CHEHALIS RESERVATION
WELLHEAD PROTECTION REPORT

Prepared for:

The Confederated Tribes of
The Chehalis Reservation
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Chehalis Reservation
wellhead protection
report

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1.0 Introduction

This Wellhead Protection Report has been prepared for the Confederated Tribes of the Chehalis Indian Reservation of Washington State. This study was authorized by Dr. C. S. Sodhi, Director of the Department of Natural Resources, the Confederated Tribes of the Chehalis Reservation. This study was performed under contract between the Washington State Department of Ecology (Centennial Grant) and the Chehalis Tribe. The purpose of this report is to help the Tribe better manage its groundwater supply wells and to better understand the contaminant risks posed to these sources. Specific objectives include:

- Assess the contaminants present in groundwater beneath the Reservation
- Model representative capture zones
- Estimate aquifer properties for use in capture zone modeling
- Perform wellhead survey

This report presents a summary of previous investigations in Section 2, discusses relevant field investigations in Section 3, existing water quality data in Section 4, capture zone analysis in Section 5, sources of contamination in Section 6, and findings and recommendations in Section 7.

1.1 Background Information

The Reservation is situated both in Grays Harbor and Thurston counties along State Route 12 (SR 12) between the cities of Rochester and Oakville. The Reservation comprises 6.6 square miles of the flood plain between the Chehalis and Black Rivers. The topography is generally flat, with surface elevations ranging from about 65 to 100 ft above sea level.

The Reservation is underlain by alluvial material and outwash deposits from the Black and Chehalis Rivers. The alluvium consists of coarse sand and gravel and extends to a depth of approximately 100 feet. The alluvium is underlain by consolidated sedimentary and volcanic bedrock through which little groundwater flows.

Groundwater is shallow and flows generally westward, parallel to the flow of the Chehalis and Black rivers. Depth to groundwater ranges from 10 to 30 feet. There are currently 97 private domestic wells on the Reservation and two public water systems with well sources, shown on **Figure 1**. Domestic wells on the Reservation are completed in the alluvium and range in depth from 20 to 80 feet. These wells typically produce 50 to 500 gpm. The Reservation relies solely on these wells as its source of drinking water. Groundwater on the Reservation is very susceptible to contamination because the aquifer lacks overlying confining layers that would prohibit the downward movement of pollutants.

1.2 Project Organization

The project manager at the Chehalis Reservation is:

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The project manager at Pacific Groundwater Group is:

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2.0 Previous Investigations

Five previous reports address water resources on the Chehalis Reservation.

2.1 USGS Open File Report

The USGS Open File Report titled *Water Resources of the Chehalis Indian Reservation, Washington* (OFR 77-708, 1979) covers the availability and quality of groundwater and surface water as well as flooding analysis. Relevant conclusions from the USGS report include the following:

- Groundwater discharges to the Chehalis and Black Rivers during both summer and winter months.
- Total groundwater use during 1975 was estimated to be 48 million gallons. Estimates of seasonally available groundwater are 20 to 60 times the annual withdrawal in 1975.
- Coliform bacteria were detected in 2 out of 25 wells sampled.
- Average discharge from the Chehalis River near Grand Mound is 2,850 ft^3/sec.

2.2 Groundwater Monitoring Project Plan

A groundwater monitoring project plan for the Chehalis Reservation was produced in 1996. This plan and some of the data are currently unavailable. In this study, 96 wells were monitored annually for two years. One sample was collected during the wet season and one sample was collected during the dry season. Each sample was analyzed for pH, conductivity, temperature, turbidity, nitrate, nitrite, and ammonia. Analytical data from

one sample event is included in Appendix A. Data from other sample event are unavailable.

The 1996 program sampled 96 wells twice. In contrast, the present study focuses on a smaller number of wells with long term quarterly sampling. Data from longer-term sampling will allow identification of trends and seasonal variation in groundwater quality.

2.3 David Evans and Associates Report

David Evans and Associates prepared a report titled *Aquifer Evaluation for Confederated Tribes of the Chehalis Reservation* (January 1998). This report includes well logs for domestic wells on the Reservation and aquifer test results. This report presented hydraulic conductivity estimates of 500 to 1,000 gpd/ft^2 for the upper portion of the aquifer and 10,000 to 15,000 gpd/ft^2 for the lower portion. Recommendations of the David Evans report included:

- Perform spatially distributed aquifer tests to assess hydraulic conductivity regions.
- Perform aquifer tests using higher capacity wells.
- Update database with new water level measurement data.
- Prepare water table contour maps for various seasons.
- Develop a computer model for wellhead protection purposes.

Many of these recommendations are currently being pursued, although not necessarily in conjunction with this report. Higher capacity testing was performed at the Icy Fresh Fish company. Water level and water quality data are being added to the Chehalis Tribe Environmental database. Water table contour maps have been prepared and are included in this report. A computer model is planned for completion over the next year.

2.4 Pacific Groundwater Group Reports

PGG published the two Groundwater Monitoring Reports, one in September 2000 and the other in December 2001. These reports document groundwater samples collected up to the publication date. Findings of the 2001 Groundwater Monitoring Report include:

- Pesticides and herbicides were not detected in any of the samples collected.
- Nitrate concentrations were highest immediately downgradient of Briarwood Farms and the Casino. Concentrations were detected up to 7.86 mg/l. Increasing trends were observed in some wells.
- Total coliform was detected in 26 wells on the Reservation. Coliform was detected nine times in well AAD727.
- Regional groundwater flow is from southeast to northwest at a gradient of 0.001.
- There is good correlation between EPA and Chehalis Tribe analytical results.

A more complete discussion of water quality results from the December 2001 Groundwater Monitoring Report is given in Section 4.

3.0 Field Investigations

Field investigations conducted as part of the wellhead protection program include the installation of an observation well, a short-term constant rate aquifer test, and push probe sampling.

3.1 Observation Well Installation

An observation well was installed on the Icy Waters property on October 17, 2000 for use during the aquifer test. The observation well was installed to collect groundwater level data that was more representative of the surrounding aquifer than data from the pumping well. Considerations for well siting included producing sufficient drawdown during the test and minimizing turbidity in the nearby production well during drilling. Turbidity was a concern because the production well supplies fish hatcheries which house hatchlings that are sensitive to turbidity. Eric Johnson of Icy Waters selected the final well location.

The well was drilled by Arcadia Drilling of Shelton, WA using a Reich T-690-W air rotary rig. The well was originally designed as a 2-inch monitoring well. However, Icy Waters requested that the well be installed as a backup production well. Therefore, Arcadia installed 6-inch steel casing to 100 feet and perforated from 65 to 95 feet with an air perforator. The perforations are rows of vertical slots, ¼ by 1 inch; the rows are separated by 3 inches. Eight columns of perforations were made in the casing. Depth to water at completion was approximately 30 feet. The well was developed by Arcadia for two hours but continued to produce sand after development. The well should be developed further before being used as a production well. The geologic materials encountered were mostly coarse sand and gravel.

3.2 Aquifer Test

A short-term aquifer test was conducted on the Icy Fresh Fish Company's Well 4. The purpose of the test was to evaluate aquifer parameters that could be used to model capture zones. The Icy Fresh Fish Company's facility was selected because their wells are of sufficient capacity to stress the aquifer and provide drawdown necessary to evaluate aquifer parameters. Well 4 was selected for testing because it could be brought off line without compromising their operation. Well 4 is an eight-inch steel cased well perforated from 60 to 98 feet with 3/8 inch by 2 inch perforations. The well is connected to a distribution system that feeds two sets of fish tanks: a hatchery with 23 tanks, and a set of 12 tanks for mature fish. An observation well was installed near Well 4 to increase the accuracy of the test (see Section 3.1).

3.2.1 Field Methods

The short-term, constant-rate pumping test was conducted on November 15, 2000. Because the well is in constant operation, the recovery test was conducted first. When recovery diminished after about 100 minutes, the pump was switched back on and drawdown data was collected. During the test, the pumped water was discharged into the

existing distribution system. Flow rates were measured at each of the tanks with a 5-gallon bucket and a stopwatch. The flow rate was only measured once during the test because of the time required for measurement. The pumping rate was approximately 460 gpm.

Water levels in the observation well were measured using a pressure transducer and data logger, but backup measurements were obtained manually with an electric water level sounder. The diameter of the pumping well access port was too small to accommodate a transducer so only manual measurements were collected in the pumping well.

3.2.2 Water Level Data

Water levels were monitored in the background well for five days before the start of the test (**Figure 2**). The water level varied by two hundredths of a foot over the five day period and no trend was indicated. The constant water levels also indicate that the pump operates at a constant rate.

The initial water level in the pumping well was 32.01 feet below the top of casing. After the recovery period (105 minutes) the water level was 27.50, for a total recovery of 4.51 feet. The initial water level in the observation well was 30.91 feet below the top of casing. After the recovery period the water level was 28.89, for a total recovery of 2.02 feet. Recovery data for both wells is shown on **Figure 3**.

The water level in the pumping well was 27.50 feet below the top of casing when pumping resumed. After the pumping period of 180 minutes, the water level was 31.90 feet below the top of casing, for a total drawdown of 4.4 feet. The water level in the observation well was 28.89 feet below the top of casing when pumping resumed. After 107 minutes of pumping, the water level was 30.88, for a total drawdown of 1.99 feet. Drawdown data for both wells is shown on **Figure 4**.

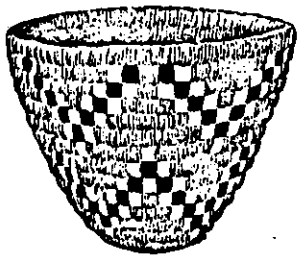
3.2.3 Analysis and Results

Graphs of logarithmic time versus drawdown were used to compute the aquifer parameters of transmissivity and storativity using the following equations developed by Cooper and Jacob (1946):

$$T = 264Q/\Delta s$$

where:

T	=	transmissivity, in gpd/ft
Q	=	pumping rate, in gallons per minute (gpm)
Δs	=	drawdown over one log cycle on the straight-line part of the drawdown



CONFEDERATED TRIBES of the CHEHALIS RESERVATION

March 28, 2002

Ms Cindy James
Financial Assistance Program Manager
Water Quality Division
Washington State Department of Ecology
P.O. Box 47600
Olympia WA 98504-7600

Sub: Wellhead Protection Grant, Grant # G9700162

Dear Ms. James

The Tribe would like to thank the Washington State Department of Ecology for funding the wellhead protection project through the Centennial grants. The final report that was submitted to you summarized the project objectives, methodology and results during the project period that ended in December 31, 2001. However, one of the objectives, wellhead ordinance for the Tribal community water system, could not be accomplished due to lack of sufficient data and available funds under the grant.

Nonetheless, the ordinance will be developed and supporting resolution formulated by the tribal business committee later this year. Thank you for meeting with Harry and myself on March 12th. If you have any questions, please do not hesitate to contact me at the number indicated below.

Thank you

Sincerely

Raman Iyer
Natural Resources Department
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Figures 2 and 3 present drawdown and recovery data for the observation and pumping wells. In all plots, drawdown appeared to flatten towards the end of the test. This decrease relative to theoretical drawdown is likely due to the Chehalis River acting as a positive recharge boundary to the south.

Calculated transmissivity ranges from 323,000 to 379,000 gpd/ft. Hydraulic conductivity is calculated as the transmissivity divided by aquifer thickness. The pumping well screens approximately 40 feet of the aquifer. Based on the well log for the observation well, the pumping well likely draws water from a thicker interval of the aquifer than is perforated. Assuming an aquifer thickness of 50 feet, hydraulic conductivity ranges from 6,460 to 7,580 gpd/ft^2.

3.3 Tribal Housing Well Step-Pumping Test

A step-drawdown pumping test was conducted by Moerke and Associates during summer 2001, on the Tribal Housing Wells 1 and 2. The purpose of the test was to assess pump flow rate and associated drawdown as part of an evaluation of the water system and design requirements to expand the tribal community water system. The test was not conducted as part of the wellhead protection scope of work, however, results from these tests were analyzed to evaluate aquifer parameters and to compare results with results from the aquifer test conducted on the Icy Fresh well. The data was analyzed using the variable discharge solution in AQTESOLV^{TM}, a commercial software designed for aquifer test analysis. Results for hydraulic conductivity are 8,400 gpd/ft2 for Well 1 and 4000 gpd/ft^2 for Well 2, and are consistent with results from the Icy Fresh well aquifer test of 7000 gpd/ft^2.

3.4 Push Probe Sampling

Push probe samples were attempted as part of the WHP program to collect data in areas where domestic wells were not available. Domestic wells were sampled as part of the Groundwater Monitoring Program (see Section 4.0). Push probe sampling was accomplished by advancing small diameter casing through direct pressure on the casing. No rotary drilling methods were used. Once the desired depth was reached, the probe was retracted and water was pumped out of the casing using a peristaltic pump. Detailed push probe methodology is presented in the approved Groundwater Monitoring Plan (PGG, 1999). Push probe sampling was performed by Cascade Drilling of Woodinville, WA on April 10, 2000.

Sample collection was attempted at three locations, on the east and west sides of Briarwood Farms, and along Moon Road. Multiple attempts were made at each location. However, the drill rig was unable to penetrate deeper that 8 feet in all 6 borings attempted. Depth to groundwater is approximately 20 feet. The difficulty in reaching the water table is likely due to the coarseness of the aquifer material.

3.5 Wellhead Condition Survey

A wellhead condition survey was attempted to gather information on wellhead integrity and possible sources of contamination. The form developed for the survey is included as **Figure 5**. The wellhead condition survey could not be performed because of difficulty gaining access. The Tribe plans to make further attempts to gather the data.

4.0 Existing Groundwater Quality Data

Ten quarters of groundwater samples were collected between June 1999 and September 2001 as part of the Groundwater Monitoring Program. In addition, six rounds of samples were collected in the eastern half of the site between August 23 and September 27, 2001. Nitrate, coliform, and e. coli were analyzed each sampling event.

Nitrate concentrations detected during the monitoring program ranged from less than 0.05 mg/l (detection limit) to 7.86 mg/l (in AAD730). Maximum historic nitrate concentrations are presented in **Figure 6**. Nitrate was not detected at concentrations over the MCL of 10 mg/L. In general, nitrate concentrations were higher in the eastern half of the Reservation compared to the western half. Samples collected from domestic wells AAD727, AAD730, and IH124D consistently had the highest concentrations of nitrate on the Reservation. Nitrate concentrations for these three wells ranged from 3.53 to 7.86 mg/L, which are likely above natural background. All three wells are located on Anderson Road adjacent to Briarwood Farms and the Casino. Groundwater flow directions are not well understood in this area so the source of the nitrate cannot be assessed. Domestic well AAD730 consistently has the highest nitrate concentration and is likely closest to the center of the plume. Nitrate concentrations are also elevated in nearby wells AAD725 and AAD732 although they have a shorter monitoring record.

Total coliform was detected in 26 wells on the Reservation. Coliform detections are presented in **Figure 7**. Coliform was detected most frequently in AAD727 where coliform was detected nine times. This well is adjacent to Briarwood Farms and the Casino. Other wells with high frequency coliform detections include AAD704, AAD705, and AAD703, which had five, four, and three detections respectively. These wells are located in the northeast corner of the site near the intersection of Anderson and Moon roads. Coliform was detected four times in AAD792, which is located in the northwest corner of the site south of Oakville. E. Coli was detected once in well AAD704.

Pesticide and herbicide samples were collected during the fourth quarter of 1999 and analyzed EPA methods 8081 and 8051. The ten sample locations were selected to cover collected were distributed to cover a wide area of the Reservation. Pesticide and herbicides were not detected in any of the samples collected. Analytical results for all constituents discussed in this section are presented in greater detail in the 2001 Groundwater Monitoring Report (PGG, 2002).

5.0 Capture Zone Modeling

Time-of-travel capture zones for the Tribal Housing Well were modeled to estimate the approximate dimensions of capture zones on the Reservation. Model results reported in this report are from a simplified model configuration (described below). A more detailed and calibrated model configuration is currently in development and is referred to as the Wellhead Protection Model. This section presents a brief general discussion about capture zones, the selected model, the simple model configuration for the Chehalis Reservation, and the Wellhead Protection Model that is currently in progress.

5.1 Background Information

Time-of-travel capture zones are defined as the area of the aquifer that contributes water to the well. Capture zones also have an associated time period. A one-year capture zone is the area of the aquifer that has contributed water to a well after one year of pumping. The dimensions of a capture zone depend on the time period, pumping rate, hydraulic gradient, and aquifer transmissivity.

The time period defines the length of a capture zone, the longer the time period, the longer the capture zone. A ten-year capture zone is longer than a one-year capture zone.

The pumping rate is proportional to the width of the capture zone. The width of a capture zone increases with increasing pumping rate.

Hydraulic gradient is inversely proportional to capture zone width. As the gradient increases, the capture zone becomes narrower. For groundwater conditions where the water table is flat, the hydraulic gradient is zero, and the capture zone is circular with the pumping well at the center of the circle.

Aquifer transmissivity is inversely proportional to capture zone width. An aquifer with a higher transmissivity would have a narrower capture zone.

5.2 Model Selection

The analytic element model GFLOW was used to simulate the capture zones. GFLOW 2000 is a stepwise groundwater flow model that simulates steady-state flow in a single heterogeneous aquifer using the Dupuit-Forchheimer assumption. The GFLOW code has been used in academia, government agencies and consulting firms for more than five years. GFLOW 2000 is similar in design to the US EPA program WhAEM.

5.3 Model Configuration

The aquifer was modeled as 50 feet thick based on the well log for the observation well. A hydraulic conductivity of 7000 gpd/ft2 was used based on the aquifer testing at the Icy Fresh Fish Company. A hydraulic gradient of 0.001 was assigned as estimated in the 2001 Groundwater Monitoring Report (PGG, 2001).

Model runs were conducted using four different pumping rates: 1) The average usage per connection of the Tribal housing system (0.36 gpm), 2) current pumping rate for the Tribal Housing well (35 gpm), 3) projected future pumping rate (250 gpm) and 4) maximum capacity of the pump (500 gpm).

The maximum width of the 10-year capture zones are 30, 130, 960, and 1780 feet for the well pumping at 0.36, 35, 250, and 500 gpm, respectively. Capture zone lengths are summarized in **Table 1** and ranged from 1,000 to 1,500 feet for the six-month capture zone and from 17,300 to 18,500 feet for the 10-year capture zone. The capture zones for pumping rates 35, 250, and 500 gpm are presented in **Figures 8, 9, and 10,** respectively. The capture zones appear linear because a simplified planar water table configuration was used. The capture zones for the lowest pumping rate are not shown because they are approximately the same length as those current Tribal well pumping rate, but too narrow to be discerned on the figure. **Figure 11** shows all the capture zones for each of the pumping rates with development features to allow captures zones to be compared and development features to be identified within the capture zones.

5.4 Wellhead Protection Model

The Wellhead Protection Model is currently in progress as part of a separate scope of work and is scheduled for completion later this year. The wellhead protection model has fewer simplifying assumptions compared to the simple model used for this report, and therefore, is expected to provided more realistic and reliable results. The new model configuration will consider the effect of other pumping wells on the Reservation, recharge from precipitation, and interaction with the Chehalis River. In addition, groundwater elevations in the new model will be calibrated to the last round of monthly groundwater elevations measured during the first quarter of 1995.

6.0 Sources of Contamination

The Chehalis Reservation is located in a rural part of western Washington. The Reservation is predominantly residential with a small number of industries. The predominant industries are Briarwood Farms and the Lucky Eagle Casino. The Black River Turf Farm is located off, but immediately upgradient of, the Reservation. At all three sites, nitrate is the primary contaminant of concern. Herbicides are a secondary contaminant of concern at the turf farm. Total coliform is a contaminant of concern at Briarwood Farms, an egg processing facility that processes 500,000 eggs daily. The Lucky Eagle Casino is a large source of nitrogen to the shallow groundwater system.

6.1 Data Source

Potential and known contaminant sources that lie within the vicinity of the Chehalis Reservation were investigated and mapped using Environmental Geographics™ *VISTA* database. The *VISTA* database is a commercially available data set of geocoded location and attribute information for regulated and unregulated hazardous waste generators,

leaking tank sites, toxic spills, and other sites affecting the environment throughout the United States.

The environmental information from these data sources was plotted on GIS coverages for the study area to evaluate whether existing and potential contaminant sources were located in the vicinity of the Chehalis Reservation.

The *VISTA* database was used to inventory sources of potential and confirmed contamination in the study area. This GIS package combines data from the following regulatory databases:

- *Comprehensive Environmental Response, Compensation, and Liability Information System*. This database originates from the EPA and includes nationally identified sites that are or have been investigated for contamination.
- *Emergency Response Notification System (ERNS)*. This database originates from the EPA and includes information on reported spills of oil and hazardous substances.
- *Hazardous Materials Incident Reporting System*. The database originates from the Federal EPA database, and contains information pertaining to all hazardous materials spills which have been reported by the US Department of Transportation.
- *Leaking Underground Storage Tank (LUST) List*. This database originates from Ecology. It contains a list of sites with reported leaking USTs and indicates the status of each site.
- *No Further Remedial Action Planned (NFRAP)*. This database includes sites that have been removed from CERCLIS.
- *National Priority List (NPL)*. This Federal database includes sites listed under the Federal Superfund program.
- *Resource Conservation and Recovery Act Information System (RCRIS)*. This Federal database includes all sites where hazardous waste is generated, transported, stored, treated, or disposed of.
- *State Priority List (SPL)*. This database originates from Ecology and contains a list of sites with suspected or confirmed contamination.
- *Solid Waste Landfill Sites (SWLF)*. This database originates from Ecology and includes active landfills, inactive landfills, transfer stations, incinerators, recycling stations, or other facilities where waste is treated or stored.
- *Toxics Release Inventory System Database (TRIS)*. This database includes annual reporting by all owners or operators of facilities that manufacture, process, or import toxic chemicals in quantities that exceed 25,000 pounds annually.
- *Underground/Above Ground Storage Tank Registration (UST, AGST)*. This database lists storage tanks registered in the State of Washington.

- *Washington State Toxic Cleanup Program Site Register*. This database originates from Ecology and contains sites listed under the Model Toxics Control Act (MTCA) and the Independent Remedial Action Program (IRAP). It includes some leaking underground storage tanks.

Since many of these individual databases contain information about the same sites, the *VISTA* database produces some duplication.

6.2 Contaminant Sources

No sites with confirmed contaminant sources occur within the boundaries of the Reservation. One site with a confirmed contaminant source occurs just outside the southwest boundary of the Chehalis Reservation. This site, Monarch Bullet, is from the State Priority List and is shown and identified on **Figure 12** and in **Table 2.** Information in the *VISTA* database indicates that an independent remedial action is occurring for this site for which the status is unknown. The rest of the sources discussed below are considered potential contaminant sources.

In addition to sources of potential contamination included in the *VISTA* database, on-site septic systems, livestock, and agriculture are also considered a potential source of contamination. The following potential contamination sources have been identified near the Chehalis Reservation; only one site, an underground storage tank, lies within the Reservation boundaries:

- Hazardous Materials
- On-site Septic Systems
- Underground Storage Tanks
- Agriculture and Livestock

6.2.1 Hazardous Materials

The commercial use of chemicals poses a major threat to groundwater quality, since the chemicals can be accidentally spilled or disposed of improperly. Spills can occur, although the likelihood of such releases can be reduced by proper methods of handling, spill prevention measures, and emergency response strategies. Risk reduction strategies should target on-site waste management practices. Improper disposal is likely the most common pathway for chemicals to be released into the environment.

The EPA defines three categories of hazardous waste generators based on the quantity of waste they generate per month:

- Conditionally exempt small quantity generators (CESQGs), which generate less than 200 lbs. of per month
- Small quantity generators (SQGs), which generate between 220 and 2,200 lbs. per month
- Large quantity generators (LQGs), which generate more than 2,200 lbs. per month

SQGs and LQGs are regulated under the Resource Conservation and Recovery Act (RCRA) and are required to keep "cradle to grave" documentation of all activities involving hazardous materials. Disposal facilities must be licensed. RCRA regulates all facilities that generate, transport, store, treat, or dispose of hazardous materials such as fuels, chemicals, solvents, and other miscellaneous wastes. These facilities must be registered with RCRA to be in compliance with government regulations.

The most significant threats to groundwater are related to the use and storage of solvents. Solvents are persistent, both miscible and immiscible in water, and highly mobile. A large plume of contamination can be created with a small quantity of solvent.

6.2.1.1 Occurrence in Study Area

Potential hazardous waste contamination is indicated on **Figure 12.** There are two RCRA-notifiers sites and one RCRA-sqg site. RCRA notifiers facilities are registered with RCRA. It is likely that they handle wastes, but there is no further information. As indicated in Section 6.1, the RCRA-sqg site generates small quantities of hazardous wastes. **Table 2** summarizes these RCRA sites within the Reservation vicinity.

6.2.2 On-Site Septic Systems

On-site septic systems pose a risk to a groundwater where they are relatively high in density and/or where hazardous wastes are discharged to them. Potential contaminants from septic systems include pathogenic organisms (bacteria and parasites), toxic substances, and nitrogen compounds.

The extent to which pathogens are transported in the subsurface away from a septic drain field depends on the type of pathogen and the chemical and physical conditions in the subsurface. In general, if a septic system is properly sited, constructed, and maintained, the transport of microorganisms will be limited. Household hazardous chemicals such as cleaners, polishes, waxes, and paints can be transported to groundwater via a septic system. Some products contain toxic and persistent chemicals that can cause low-level contamination when coupled with a high density of septic systems. Homeowners can improperly apply or dispose of chemicals because they do not understand the threat they pose to groundwater quality. Business, commercial, and industrial operations that rely on on-site systems need to take special precautions to avoid contamination of their wastewater.

Ammonia and nitrate are highly soluble in water and can be expected in detectable quantities wherever portions of an aquifer are affected by septic system discharges. Septic systems are a source of nitrates in groundwater in many areas of nearby Thurston County. Nitrate is regulated, since ingestion can result in methemoglobinemia, or "blue baby" syndrome. Other sources of nitrate include fertilizers, feedlots, and natural mineral deposits. Background concentrations of nitrates in groundwater are typically less than 1 milligram of nitrogen per liter (mg-N/L). The Maximum Contaminant Level (MCL) for nitrate is 10 mg-N/L.

6.2.2.1 Occurrence in Study Area

The entire Chehalis Reservation relies on septic system. Homes with individual water systems generally have individual onsite-septic systems. Homes that are part of community water systems generally have septic systems that use community drainfields. The Lucky Eagle Casino pre-treats the effluent before it discharges to a community drainfield. The pre-treatment removes oil and grease and brings the effluent to approximate residential conditions; however the Casino is likely a large source of nitrate. Maximum historic nitrate concentrations for groundwater at wells throughout the Reservation are shown on **Figure 6.** Several groundwater samples have been collected at each of these wells over the past few years. The results are presented in Section 4.0.

6.2.3 Underground Storage Tanks

Contamination in soil and groundwater caused by leaking USTs (LUSTs) is a major environmental, legal, and regulatory issue. In 1991, the EPA estimated that 35 percent of all USTs could be leaking (EPA, 1991). USTs usually contain flammable motor fuels or heating oils, however, they may contain other compounds used by industry, government, or business. Documented LUSTs are considered confirmed sources of contamination and are discussed in Section 4.3.2.2. The most common causes of leaks are structural failure, corrosion, improper fittings, improper installation, and natural phenomena. All USTs are considered potential sources of contamination.

Leakage from USTs and associated piping often occurs without detection. Even relatively small amounts of certain compounds can adversely impact on groundwater quality. For instance, 1 gallon of gasoline can render a million gallons of groundwater "unpotable" for several decades. A 1/4-inch hole in a UST can release up to 930 gallons of gasoline in a single day. Once released from an UST, some VOCs and petroleum products can rapidly migrate to groundwater, a problem that is especially serious in areas with permeable soils such as sand and gravel.

Of the many materials stored in USTs, solvents are considered the most toxic. However, petroleum products may pose a greater risk because a large number of tanks contain them. In addition, petroleum products contain many potential contaminants, including three EPA priority pollutants: benzene, toluene, and ethylbenzene. Benzene is a known human carcinogen.

6.2.3.1 Occurrence in Study Area

There are eight USTs within the Chehalis Reservation vicinity included in the *VISTA* database (**Table 2**). Locations of USTs are shown and identified on **Figure 12**. All but one of the USTs occurs in the Oakville area, and only one of those occurs within the boundaries of the Reservation. None of the LUSTs occur within the Reservation boundary.

6.2.4 Agriculture and Livestock

Agricultural and livestock activities can introduce nitrogen to the groundwater in the form of fertilizers and livestock manure. Agriculture can also be the source of pesticides and herbicides such as EDB, DBCP, and dicamba. Two of the three predominant industries in the vicinity of the Reservation are Briarwood Farms and the Black River Turf Farm. The turf farm is located upgradient and just outside the Reservation boundary. At these sites, nitrate is the primary contaminant of concern. Nitrate concentrations are discussed in section 5. Herbicides are a secondary contaminant of concern at the turf farm. Herbicides were analyzed for as part of the Groundwater Monitoring Program but not detected. Briarwood Farms is an egg processing facility that processes 500,000 eggs daily.

7.0 Summary of Findings and Recommendations

The following bullets summarize the findings of this study:

- Nitrate and total coliform are the primary contaminants of concern on the Reservation.
- Eight underground storage tanks occur in the vicinity of the Reservation, one occurs within the boundaries of the Reservation.
- Monarch Bullet is a state priority list site that outside the Reservation near the southeast boundary. One small quantity hazardous waste generator occurs just outside the Reservation, near the northwest boundary.
- Aquifer test results indicate aquifer transmissivity ranges from 323,000 to 379,000 gpd/ft. Hydraulic conductivity ranges from 6,460 to 7,580 gpd/ft^2.
- The 6-month, 1-, 5-, and 10-year capture zones for the Tribal housing well are 130 feet wide and the lengths are 1000, 1900, 8700, and 17,300 feet, respectively.

We recommend the following actions to further protect groundwater quality water quality at the Chehalis Reservation.

- Continue to collect and analyze groundwater samples quarterly for nitrate and total coliform.
- Measure groundwater elevations as part of groundwater sampling events.
- Install monitoring wells at Briarwood Farms and the Lucky Eagle Casino. Measure groundwater levels to assess groundwater flow direction and collect groundwater samples to analyze nitrate concentrations. Assess groundwater flow direction in the

vicinity of the monitoring wells.

- Connect wells near Briarwood Farms and the Lucky Eagle Casino to the distribution system once it is constructed.
- Further refine well capture zones through development and use of a calibrated computer model.

8.0 References

Cooper and Jacob. 1946. A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History. *Transactions of the American Geophysical Union.* 27:526-534.

David Evans and Associates. 1988. Aquifer Evaluation for Confederated Tribes of the Chehalis Reservation. Consultants Report.

[SPS1]Pacific Groundwater Group. 1999. Chehalis Reservation Groundwater Monitoring Plan. Consultants Report prepared for the Chehalis Tribe.

Pacific Groundwater Group. 2000. Chehalis Reservation 2000 Groundwater Monitoring Report. Consultants Report prepared for the Chehalis Tribe.

Pacific Groundwater Group. 2002. Chehalis Reservation 2001 Groundwater Monitoring Report. Consultants Report prepared for the Chehalis Tribe.

Pearson, H.E., and Higgins, G. T. 1979. Water Resources of the Chehalis Indian Reservation, Washington. USGS Open File Report 77-704.

Table 1. Capture Zone Lengths

Capture Zone	Tribal Well (in feet)
6 month	1000
1 year	1900
5 year	8700
10 year	17,300

Table 2. Summary of VISTA Sites In Vicinity of the Chehalis Reservation

Name	Address	City	State	Zip	UST	State Priority List	RCRA-notifiers	RCRA-sqg
DON ZEPP	714 BLOCKHOUSE ST W	OAKVILLE	WA		x			
JOHN R BENNETT	PINE ST CENTER ST	OAKVILLE	WA	98568	x			
HARRY'S GROCERY	312 PINE ST	OAKVILLE	WA		x			
ORVAL ALLEN	3RD PINE	OAKVILLE	WA	98568	x			
RON REDELL	214 E PINE	OAKVILLE	WA	98568	x			
JACKPOT 391	415 EAST PINE ST	OAKVILLE	WA	98568	x			
CITY OF OAKVILLE	403 E PINE ST	OAKVILLE	WA	98568	x			
JAMES R ABBOTT	388 GARRARD CREEK RD	OAKVILLE	WA	98568	x			
DREWS BERRY FARMS	17132 MOON RD SW	ROCHESTER	WA	98579	x			
MONARCH BULLET	12207 INDEPENDENCE RD	ROCHESTER	WA	98579		x		
TIME OIL CO OAKVILLE	415 E PINE ST	OAKVILLE	WA	98568			x	
OAKVILLE POLICE DEPT IMPOUNDMENT	PINE AND ALLEN	OAKVILLE	WA	98568			x	
OAKVILLE FOREST PRODUCTS INC	208 PARK ST	OAKVILLE	WA	98568				x

Oakville
Balch Creek RD
Icy Waters
Elma Gate RD W
Black River
Hamilton Dairy Farm
Turf Farm
Anderson RD SW
Moon RD SW
Howanut RD
Tribal Center
Casino
Niederman RD
Secena RD
Briarwood Farms
Chehalis River
Chehalis
12
789 790 773 773-A 800 792 796 795 793 794 791 799 797 788 783 781 784 782 779 780 777 776 772 767 770 771 769 768 769-A 763 761 760 758 759 755 752 751 750 749 747 754 744 746 741 738 737 736 732 717 716 701 734 715 714 712 713 708 739 740 730 727 726 725 728 724 710 711 723 719 721 722 720 718 704 706 705 703 707

Legend

716 Well ID#

Reservation Boundary

N

1000 0 1000 2000 Feet

Figure 1
Reservation Boundary and Well Location Map

Chehalis Reservation
Wellhead Protection Report 2002

Pacific Groundwater Group

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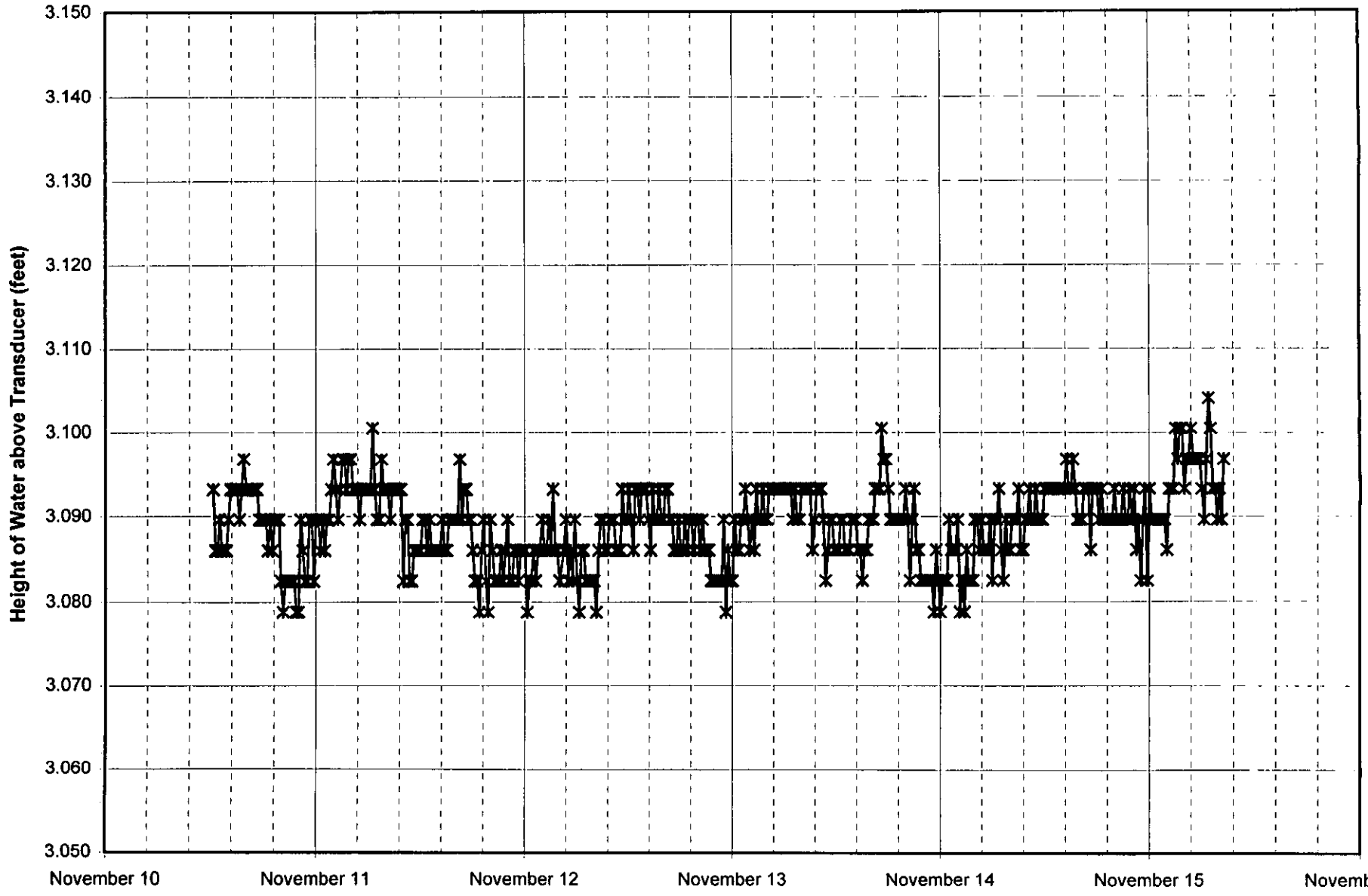
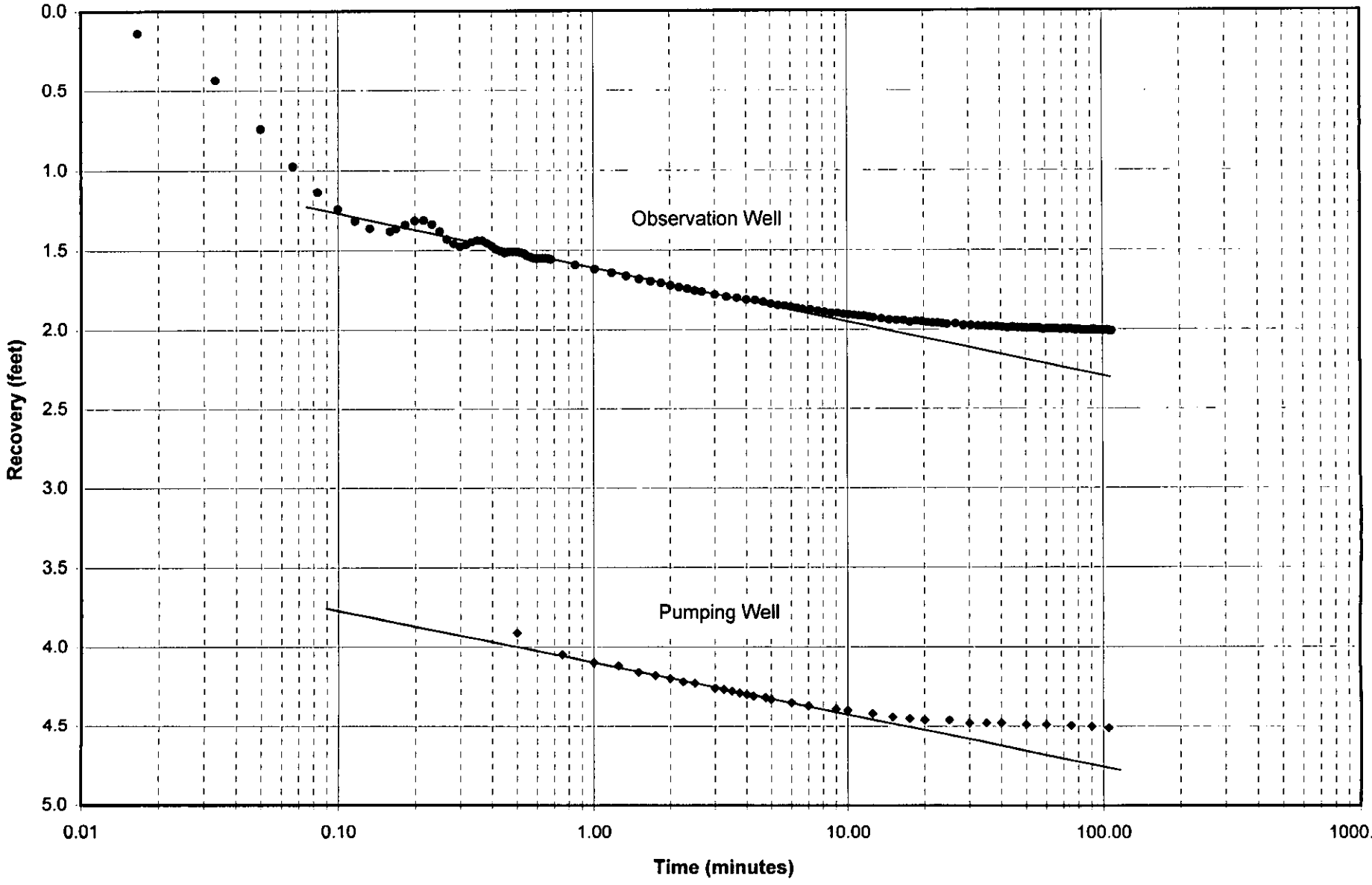


Figure 2
Background Data For Observation Well For Five Days Before Pumping Test

Chehalis Reservation
Wellhead Protection Report 2002
JS9802K:...Steve\Chehalis\AquiferTest

Pacific Groundwater Group



TEST CONDITIONS:
Pump off at 11/15/2000 10:42
Pump on at 11/15/2000 12:52
Average Pumping Rate: 460 gpm

RESULTS
$T = \frac{264\ Q}{\Delta s}$

RESULTS:
Pumping Well
$T = \frac{264\ (460)}{0.32} = 379{,}000$ gpd/ft
Observation Well
$T = \frac{264\ (460)}{0.35} = 323{,}000$ gpd/ft

KEY:
T = Transmissivity (gpd/ft)
Q = Discharge rate (gpm)
Ds = Change in drawdown over one log cycle (feet)
gpm = Gallons per minute
gpd/ft = Gallons per day per foot

Figure 3
Recovery Data For Pumping and Observation Wells During Pumping Test
Chehalis Reservation
Wellhead Protection Report 2002
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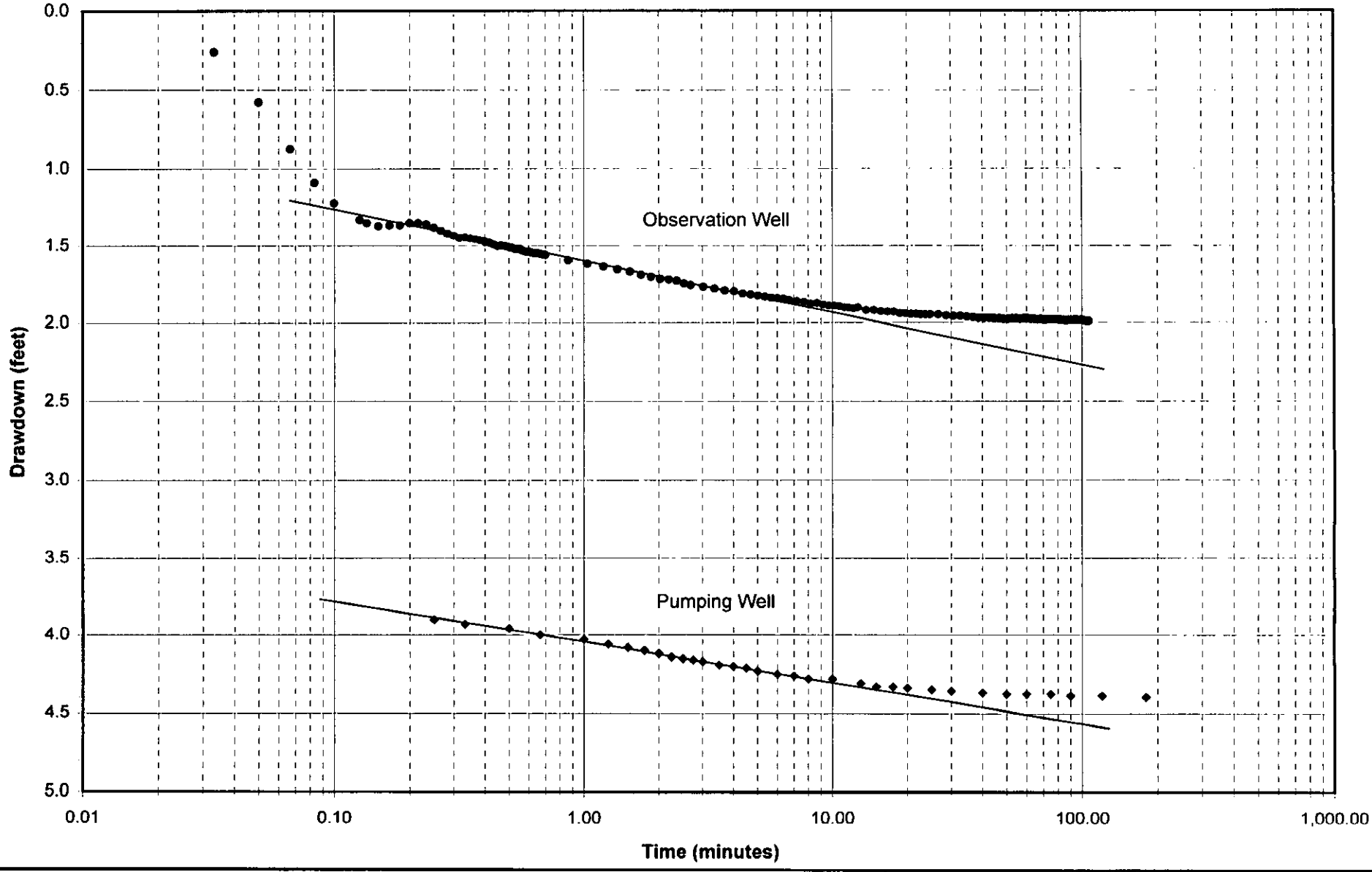
Pacific Groundwater Group



TEST CONDITIONS:
Pump off at 11/15/2000 10:42
Pump on at 11/15/2000 12:52
Average Pumping Rate: 460 gpm

RESULTS
$T = \frac{264\ Q}{\Delta s}$

RESULTS:
Pumping Well
$T = \frac{264\ (460)}{0.26} = 467{,}000$ gpd/ft
Observation Well
$T = \frac{264\ (460)}{0.34} = 357{,}000$ gpd/ft

KEY:
T = Transmissivity (gpd/ft)
Q = Discharge rate (gpm)
Ds = Change in drawdown over one log cycle (feet)
gpm = Gallons per minute
gpd/ft = Gallons per day per foot

Figure 4
Drawdown Data For Pumping and Observation Wells During Pumping Test

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Wellhead Protection Report 2002
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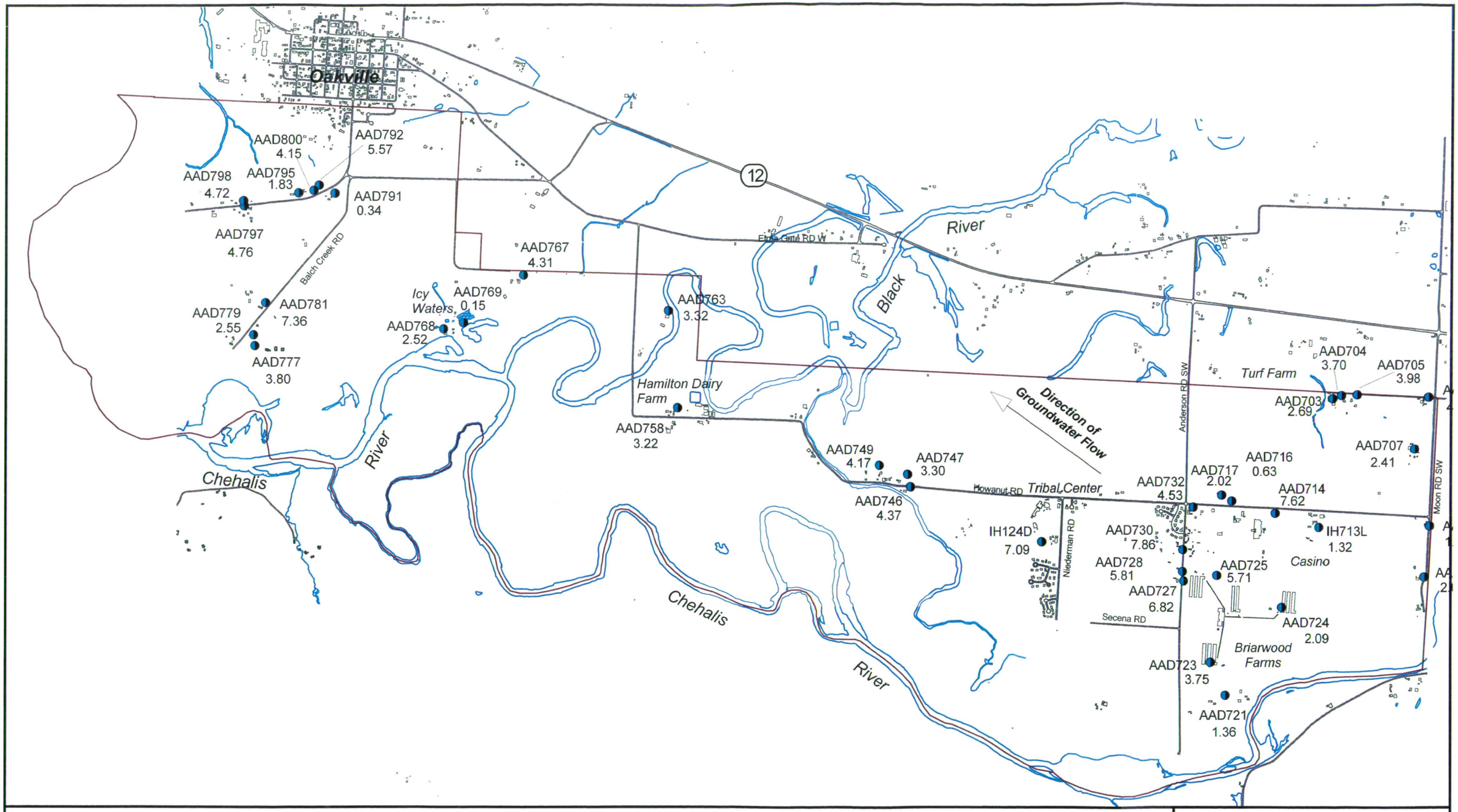
Pacific Groundwater Group

Figure 5. Chehalis Reservation Wellhead Condition Survey

Well depth
Sampling port
Pump information – horsepower, depth, submersible
Casing size
Number of homes served
Presence and condition of seal
Well house – presence, condition, and contents
Possible sources of contamination
Flooding potential
Sanitary radius – structures
Local land use
Location of septic tank – distance and direction



Legend

AAD716 5.49 — Well ID# / Maximum Nitrate Concentration, mg-N/L

Reservation Boundary

N

1000 0 1000 2000 Feet

Figure 6

Maximum Historic Nitrate Concentrations

Chehalis Reservation
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01/2002

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Oakville

AAD798 1

AAD792 4

Balch Creek RD

12

Elma Gate RD W

River

Black

AAD767 1

Icy Waters

AAD781 1

AAD779 2

AAD777 1

AAD763 1

Hamilton Dairy Farm

AAD758 1

Anderson RD SW

Turf Farm

AAD704 5

AAD706 2

AAD703 3

AAD705 4

AAD707 2

Moon RD SW

AAD747 1

Tribal Center

AAD732 1

AAD716 1

AAD714 2

AAD746 2

AAD708 1

AAD730 2

AAD728 1

Casino

AAD729

Niederman RD

Secena RD

Briarwood Farms

AAD721 1

Chehalis River

Chehalis River

Chehalis River

Legend

AAD716 — Well ID#

1 — Number of Detections

Reservation Boundary

Number of Detections

1

2

3 - 4

5 - 9

N

1000 0 1000 2000 Feet

Figure 7

Coliform Detection Count

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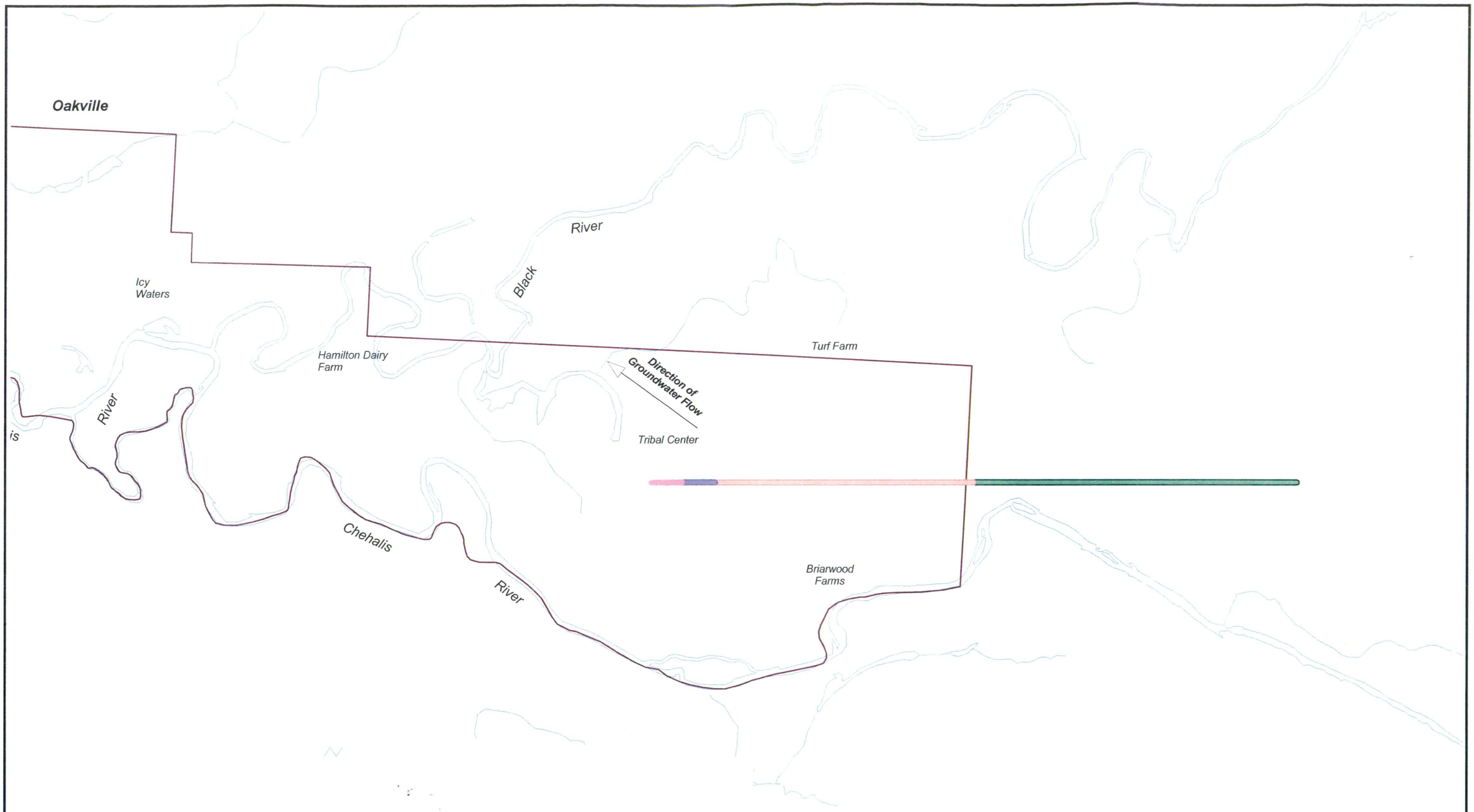

Legend

- Reservation Boundary
- Rivers
- 6-Month Time of Travel Capture Zone
- 1-Year Time of Travel Capture Zone
- 5-Year Time of Travel Capture Zone
- 10-Year Time of Travel Capture Zone

N

1000 0 1000 2000 Feet

Figure 8

Time of Travel Capture Zones For the Tribal Housing Well Pumping Rate = 35 gpm

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Pacific Groundwater Group

Oakville

River

Black

Icy
Waters

Hamilton Dairy
Farm

Turf Farm

Direction of
Groundwater Flow

Tribal Center

River

is

Chehalis

River

Briarwood
Farms

Legend

Reservation Boundary

Rivers

6-Month Time of Travel Capture Zone

1-Year Time of Travel Capture Zone

5-Year Time of Travel Capture Zone

10-Year Time of Travel Capture Zone

N

1000 0 1000 2000 Feet

Figure 9

**Time of Travel Capture Zones
For the Tribal Housing Well
Pumping Rate = 250 gpm**

Chehalis Reservation
Wellhead Protection Report 2002

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01/2002

Pacific
Groundwater
Group

Oakville

Icy Waters

Black River

Hamilton Dairy Farm

Turf Farm

Direction of Groundwater Flow

Tribal Center

Briarwood Farms

is River

Chehalis River

Legend

Reservation Boundary

Rivers

6-Month Time of Travel Capture Zone

1-Year Time of Travel Capture Zone

5-Year Time of Travel Capture Zone

10-Year Time of Travel Capture Zone

N

1000 0 1000 2000 Feet

Figure 10

Time of Travel Capture Zones For the Tribal Housing Well Pumping Rate = 500 gpm

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Pacific Groundwater Group

River
Black
Turf Farm
Direction of Groundwater Flow
Anderson RD SW
Moon RD SW
Burlington Railroad
SR 12
Rochester
Howanut RD
Tribal Center
Niederman RD
Casino
Secena RD
Briarwood Farms
Helsing Junction
James Rd. SW
Independence Rd SW
Michigan Rd SW

Legend

- Railroad
- Reservation Boundary
- Rivers
- County Roads
- State Route Highways

- 6-Mo. Capture Zone - 35 gpm
- 1-Year Capture Zone - 35 gpm
- 5-Year Capture Zone - 35 gpm
- 10-Year Capture Zone - 35 gpm
- 6-Mo. Capture Zone - 250 gpm
- 1-Year Capture Zone - 250 gpm
- 5-Year Capture Zone - 250 gpm
- 10-Year Capture Zone - 250 gpm
- 6-Mo. Capture Zone - 500 gpm
- 1-Year Capture Zone - 500 gpm
- 5-Year Capture Zone - 500 gpm
- 10-Year Capture Zone - 500 gpm

N

1000 0 1000 2000 Feet

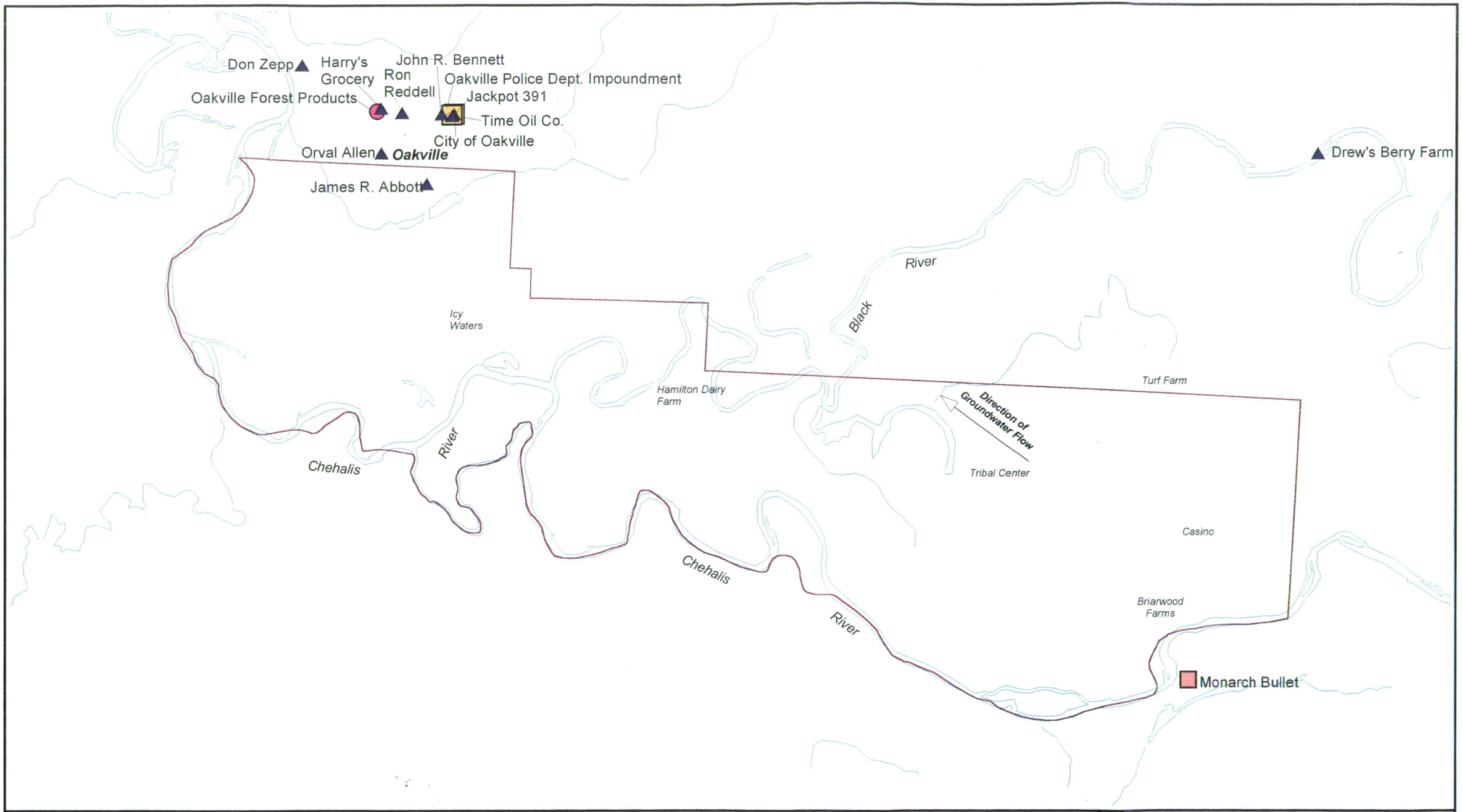
Figure 11

Comparison of Time of Travel Capture Zones For the Tribal Housing Well Pumping Rates = 35, 250, and 500 gpm

Chehalis Reservation
Wellhead Protection Report 2002

Pacific Groundwater Group

JOB JS9802,\OTHERS\Steve\Chehalis\GIS\chehalis_rmp.apr 02/2002, scale 1:20,000



Legend

- Reservation Boundary
- Rivers

VISTA Environmental Sites

Potential Contaminant Sources
- RCRA-sqg
- UST
- RCRA Notifiers

Confirmed Contaminant Sources
- State Priority List

N

1000 0 1000 2000 Feet

Figure 12
Locations of VISTA Environmental Sites in the Vicinity of the Chehalis Reservation

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01/2002

Pacific Groundwater Group