production Well 19 at Allison Springs*, Robinson & Noble, Inc., December 1989. (R & N)

The Allison Springs Aquifer is interpreted to be confined on a regional scale and is recharged from the upland area to the east A review of water level data indicates that the direction of groundwater flow is westerly towards Eld Inlet. The springs represent a local breach of the confining layer, but drain only a small portion of the aquifer underflow (JMM 1989). Allison Springs discharges directly to Eld Inlet and is located on property owned by the City of Olympia.

During the drilling of Wells 13 and 19, two distinct aquifers were found (JMM 1989) (R & N 1989). At well 19, the upper aquifer extends from 96 ft to 114 ft below ground surface (bgs) (24 ft to 6 ft above mean sea level (msl). This upper aquifer is likely located in the Qva hydrologic unit (Drost, 1998). Well 19 is cased off from the upper aquifer, and completed within the lower aquifer. The lower aquifer, or Allison Springs Aquifer, extends from 120 feet to 160 feet bgs (sea level to 40 ft below msl). The aquifer, at this location, is exclusively highly permeable, clean, brown gravels (from ½ inch to 4 inch in diameter cobbles) with a few sandy zones (R & N 1989). Based on interpretation using Drost (1998), this well is likely drawing water from the Qc hydrologic unit.

Mud Bay Observation Well

An observation well, installed near Mud Bay, was constructed to monitor the impacts that groundwater withdrawals by City of Olympia Wells 12 and 13 may have on area wells. This installation of this well was authorized by a preliminary permit issued to the City of Olympia on November 14, 1988 in response to a request to install and test another municipal water supply well (Well 13). Several flowing artesian wells, ranging in depth from 90 to 110 feet bgs (80 to 100 feet below msl) are utilized for domestic and commercial purposes along Mud Bay near the site of the observation well.

The Mud Bay Observation Well has a total depth of 105 ft with an artesian pressure of approximately 12 feet measured using a standpipe manometer (5.2 pounds per square inch, psi) (JMM, 1989). Subsurface materials encountered during drilling consisted of clays and silty clays from near ground surface to a depth of over 100 feet. These clays are plastic, and range in character from soft to firm and are interbedded with thin seams of sand and gravelly sand.

Based on the information gained during drilling of the observation well, it appears that the Allison Springs Aquifer does not extend to the developed area along Mud Bay. Instead, this aquifer is truncated near the base of the slope in the Allison Springs area. The flowing wells along Mud Bay appear to be tapping thin aquifers approximately 40 to 60 feet below the bottom of the Allison Springs Aquifer (JMM, 1989). Utilizing information provided in Drost (1998), these wells are likely drawing water from zones within the TQu hydrologic unit.

Pump Test Results

A variable rate step test was performed to determine optimum pumping rate for the 24-hour pump test. The 24-hour pump test of Well 19 was performed at the rate of 1,200 gpm on September 20 and 21, 1993. Prior to the test, an electronic, transducer-based, data logger was installed in Exploration Well 4 (150 ft south of Well 19). In addition, an electric water level sounder was installed in Well 13, located 500 ft east of Well 19. All wells are completed in the same aquifer (JMM, 1989).

The long-- term, constant rate pumpdischarge test was started conducted ? at a rate of1,200 gpm and was maintained for 24-hours. The water level at the conclusion of the test was 104.8 ft below the top of the casing, approximately 14.5 ft below the pre-test static water level of 90.25 ft. The drawdown data indicate a transmissivity (T) 113,000 gallons per day per ft (gpd/ft) for the early part of the test (less than one hour of pumping), reflecting near well conditions. After one hour of pumping, drawdown appeared to decrease. The decrease in drawdown rate appears to be the result of an increase in "apparent transmissivity" and is likely the result of leakage from underlying and/or overlying aquifers (JMM, 1989).

The water level response in the observation wells, (Well 13 and Exploration Well 4), show the same general trends as observed in the pumping well. The drawdown data for Well 13 suggest an early T value of 76,000gpd/ft, indicating less permeable conditions at this location than near Well 19. Exploration Well 4 drawdown data shows a much higher T value of 115,000 gpd/ft (JMM, 1989).

Testing indicates well interference between Wells 13 and 19, but does not preclude concurrent use of both wells.

September 1994 Pump Test

In August 1994, a domestic well jointly used by Mud Bay Pottery and Blue Heron Bakery reportedly suffered a loss of head. This flowing artesian well normally flows to a cistern from which the water supply is pumped. The well owners approached the City of Olympia, believing that the head loss was caused by pumping from the Allison Springs Aquifer. In response to this request, additional well testing was conducted September 1996 and is summarized in *City of Olympia, Allison Springs Wellfield Test* by Robinson and Noble, Inc., dated September 1994.

A well test was designed to address possible impacts effects at Allison Springs and the Pottery Shop Well. The test was performed by pumping Well 19 at 1,250 gpm for 24 hours. Well 13 was run pumped at an average of 650 gpm continuously for several days prior to, and for the duration of the testing period, averaging 650 gpm. The test was performed by pumping Well 19 at 1,250 gpm for 24 hours. Monitoring ofTthe response of the aaquifer to the pumping response was performed monitored at both pumping wells (Wells 13 and 19) and four observation wells (Robinson & Noble, 1994).

Well 19 is the primary production well for the Allison Springs Wellfield. The current production rate of the well is approximately 1,200 gpm. Noticeable responses at the Pottery Shop Well and Allison Springs were reported only when Well 19 was pumping. This is partly likely because Well 19 is completed in a more productive portion of the aquifer with a higher transmissivity than Well 13. Well 19 is also located closer to the Allison Springs's outflow area (Robinson & Noble, 1994).

The test results indicated a clear interference at Allison Springs and the observation wells as a result of pumping from the Allison Springs Well field. However, the imposed drawdown at the Pottery Shop Well

does not reduce the production capacity of that well, but only causes a reduction of water level, causing the well to no longer be free flowing. The interference was sufficient to warrant installation of a pump in the Pottery Shop Well (Robinson & Noble, 1994).

Seawater Intrusion

While the aquifer is below sea level, the water levels in Well 19 are above sea level, making the aquifer confined. Confined aquifers are generally not at high risk for seawater intrusion. However, to further evaluate area conditions with regard seawater intrusion, Ecology's Environmental Information Management (EIM) system and the Southwest Regional Office (SWRO) Ground Water Data Base were consulted to determine if elevated chloride concentrations occurred near the location of Wells 13 and 19. As such, these sources contained no elevated chloride results, suggesting the project area is at low risk for seawater intrusion. Additional data was reviewed from the following U.S. Geological Survey reports:

Available data from wells in the area shows chloride concentrations are relatively low. Based on the available information, it does not appear that this area is at risk of seawater intrusion

Recommendations

The general direction of groundwater in the Allison Springs Aquifer is westerly towards Eld Inlet, and Olympia's Well 19 is pumping groundwater that discharges to Puget Sound. As such, well operations would not be expected to affect flow in any regulated surface waters within the Deschutes River Basin. Although pumping of Well 13 does cause a reduction in the amount of discharge from Allison Springs, these springs are located on property owned by the City of Olympia and discharge directly to Eld Inlet.

Pumping high rates of water from the Allison Springs Wellfield does impact some free flowing artesian domestic wells, specifically, the Pottery Shop Well. The yield of the well is not reduced by this interference, however, it did necessitate the installation of a pump. Both Wells 13 and 19 have been in use since 1995, pumping rates of 900 and 1200 gpm, respectively, reportedly with no adverse effects.

G2-29331 Mobbs Water System

This application was filed November 20, 1995. The applicant requested water for commercial supply and domestic use for one residence and commercial supply for 9 connections. The location of the proposed withdrawal is on Madrona Beach Road, near the southern extent of Eld Inlet.

A well log on file in the data base corresponding to the applicant was drilled in 1985 and is approximately 100 feet in depth. Information on the well log indicates the well was tested at 25 gpm and the static water level was recorded at 28 feet below ground surface (bgs). The applicant requests 45 gpm. The approximate surface elevation is less than 10 feet above msl.

Ecology's well log data base listed approximately 18 wells within a mile of the Mobbs system well. Most of these wells, like the Mobbs well, are located on properties bounded by Eld Inlet and also discharge to marine water. According to available information, this area may be at risk for SWI. Dion and Sumioka (1978) reports a nearby well with chloride concentrations near 100 milligrams per liter (mg/l) in 1967 and again in 1978. However, no well depth is given. It is likely that this high chloride well is located along shoreline not continuous with the property where the Mobbs well is located, and therefore chloride concentrations may not be the same at the Mobbs well. However, given the potential for SWI, it is probably applicable to request the applicant to submit chloride data as part of the conditions of the permit.

G2-29373 Robert Meenk

This application was filed April 12,1996. The applicant requested water for multiple domestic for 2 connections and irrigation of 2 acres. The proposed withdrawal is located on the east side of the Cooper Point Peninsula, on waterfront property that looks across Bud Inlet, approximately 1 mile from the point. At

the location of the proposed withdrawal, the Cooper Point Peninsula is approximately ½ mile wide, bounded on the east by Budd Inlet and on the west by Eld Inlet.

Ecology's well log data base listed approximately 20 wells within one-mile from the proposed withdrawal. All wells lie no greater than ¼ mile from marine water. A log for a well owned by Bill Myers appears to closely match the address listed on the application. This well was drilled in 1978 and is approximately 114 feet in depth. The static water level was recorded at a depth of approximately 80 feet, making the elevation of the water table near to sea level, extrapolating from a USGS quadrangle map.

Dion and Sumioka (1978) list a well in the same general location as the application with a comparable depth (105 ft) as the Myers well. This well was sampled in 1967 and 1978 for chloride and reported concentrations of 7.5 and 14 mg/l, respectively, well below the 100 mg/l threshold level. Two deeper wells in the same general area were also sampled and chloride concentrations were also low (less than 6.2 mg/l). One shallower well (70 ft deep) reported elevated chloride concentrations of 120 mg/l. This well is located on the opposite side of the Cooper Point Peninsula.

Groundwater at this location is discharging to marine water. Given the close proximity of the well to salt water both to the east and the west, and that the elevation of the water table is near sea level, SWI risk at this location could be considered high. It would be applicable to request the applicant to submit chloride data as part of the conditions of the permit.

S2-29790 George Yantis, Jr.

On August 13, 1998, George Yantis, Jr., applied for a permit to appropriate public water from an unnamed spring at withdrawal rate of 0.22 cubic feet per second (cfs) for multiple domestic use and lawn and garden irrigation. The project site is within the Deschutes River watershed in Water Resources Inventory Area (WRIA) 13.

The Yantis property is located on the southern portion of the Cooper Point Peninsula at an approximate elevation of 120 feet above mean sea level (msl) on property that looks eastward towards Budd Inlet. The Yantis property lies within Olympia city limits, in a residential area served water by the City of Olympia. Mr. Yantis owns three parcels of property. The residence and yard area occupy two nearly-level parcels that total 2 acres. The third parcel is an adjacent undeveloped parcel that consists of a steep-sided ravine that is forested. An unnamed stream occupies the bottom of the ravine and discharges to Budd Inlet.

The spring discharges above the level of the unnamed stream, at an elevation of approximately 50 feet below the top of the slope. The spring discharge site is completely enclosed by a pumphouse that has been built directly over the spring. The spring discharges to a cistern and overflow is allowed to flow into the unnamed stream. At the time of the site visit, on February 6, 2003, the stream was approximately 5 feet wide with an average depth of 6 to 10 inches. The spring discharges on property owned by Mr. Paulsrude. Mr. Yantis owns the pumphouse.

The Paulsrude property is located on the hillside directly above the spring. It consists of approximately ½ acre of ornamental and native plants and a vegetable garden.

During the site visit, several springs were observed to be discharging along the ravine at a distance of approximately 50 feet below the top of the slope. The springs appeared to be discharging above a finely layered sequence of clays, well above the base of the creek. Vegetation along the hillside above the discharging springs indicated moist soil conditions. Based on information in Drost (1998), it is likely that the springs are discharging at the base of the Qvr geohydrologic unit. Drost (1998) also indicates the presence of the Qva geohydrologic unit within the ravine for Schneider Creek.

Use from this spring is not expected affect regulated surface waters within the Deschutes watershed. The spring discharges to the stream that empties directly to Budd Inlet. There do not appear to be any other

water uses from this creek. The unnamed creek has also been called Schneider Creek by local residents; however, on USGS quadrangle maps no name is listed. This creek is approximately 1 mile long and appears to originate in Olympia's westside community.

Although springs provide some flow to the creek, baseflow is likely supported primarily by groundwater discharge from the Qvr and Qva geohydrologic units. Both Qvr and Qva geohydrologic units serve as aquifers within the WRIA.

G2-29794 Herzog

On September 16, 1998, Karl F. Herzog applied for a permit to appropriate public water from a well at withdrawal rate of 30 gallons per minute (gpm) and 5 acre-feet (ac-ft) for year-round use for single domestic supply, stockwater, and seasonal use for irrigation of 2.5 acres of community garden.

The project site is located on the southern portion of the Cooper Point Peninsula on property that is midway between Eld Inlet, to the west, and Budd Inlet, to the east. At the project site location, the approximate elevation is 180 feet above mean sea level (msl).

The Herzog property is a 3.77-acre parcel which is occupied by one single-family residence. The well is 6 inches in diameter, has an estimated depth of 108 feet, and currently is metered for water use. The residence and the garden are served by separate water lines.

A well report is not available for the Herzog well. A well test conducted in February 1997 measured the static water level (swl) of the well at 93 feet bgs and estimated the well capacity to be 30 gpm. The depth of the well was estimated at 108 feet. The well is equipped with a 1 ½ horse-power (h.p.) pump and one pressure tank serves to pressurize the system. The estimated elevation at the subject site is 180 feet above msl.

The Lena Beach (Beach) well, located within ¼ mile from the Herzog property, is completed at a similar depth (117 feet) and has a comparable static water level (swl 90 feet). The well log for the Beach well reports packed coarse sand and gravel to a depth of 97 feet below ground surface. This well draws water from a water bearing zone approximately 23 feet in thickness from a depth of 94 feet to 117 feet below ground surface. This well appears to span the entire thickness of this water bearing zone. According to information in Drost (1998) a well at this completed depth at this location is likely drawing water from the Qva hydrologic unit.

Available information indicates that the Herzog well is completed in an aquifer approximately 90 feet above msl, the Qva geohydrologic unit (Drost, 1998).The Qva geohydrologic unit in the area of the subject site is discharging directly to Eld Inlet, therefore groundwater withdrawals from the Herzog well are not expected to affect surface flows in the WRIA.

Based on the distribution of wells in the area and the relatively minimal water needs of the project , I do not anticipate well interference from the Herzog well with area users.

<u>Upper Deschutes Applications</u>

G-2-29778 Sally Myers

This application was filed on June 29,1998. The applicant, Sally Myers, requested to withdraw public groundwater from one well for commercial supply at a rate of 40 gallons per minute (gpm). The proposed withdrawal is located approximately ¼ mile north east of the Town of Rainier in the upper Deschutes River watershed. Surrounding land use is comprised of single and multiple-domestic developments, small farms and agriculture. The well site is located less than 500 feet southeast of SR 507. The Deschutes River is located approximately two miles southwest of the project location. Currently the well is utilized for domestic purposes and serves one residence and a commercial business.

A well log is not available for the subject well, but according to the applicant, the well is 6-inches in diameter and approximately 225 feet deep. According to information in Drost and others (1998), at this depth this well is likely drawing water from the Qc hydrologic unit.

Given the depth of the well and the hydrogeologic properties of the water bearing unit, it is likely that a hydraulic connection exists between the hydrogeologic units at the subject well site and the Deschutes River. A withdrawal from the subject well will likely capture groundwater that would otherwise discharge as surface water to the Deschutes River.

State of Washington
Hydrogeologist
749
Licensed Geologist

TAMMY L. HALL

Nearest well

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W101368
Unique Well I.D. # AEC998
Water Right Permit No.

(1) OWNER: Name **BEACH, LENA** Address **2050 LAKEMOOR SW OLYMPIA, WA 98512-**

(2) LOCATION OF WELL: County **THURSTON** - **SE** 1/4 **NW** 1/4 Sec **17** T **18N** N., R **2W** WM

(2a) STREET ADDRESS OF WELL (or nearest address) **806 OVERHULSE ROAD, OLYMPIA**

(3) PROPOSED USE: **DOMESTIC**

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL Method: **ROTARY**

(5) DIMENSIONS: Diameter of well **6** inches
Drilled **117** ft. Depth of completed well **116** ft.

(6) CONSTRUCTION DETAILS:
Casing installed: **6** " Dia. from **+1** ft. to **115** ft.
WELDED CASING " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: **NO**
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: **YES**
Manufacturer's Name **HOUSTON**
Type **SLOTTED** Model No.
Diam. **5** slot size **000** from **110** ft. to **111** ft.
Diam. **5** slot size **.020** from **111** ft. to **116** ft.

Gravel packed: **NO** Size of gravel
Gravel placed from ft. to ft.

Surface seal: **YES** To what depth? **20** ft.
Material used in seal **BENTONITE**
Did any strata contain unusable water? **NO**
Type of water? Depth of strata ft.
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level **90** ft. below top of well Date **06/20/98**
Artesian Pressure lbs. per square inch Date
Artesian water controlled by

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
PACKED BROWN COURSE SAND	**0**	**6**
PACKED COURSE SAND GRAVEL	**6**	**94**
WET COURSE SAND GRAVEL	**94**	**105**
BROWN COURSE SAND GRAVEL & WATER	**105**	**117**
PACKED BROWN COURSE SAND	**117**	

Work started **06/19/98** Completed **06/20/98**

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? **NO** If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data

Time	Water Level	Time	Water Level	Time	Water Level

Date of test / /
Bailer test gal/min. ft. drawdown after hrs.
Air test **20** gal/min. w/ stem set at **112** ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? **NO**

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME **ARCADIA DRILLING INC.**
(Person, firm, or corporation) (Type or print)

ADDRESS **SE 170 WALKER PARK RD**

[SIGNED] License No. **1149**

Contractor's Registration No. **ARCADDIO98K1** Date 06/22/98

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