Ground Water Quality Technical Report No. 41

Ground Water Quality Report

Chilco Area of the Spokane Valley-Rathdrum Prairie Aquifer

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Executive Summary

This study presents water quality data collected by the Idaho Department of Environmental Quality (DEQ) from surface water and ground water sources in the vicinity of Chilco, Idaho, within the Chilco **Channel**[1] of the Rathdrum Prairie **Aquifer**, approximately 15 miles north of Coeur d'Alene, Idaho. The objectives of this study were to evaluate the local ground water quality, identify potential source(s) of elevated concentrations of chemical **constituents**, and identify the source(s) of total **coliform** and *E. coli* bacteria that have been detected in water samples from a former **public water system** well.

The geology of the area consists of basalt or granite basement rocks up to 250 feet below ground surface (bgs) (Idaho Department of Reclamation, 1969) within the Chilco Channel, overlain by glacial deposits and very coarse and highly transmissive deposits from the Missoula floods (SCS, 1981). Ground water in the study area is generally found 75 feet bgs and shows fluctuations as great as 35 feet per year (IDWR, accessed 2009(a)). Due to the coarse sediments and shallow depth to ground water, it is common for land use activities in the area to impact the ground water within a relatively short time. Previous studies indicated that, generally, ground water flow within the aquifer is from northeast to southwest (Graham and Buchanan, 1994); however, along eastern portions of the study area, water-level measurements from summer and winter indicate a consistent westerly ground water flow.

Ground water samples were collected from as many as nine different domestic wells, on a quarterly or monthly basis. The aquifer is unconfined, and sampled wells were completed between 94 feet bgs and 158 feet bgs. A milling site is located in the study area that belongs to Louisiana Pacific (LP) Mill, and encompasses approximately 175 acres containing the mill and log yard. Surface water from Chilco Lake is applied to log decks at the LP Mill site during the second half of each summer, so lake water was sampled, as were two locations where runoff water from log deck application ponded.

DEQ documented that, aquifer-wide, **nitrate** and **chloride** concentrations have increased since monitoring began in 1993, and bacteria contamination has occurred in several wells within the study area. Possible **sources** of contamination to the aquifer include septic tank **effluent**, runoff from road de-icers, **infiltration** of surface water from Chilco Lake, wood milling activities, a golf course, transportation corridors, a railroad, and agriculture activities.

Of the wells sampled over the course of the study, the DEQ529 well, formerly a public water system well, had the highest frequency of bacteria detections (n=5). The direction of ground water flow and water chemistry suggests that ground water impacts to the DEQ529 well are originating from an easterly direction, and that surface water contamination can enter this well **casing** from a crack near the ground surface.

[1] See glossary for definitions of bolded terms.

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Introduction

This section describes previous investigations related to this study as well as its purposes and objectives.

Purpose

Chilco, Idaho is a rural community located approximately 15 miles north of Coeur d'Alene, Idaho, along Highway 95. The Idaho Department of Environmental Quality (DEQ) conducted a ground water study in the Chilco area from 2006 until 2009. The purposes of this study were:

- to assess the overall condition of the aquifer's quality, and
- to evaluate the potential sources of contamination that may have contributed to the bacteria detected in a drinking water well.

The DEQ529 well, which formerly served the public as part of a registered **public water system** (PWS) until approximately 2006, has had past issues with total **coliform** and ***E. coli*** contamination, and **turbidity** which have been measured at levels greater than **background** concentrations.[2] A photo taken in October 2004 showed a cracked **well casing** that was exposed at ground level (DEQ, 2005). During December 2005, residents reported having cloudy drinking water following heavy rainstorms. As a result, DEQ conducted a study in 2006 to determine if the source of bacteria was the result of overland flow entering the well via the cracked casing or if local land use activities were impacting ground water.

Information used in this report is taken from DEQ field observations, laboratory analysis results, and a 1994 report prepared for DEQ by William A. Graham and John P. Buchanan titled "A Hydrogeologic Characterization and Reconnaissance Water Quality Study of the Chilco Channel Area, Kootenai County, Idaho."

Previous Investigations

Previous ground water investigations in the Chilco area by DEQ focused on the potential contamination to soil, ground water, or both, from metals, petroleum hydrocarbons, and bacteria (Stevens, 2006; Gary Stevens, personal communication, February 17, 2010.). The bacterial contamination investigation consisted of collecting surface water and ground water samples from the Louisiana Pacific Corp. Chilco Lumber Mill (LP Mill) site, along with ground water samples from domestic wells in the vicinity of the mill. These samples were analyzed for the presence of **coliform** and fecal bacteria. Although the surface and ground water samples obtained at the LP Mill site indicated large concentrations of coliform, and in some cases fecal, bacteria, the results of three to six years of sampling did not indicate a correlation between activities at the LP Mill and

[2] See glossary for definitions of bolded terms.

water quality in **down-gradient** wells. While it had been reported that a well located **up-gradient** of the LP Mill (identified as the DEQ528 well in this report) contained significant bacterial contamination, Stevens (2006) found no analytical results to support that previous claim.

Objectives

The objectives of this study were as follows:

- Evaluate ground water quality and flow direction within the Chilco Channel
- Identify whether inorganic chemical constituents are increasing or decreasing in the aquifer within the study area and determine the possible source(s) of these constituents
- Determine the possible source(s) of bacteria concentrations in one well, DEQ529, which is located near the southeastern corner of the LP Mill site

Study Area

The study area encompasses approximately 2 square miles, located in Chilco, Idaho, along State Highway 95, approximately 6 miles south of Athol (Figure 1) and 15 miles north of Coeur d'Alene. It is situated on the eastern edge of the Spokane Valley-Rathdrum Prairie Aquifer (SVRPA).

Land use within the study area is considered rural residential with some dry-land agriculture and a horse pasture. Most houses in the area are on approximately 5-acre lots and have individual wells and septic systems, along with lawns, which may be fertilized. A nine-hole golf course is located just outside the northeast corner of the study area and the LP Mill is centralized within the study area.

Climate

The region is characterized by a cool and temperate climate. The area receives approximately 25 inches of precipitation annually (up to 41 inches on surrounding highlands) (OSU, 2004), most of which occurs during the winter months. According to the Idaho Transportation Department, snow is typically cleared from roads from mid-December until March, indicating the approximate time span when the ground is frozen (personal communication, November 2009). Within the Chilco area's valley floor, snowmelt **infiltrates** into the subsurface and does not discharge to surface water.

Geologic Setting

Evidence indicates that the SVRPA in the Chilco vicinity is composed of three bedrock paleochannels (Kahle and Bartolino, 2007): the Chilco, Ramsey, and Main channels (from east to west). These channels are bounded by Tertiary basalt outcrops to the east, Precambrian Belt and Tertiary basalt rocks separating the Chilco and Ramsey channels, and Cretaceous and Tertiary granitics separating the Ramsey and Main channels to the west. The lateral limits of these channels have been described in Graham and Buchanan (1994), Baldwin and Owsley (2005), and Kahle and Bartolino (2007). The Main and Ramsey Channels are open at both the north and south ends, allowing ground water to flow through them roughly southward from the north Rathdrum Prairie area to the south Rathdrum Prairie area.

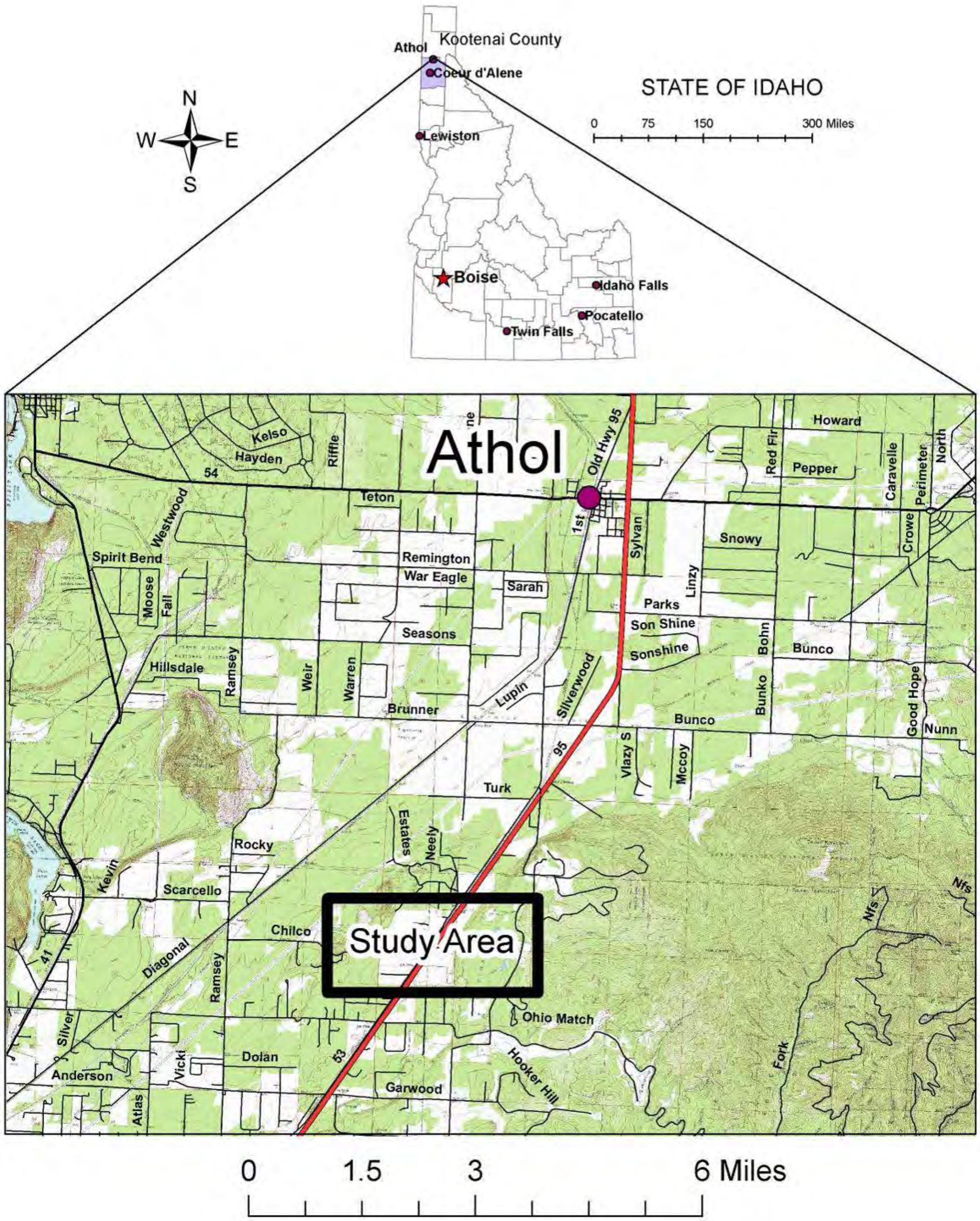

Figure 1. Site vicinity map of study area.

The sediments in the Chilco area consist primarily of **fluvial** and glacial flood deposits that are unconsolidated and highly **permeable,** allowing rapid infiltration of water through the unsaturated zone down to the water table.

Hydrogeology

The SVRPA is a largely **unconfined aquifer** covering the area from Lake Pend Oreille, Hoodoo Lake, and Blanchard Lake in the north, south to the cities of Coeur d'Alene and Post Falls, and west into Washington, to the aquifer's discharge at the confluence of the Spokane and Little Spokane Rivers (Kahle et al., 2005). Regional ground water flow direction within the SVRPA is from north-northeast to south-southwest (Stevens, 2006).

The **hydraulic conductivity** of the SVRPA sediments is generally very high, with municipal water wells capable of drawing significant quantities of water with limited **drawdown**. Most domestic wells in the area have shallow completions. Wells completed to bedrock are uncommon.

Within the suite of sampled wells, water levels range from 65 to 90 feet bgs, and wells are completed between approximately 94 and 158 feet bgs. The highly permeable subsurface and shallow well completions potentially allow contaminants at ground surface to migrate vertically to domestic well production zones.

Ground water **recharge** in the Chilco Channel area comes from drainage basins located on the flanks of Cedar and Hollister Mountains to the east, leakage from Chilco Lake, direct precipitation, infiltration from the LP Mill log deck water (described later in this report), and minor contributions from septic tanks.

Ground Water Flow Direction in the Study Area

The **fluvial** deposits filling the Chilco Channel form an unconfined aquifer. Graham and Buchanan (1994) used water level information to construct a potentiometric (water level) map of Chilco Channel (adapted and shown in Figure 2). This map indicated that the general ground water flow within the Chilco Channel is from the northeast to the southwest. Shallow (15 to 60 feet) static water levels at the north end of the channel deepen to 220 to 275 feet below ground surface (bgs) in the southern end. Throughout most of the channel, the **hydraulic gradient** is fairly uniform, between 0.004 and 0.006 feet per foot. Near the southern portions of the channel outlet, the hydraulic gradient increases dramatically to approximately 0.03 feet per foot. Graham and Buchanan's potentiometric map (Figure 2) shows ground water **contours** for the Chilco channel.

The Chilco Channel appears to have a ground water/bedrock divide at the north end with water discharging from the south end. The ground water elevations of the Chilco Channel range from approximately 2,000 to 2,220 feet above mean sea level (ft amsl), while ground water elevations in adjacent portions of the SVRPA range from approximately 2,000 to 2,030 ft amsl. Given the hydraulically "closed" north end of the Chilco Channel and its ground water levels that are elevated above those of the surrounding regional SVRPA, it appears that ground water in the Chilco Channel is being derived predominantly as runoff from the upland areas to the east (Stevens, 2006). This may account for the localized westerly ground water flow direction in the vicinity of Highway 95 near Chilco.

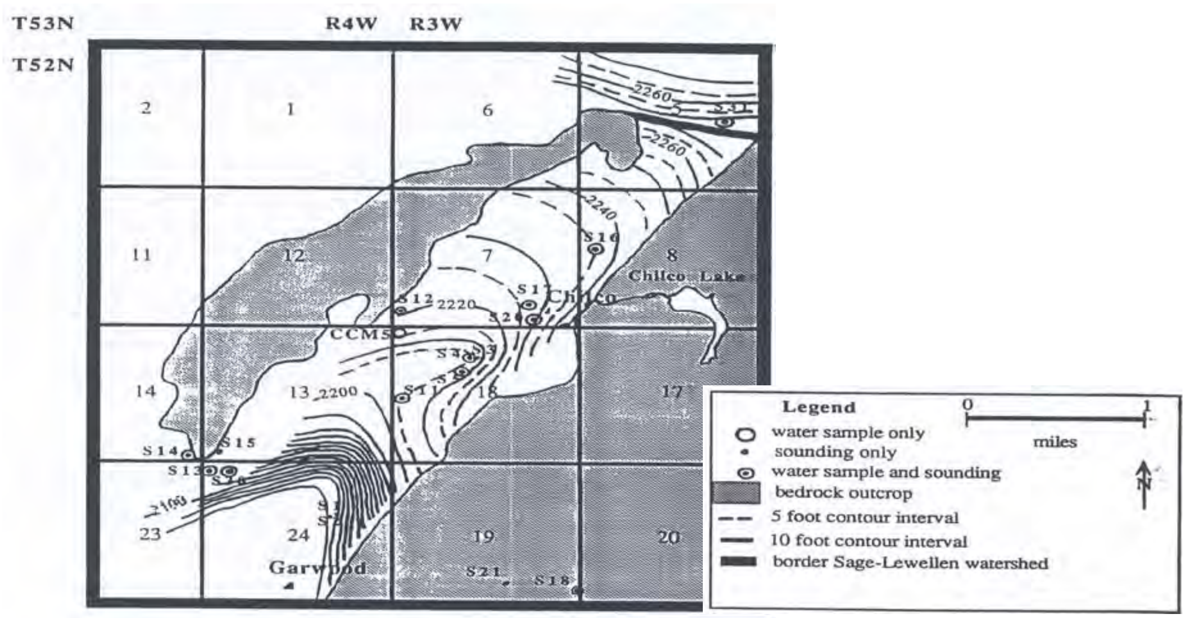

Figure 2. Ground water contour map of the Chilco channel (modified from Graham and Buchanan, 1994).

DEQ projected the information from Graham and Buchanan (1994) onto an aerial photo of the study area and approximated ground water flow paths based upon the potentiometric surface contours. As illustrated, the ground water flows westward from the eastern margins of the channel, then flows southwesterly in the central part of the channel (Figure 3). At the DEQ529 well, ground water flow direction was identified to be almost westerly.

One limitation of the information collected by Graham and Buchanan (1994) is that it was collected between July 1993 and September 1993. Water levels can fluctuate up to 35 feet per year, according to data collected by the Idaho Department of Water Resources (Hydro Online; accessed 2009) and displayed in Figure 4. Therefore, it is possible that ground water level information collected by Graham and Buchanan over a period of approximately two months did not capture potential seasonal changes in flow direction.

In an effort to identify site-specific seasonal flow directions, ground water flow direction was calculated using three-point diagrams with summer data from June 2006 and and winter data from December 2005 (Figure 5). Only two December 2005 measurements were available, so another winter measurement—from January 1978—was used. As seen in Figure 3, the ground water flow direction in the vicinity of the DEQ529 well appears to be consistently in a westerly direction, with very little seasonal variation. DEQ's findings therefore agree with the ground water flow direction described by Graham and Buchanan (1994).

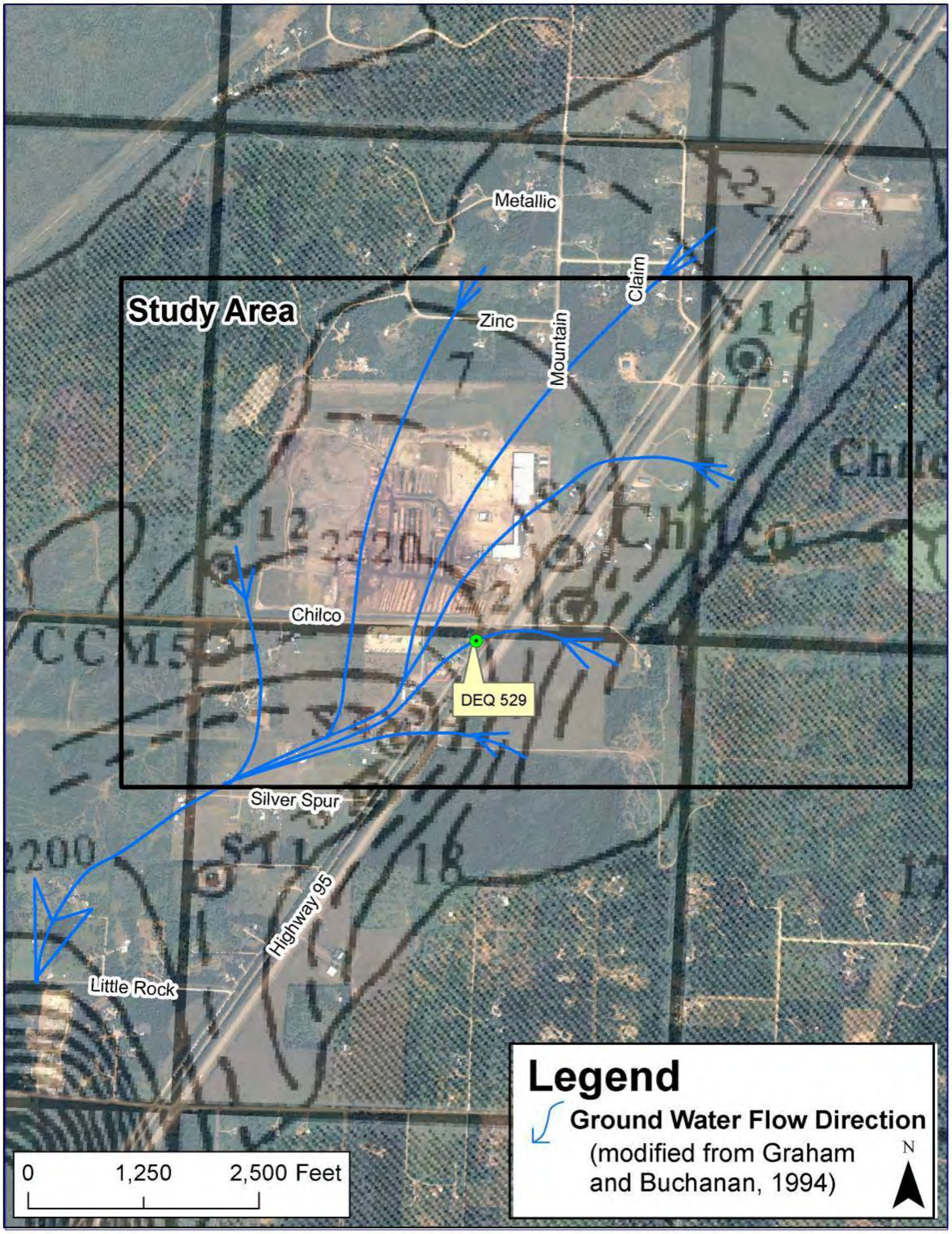

Figure 3. Ground water contours within the study area, from Graham and Buchanan (1994).Ground water flow paths are illustrated as blue lines. Street names have white backgrounds.

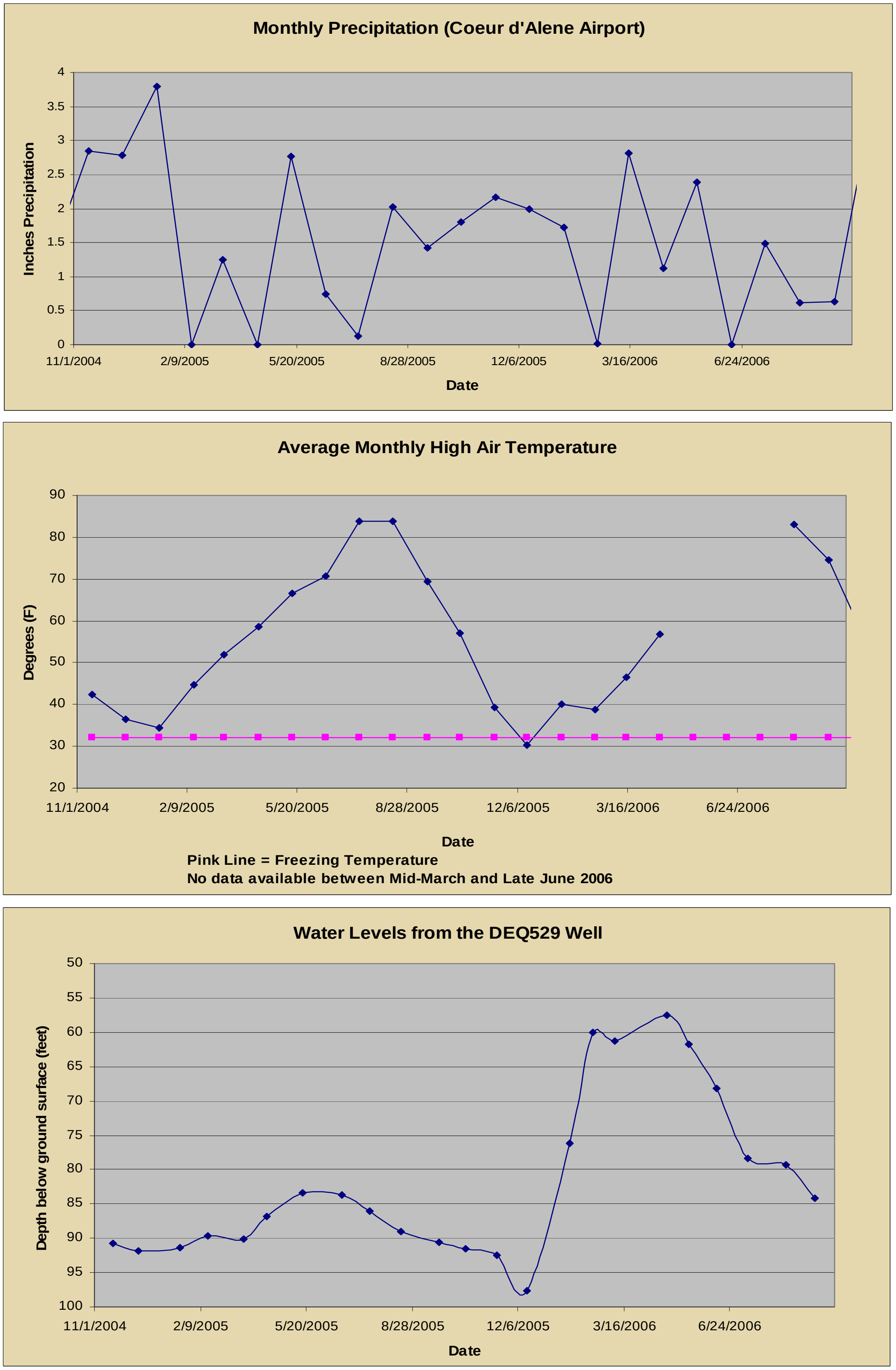

Figure 4. Monthly graphs of precipitation, average monthly high temperatures, and water levels from 11/1/2004 to 6/24/2006, illustrating short time response fluctuations in ground water levels due to precipitation/snowmelt events.

Figure 5. Calculated ground water flow direction based upon water levels measured at three sample sites in the summer (June 2006) and three in the winter (two December 2005 and one January 1978).

Discussion of Ground Water Level Fluctuations

Figure 4 illustrates the relationship between precipitation (National Weather Service, accessed November 2009), air temperature (National Weather Service, accessed November 2009), and water levels (IDWR, Hydro Online, accessed November 2009(b)) in the DEQ529 well from 2004 to June 2006.

When temperatures were below freezing in December 2005 (as shown by the pink horizontal line in the middle graph in Figure 4), water levels in the aquifer were lower, suggesting that recharge was reduced or no longer occurring. In the spring and early summer 2006, when air temperatures were above freezing and snow melt and/or precipitation occurred, water levels as measured in the DEQ529 well quickly rose to 35 feet higher than the lowest levels measured in December 2005. Conversely, water levels measured in the well dropped approximately 25 feet in the summer of 2006, after spring runoff.

This data implies that there is an immediate and direct response to aquifer levels due to precipitation events and snowmelt. Additionally, contaminants at or near the land surface can be transported into the aquifer in a relatively short time period.

Methods

To identify potential sampling locations for this study, DEQ conducted a search of IDWR's Well Information database, spoke with owners of domestic and public water supply wells, and visited the study area. Based on proximity to the LP Mill and access permission, six domestic wells, two public water system (PWS) wells, an industrial well, and four surface water locations in the vicinity of the mill were identified as sample locations. Figure 6 shows all of the sampling locations within the study area.

Well and surface water sampling locations were recorded by using a Trimble™ geographic positioning system (GPS) at the time of sampling. Ground water samples were obtained from wells in accordance with ASTM D4448-01 and D6089-97, *Standard Guide for Sampling Ground-water Monitoring Wells* and *Standard Guide for Documenting a Ground-water Sampling Event*, respectively. Ground water samples from PWS or industrial wells were collected prior to water passing through any water filtration or storage devices which may have been installed on those systems. Samples were collected when the **field parameters** (temperature, pH, **specific conductivity**, and **dissolved oxygen**) of purged water had stabilized within 10% (pH within 0.1 units). Samples were labeled, placed in an iced cooler, and recorded in a field book and on a chain-of-custody form. Samples were delivered daily to the SVL Analytical laboratory in Coeur d'Alene for analysis.

Surface water samples from the DEQ572, DEQ571, and DEQ569 sampling locations were a composite of multiple grab samples at each location. These samples were collected adjacent to the LP Mill in ponded water that appears to be seepage from the log decks and from ephemeral surface water located to the west of the facility. Chilco Lake samples were collected at the discharge point at the base of the dam or at the base of a waterfall located at the rim rock. Field parameters are included in Appendix A.

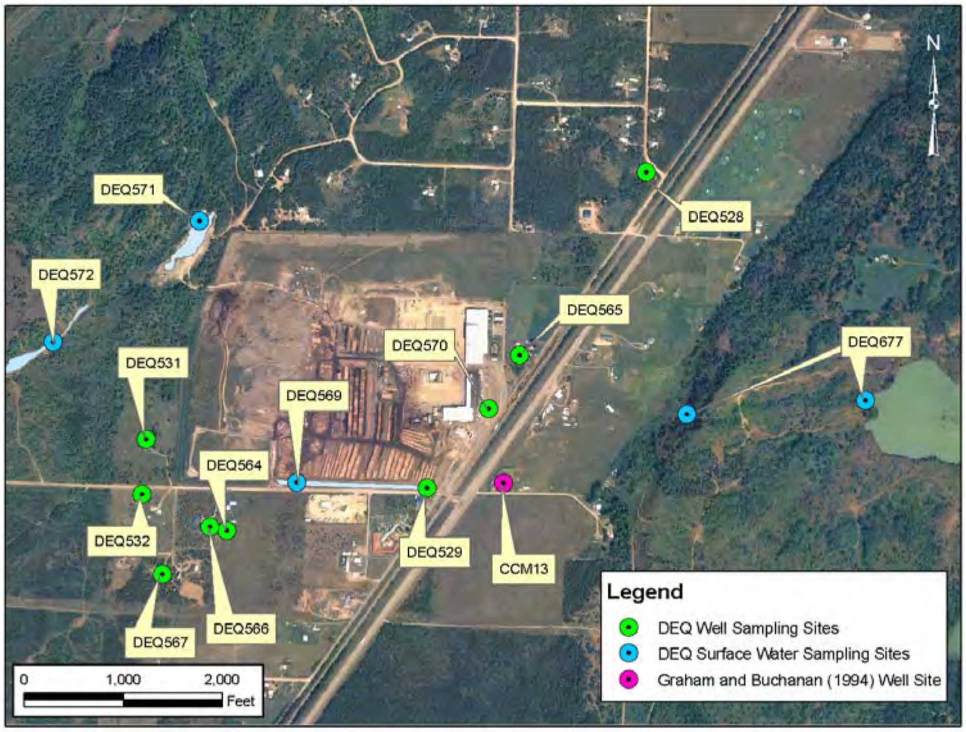

Figure 6. Sampling locations within the study area. Wells are identified with green circles, and surface water sites with blue circles. The pink circle shows the location of a well sampled in a 1994 study (Graham and Buchanan) that is referenced in this report.

There were 13 sampling events between September 2006 and May 2009. Sampling frequency was approximately quarterly, although monthly samples were taken initially. Samples were analyzed in the laboratory for **major ions**, inorganic chemicals, bacteria, oxygen and deuterium **isotopes**, tree-breakdown products[3], and **biological and chemical oxygen demand**.

Samples were submitted to four different laboratories, depending upon the type of analysis needed. The University of Arizona Environmental Isotope Geochemistry Laboratory analyzed samples for oxygen and deuterium isotope compositions. SVL Analytical analyzed major ion water chemistry, Anatek Lab analyzed tree breakdown products, and the Idaho Bureau of Laboratories analyzed samples for bacteria.

The suite of wells and surface water sampled bodies was modified throughout the study. As data was collected, some sample sites were omitted from the sample suite because the information they provided did not add value. Therefore, some figures in this report will not contain all of the original sample locations.

[3] Compounds specifically related to the decomposition of pine trees, including tannins, lignins, phenols, and others. SeeTable 4 in Appendix A.

Discussion of Potential Contaminant Sources and Pathways

The major potential contaminant sources within the Chilco area are illustrated in Figure 7 and discussed in this section. These include the LP Mill, Highway 95, septic tanks, Chilco Lake, and a golf course. Additional potential contaminant sources not identified in Figure 7 but discussed in this section include poor well construction, animal waste, plant fertilizer, and historical land uses.

Louisiana-Pacific Mill

Centrally located in the study area is a 175-acre mill that has been in operation since the 1970s. Past activities at the mill included the production of Waferwood boards (now known as Oriented Strand Board [OSB]). Currently the mill appears to be making dimensional lumber. No information was gathered regarding the past or present disposal practices of used process water. Currently, logs are stored on-site in log decks, and kept wet with ground water from an on-site well or with surface water via a piping system from Chilco Lake. According to an employee of the mill (personal communication, October 2009), the logs are watered mainly with ground water (some Chilco Lake water is used) from May to mid-July, and watered solely with Chilco Lake surface water from mid-July to September. No antifreeze or chemicals (fungicides, pesticides, etc.) are added to the applied water.

It is estimated that each sprinkler used on the mill site applies approximately 1.95 million gallons per year, based upon an application rate of 10 gallons per minute and a 135-day season. Assuming 20% - 50% evaporation, each sprinkler is responsible for approximately 0.97-1.5 million gallons of potential annual recharge to the aquifer. Therefore, any potential contaminants in the sprinkler water or in the flow path of the log deck runoff have a potential to be transported into the aquifer. Additionally, ground water mounding (a bulge in the relatively flat surface of the aquifer) may cause localized flow directions to deviate from normal flow directions in the proximity of the mill.

Runoff from the log decks appears to drain to the west and north, and to a ditch on the southern boundary of the site (Figure 8). The amount of surface area affected by log deck runoff appears to be directly related to overall mill production. In 2006, before the housing market downturn (and presumed accompanying reduction in lumber sales) that started in 2008, runoff could be seen in most of the blue-outlined area in Figure 8. In 2009, reduced production resulted in less surface area being affected by log deck runoff, which can be seen as the darker areas surrounding the log deck in Figure 8.

Studies have indicated that wood and bark wastes associated with lumberyard facilities can produce runoff with significant concentrations of TDS, lignins, tannins, coliform bacteria, and other inorganic constituents (Samis et al., 1999; McDougall, 2002). The applications of water to the log decks at the LP Mill provides a mechanism by which constituents can potentially collect, concentrate, and eventually infiltrate into the subsurface.

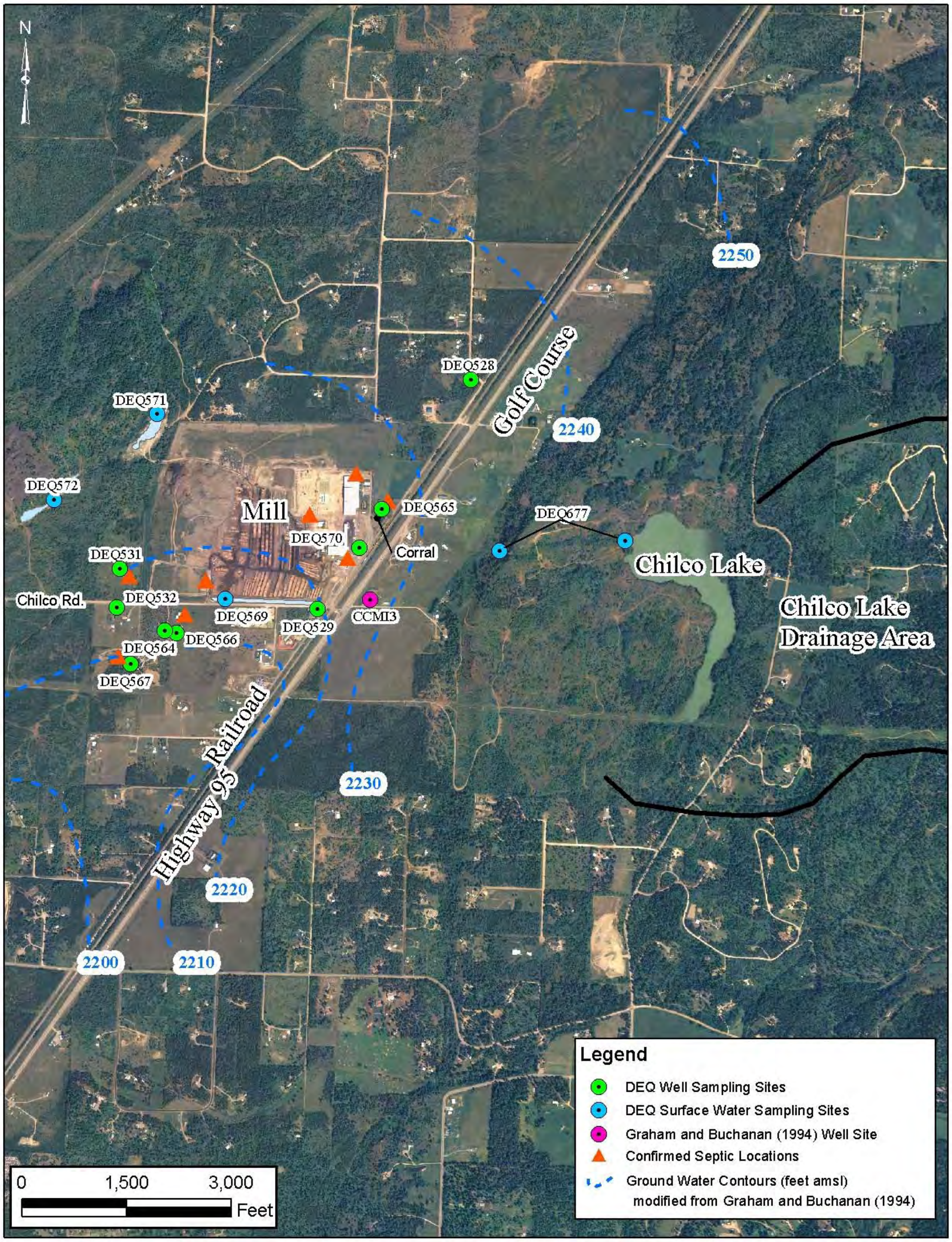

Figure 7. Locations of potential contaminant sources in the Chilco area. The LP Mill, golf course, Highway 95, Chilco Road, railroad, confirmed septic tank locations, Chilco Lake, and Chilco Lake's drainage area (bound by black lines) are specifically identified. For reference, DEQ sampling locations and ground water surface contours (modified from Graham and Buchan, 1994) are illustrated.

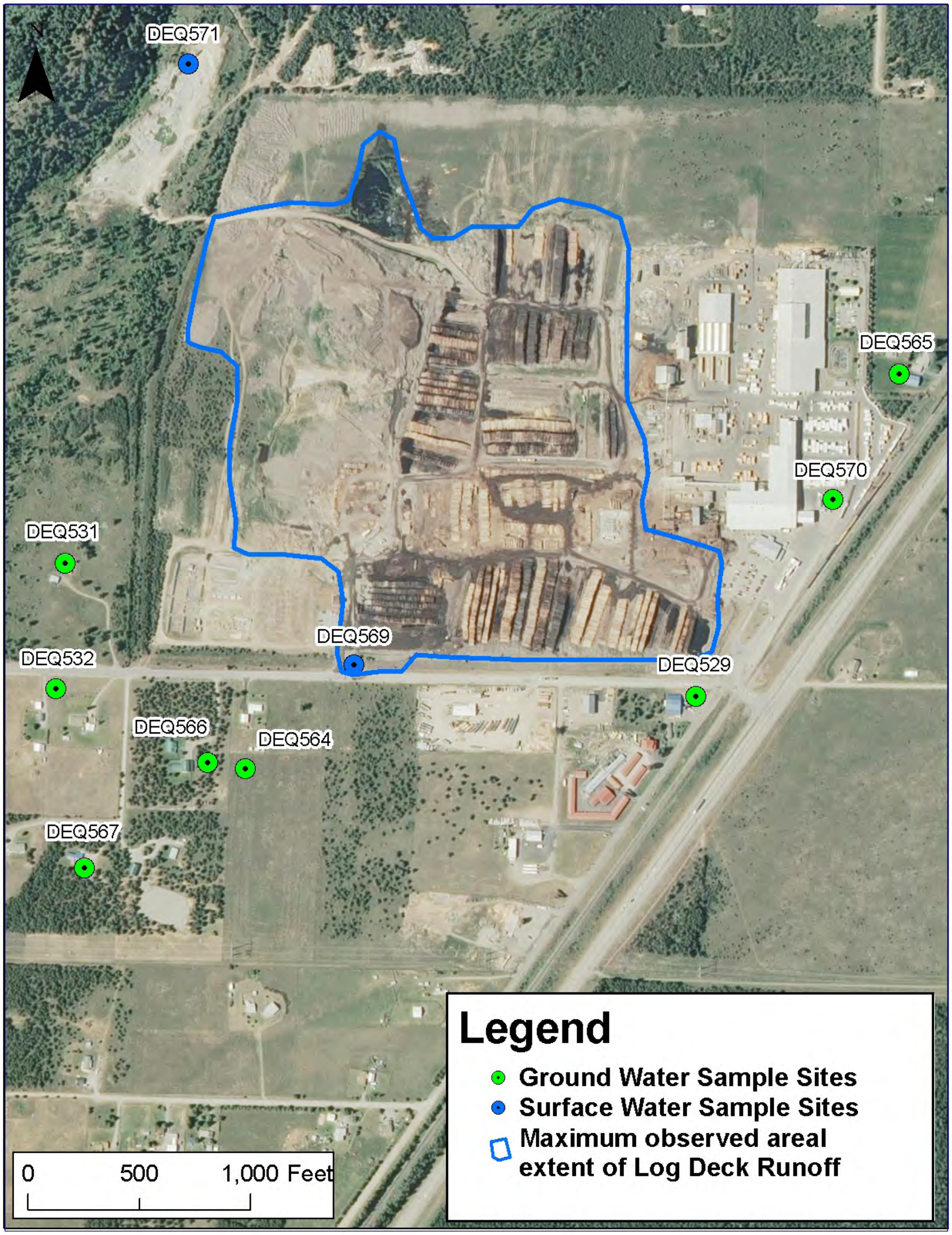

Figure 8. 2009 image (USDA) of LP Mill site. Runoff from the logs is visible as the darker areas between and around the log decks (inside the blue outlined area). The blue perimeter represents the maximum aerial extent of log deck runoff as observed from Google Earth historical imagery. When the mill is in full operation, water drains to the west and the north, and to a ditch on the southern boundary of the site.

De-icers on Roadways

Road salt (de-icer), in the form of magnesium chloride, calcium chloride, or sodium chloride has been applied to Highway 95 since the 1980s. According to the maintenance engineer for the Idaho Transportation Department district serving the Chilco area (personal communication, November 2009), road salt is applied along Highway 95 during the winter, as needed, from approximately December to March. The volume of salt applied to the highway has been approximately 150-200 pounds per lane mile, per application. The application frequency depends upon wintertime weather conditions. Highway 95 bisects the study area for approximately 2 miles. If those 2 miles of the two-lane highway are treated 10 times per winter, which represents an application rate of once every week and a half, then approximately 6,000-8,000 pounds of salt is applied annually to the section of Highway 95 that is within the study area.

Along Chilco Road, a de-icer (magnesium chloride) is only applied at the intersection of Chilco Road and the train track crossing located near Highway 95. (Lakes Highway District, personal communication, September 2010). No de-icers are applied to any other portions of Chilco Road.

Septic Tanks

The orange triangles in Figure 7 are locations of confirmed septic drainfields. The investigator talked with resident occupants and confirmed the presence of a septic tank at each residence noted on the map. Septic tanks and drainfields are the most widely used form of sewage disposal in the Chilco area. A septic drainfield can be assumed to be present at the other houses in the mapped area even though their locations were not confirmed during this study.

According to Graham and Buchanan (1994) and the Panhandle Health District (personal communication, 2009), the type and shallow depth of soils within the Chilco Channel influence the effectiveness of septic drainfields. Septic drainfields are most effective in fine-grained soils not commonly found in the study area (see IDAPA 58.01.03, Individual/Subsurface Sewage Disposal Rules). Soils on the valley floor are classified as Kootenai Series, gravelly silt loam to very gravelly loam up to 26 inches deep, with a very gravelly coarse sand substratum. Community septic systems have been recommended in the Chilco Area because of the potential for ground water pollution in areas of high population density (SCS, 1981).

Within the Chilco Lake drainage area, well logs (IDWR, accessed 2009(a)) indicate that depths to bedrock or clay layers are typically less than 20 feet, and in some cases are less than 5 feet. If septic system failure were to occur, contamination would likely follow the topography downhill and possibly enter surface water and Chilco Lake.

Septic tank effluent is a likely source of bacteria, nitrate, and chloride contamination in the study area. These constituents can leach from a drainfield and affect down-gradient ground water quality.

Chilco Lake

Chilco Lake is an approximately 35-acre impoundment of an unnamed stream draining an approximately 1,200-acre watershed located on the west flank of Hollister Mountain. Chilco Lake is located above the basalt cliffs that flank Chilco Channel. Current land use within the drainage area consists of logging in the upper portion and approximately 14 residential homes are present in the lower portion. The density of homes is low, as most homes have some pasture land surrounding them.

Chilco Lake's primary function appears to be for recreation and water storage. LP Mill has water rights for 1/3 of the lake's water, which is piped to the mill and applied to the log decks. Chilco Lake is also refuge to many waterfowl, whose feces contribute bacterial contamination to the lake. Additionally, the lake is subjected to intense summer heat, and as can be seen in Figure 7, becomes covered with algae during the summers.

DEQ tested water from Chilco Lake at its outlet below the dam and from below the basalt cliffs (at the DEQ677 sampling locations identified in Figure 6) from April 2008 to June 2009. Total coliform was detected in all 12 samples, and *E. coli* was detected in 10 of the 12 samples. Bacteria values from Chilco Lake runoff water have been as high as 3,653.5 most probable number (MPN)/100mL for total coliform and 440 MPN/100mL for *E. coli* (see Table 3 in Appendix A).

The discharge from Chilco Lake flows westward toward the Chilco Channel and infiltrates the unconfined shallow aquifer near the base of the basalt cliff at the eastern portion of the study area. The distance from the base of the cliffs to wells DEQ529 and CCM13 is approximately 0.5 miles.

Graham and Buchanan (1994) surmised that bacteria detected in the CCM13 well (Figure 6) were derived from Chilco Lake which infiltrated into the Chilco Channel. Evidence of a Chilco Lake influence included lower levels of water hardness and higher levels of iron (basalt rocks are relatively high in iron) detected in the CCM13 well than in other wells in their study area. Additionally, fewer houses were present in the area in 1993, and the septic tank near the CCM13 well was not yet in operation at the time, supporting the hypothesis that Chilco Lake was the bacterial source.

Fertilizer Application

Nitrate, typically found in fertilizers, is a very mobile constituent in ground water. Within the Chilco area, fertilizers are used in agricultural applications and on residential lawns, and it is assumed that fertilizer is used on a 9-hole golf course located just outside the northeast corner of the Study Area. Precipitation and/or irrigation can often drive nitrate-based fertilizers below the uptake zone of roots and into the ground water.

Rimrock Golf Course was incorporated in 1995 (Idaho Secretary of State, accessed November 2009). A drinking water well is present near the southwest corner of the course, which is down-gradient of the turfed areas. This well is regulated by DEQ's Drinking Water Program (DEQ, SDWISS, accessed November 2009). Based upon limited data, nitrate concentrations from this well appear to be rising over time. However, it has not been determined if the changes in nitrate concentrations are solely from on-site fertilizer application or if overall nitrate concentrations in the aquifer are increasing.

Well Construction/Well Condition

The state of Idaho requires domestic wells to comply with specific well construction standards (IDAPA 37.03.09, Well Construction Standards Rules). These rules are designed not only to protect the users of a specific well, but also other nearby users and the aquifer. If a well is constructed poorly, it could potentially become a conduit between the surface and/or shallow aquifer and a deeper aquifer, which can result in the contamination of that deeper aquifer.

An evaluation of area well logs (IDWR, accessed 2009(a)) indicates that the **vadose zone** is composed of coarse sand and gravels. These materials can allow surface waters to migrate easily into the ground water and become quite mobile in the aquifer. Therefore, ideally, new wells should be sealed to below the clay layer identified in well logs as being between 105 and 125 feet bgs (Appendix B).

An apparent contamination pathway exists at the DEQ529 well, which was constructed in 1970 and appears to have been compromised at an unknown date. Routine testing of this well detected total coliform and *E. coli* contamination. In October 2004, a local resident took two photos, which illustrated a crack in the **casing** and a gap between the bottom of the concrete surface seal and the ground surface (Figure 9). The pictured damage may establish a direct contamination pathway to the aquifer, as evidenced by discoloration in drinking water after rainy weather, and by elevated turbidity levels in the well (DEQ, 2005).

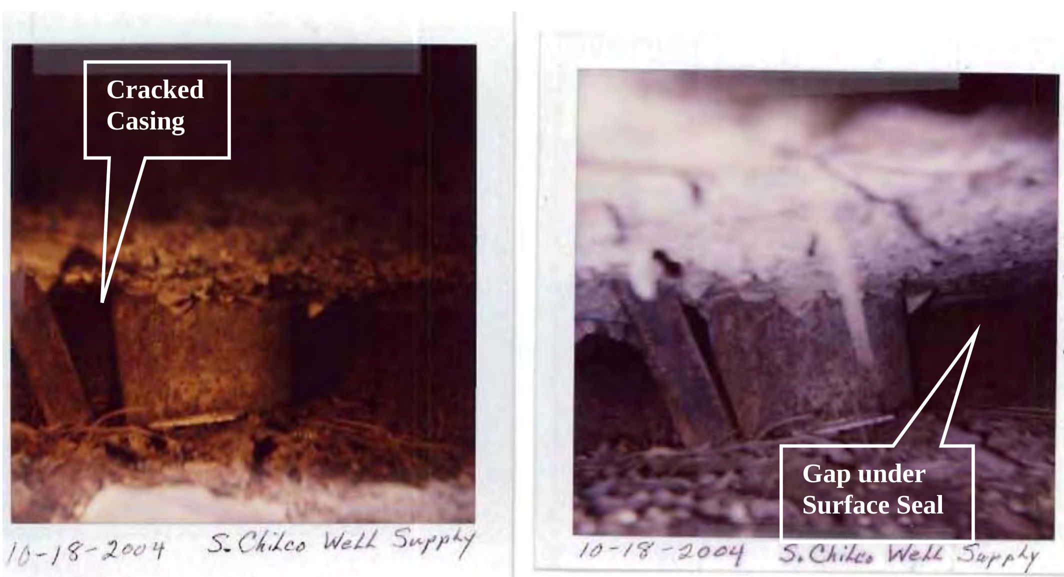

Figure 9. Photos of the DEQ529 well casing in October 2004, illustrating the cracked casing and the gap between the surface seal's underside and the ground surface.

In an effort to address this contamination, local residents reportedly packed dirt back under the surface seal and regraded the ground slope adjacent to the well in 2005 so surface water would drain away. DEQ is not aware of the depth to which the crack in the casing extends or of any efforts to fix the casing.

Because the number of well users has been less than 25 people[4] the well has not been regulated as a public water system and is therefore not subject to routine sampling requirements. Turbidity measurements have not been collected since 2005. However, as long as the casing is compromised, the DEQ529 well can potentially be a pathway for ground water contamination to the aquifer.

The DEQ529 well has the highest number of samples that tested positive for total coliform (see Table 3 in Appendix A) during this study, with five of nine samples testing positive for total coliform. It has not been determined whether constituents found in the ground water in the DEQ529 well come from surface-related sources or Chilco Lake, result from poor well construction, or are part of a larger aquifer-wide problem.

Animal Waste

Within the Chilco area, a horse pasture is located on the east side of the LP Mill. Animal waste can be a source of nitrates and bacterial contamination in the form of coliform. Large volumes of animal waste can potentially introduce these constituents into ground water depending, on quantities and /or disposal method.

Historical Land Use

Much of the historic land use within the Chilco area is unknown. Accidental spills and leaks along Highway 95 and the railroad that parallels it might contribute contaminants to the ground water. Sometimes in rural settings, waste is disposed of by simply piling it up, burning it, or burying it in small landfills.

Approximately 1 mile southwest of the study area is a drinking well for a private residence. The driller of that well described the materials between 2 feet and 20 feet below ground surface as “sand, gravel, cars, trash” (IDWR, 1994). Therefore, the unknown factor regarding historic land use practices in the area could be significant.

Analytical Results and Discussion

The goal of sampling was to identify certain chemical constituents and potential sources of these contaminants to the ground water or surface water within the study area. The overall characteristics of the surface water and ground water were determined by sampling for major ions, specific conductivity, and **total dissolved solids**. Based upon land use in the study area, **chloride, nitrate**, and bacteria concentrations were evaluated.

[4] See the definition of a public water system in the glossary.

Samples were also analyzed for constituents related to decomposing trees; however, due to analytical results that were near the laboratory method detection limits, results were inconclusive. All sample results are displayed in tables in Appendix A.

Major Ions Results

The purpose of sampling major ions[5] is to evaluate the source of ground or surface water, and/or to measure changes in water chemistry over time. By plotting the major ion results on a **Piper trilinear diagram** (Piper diagram; Piper, 1944), the chemical relationships of individual sampling locations can be compared.

The major ions were analyzed in samples collected during September 2006 and May 2009. The September 2006 data represent a period during which water from Chilco Lake was being applied to the mill's log decks, and May 2009 represents data from a period of spring snowmelt when no log deck water application was occurring.

The piper diagram for September 2006 (Figure 10) illustrates that both ground water and surface water were typically calcium-bicarbonate in the study area at that time. Water from Chilco Lake (DEQ677) shows a unique chemical signature, as does water that is collected from the ditch beside Chilco Road (DEQ569). Wells up-gradient and down-gradient of the LP Mill site have similar chemical signatures, except the DEQ531 well. The chemical signature well DEQ531 appears to be shifted toward the chemical signature of the DEQ569 sample site.

The piper diagram for May 20, 2009 (Figure 11) confirms the ground water was calcium-bicarbonate type, and surface water from Chilco Lake (DEQ677) was similar but contained less calcium than the ground water at that time. The position of the data from the DEQ 564 well on the May 2009 Piper diagram suggests significantly more sodium/potassium than all other results for this sampling event. This is most likely due to the discharging of effluent from the known domestic water softener into the known septic drainfield that is located approximately 250 feet up-gradient of this sampling point.

[5] Calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), carbonate (CO_3), bicarbonate (HCO_3), chloride (Cl), and sulfate (SO_4)

Chilco Area Piper Diagram for Samples Collected on September 6, 2006

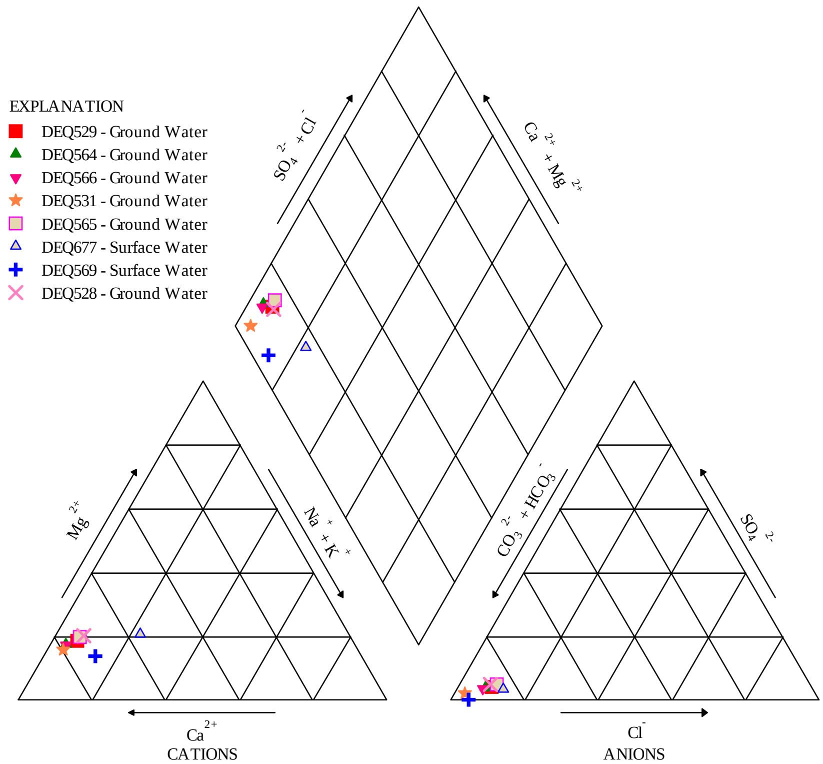

Figure 10. Piper trilinear diagram for water samples from selected wells within the Chilco study area (September 2006). Chemical symbols are defined in Appendix A.

Chilco Area Piper Diagram for Samples Collected on May 20, 2009

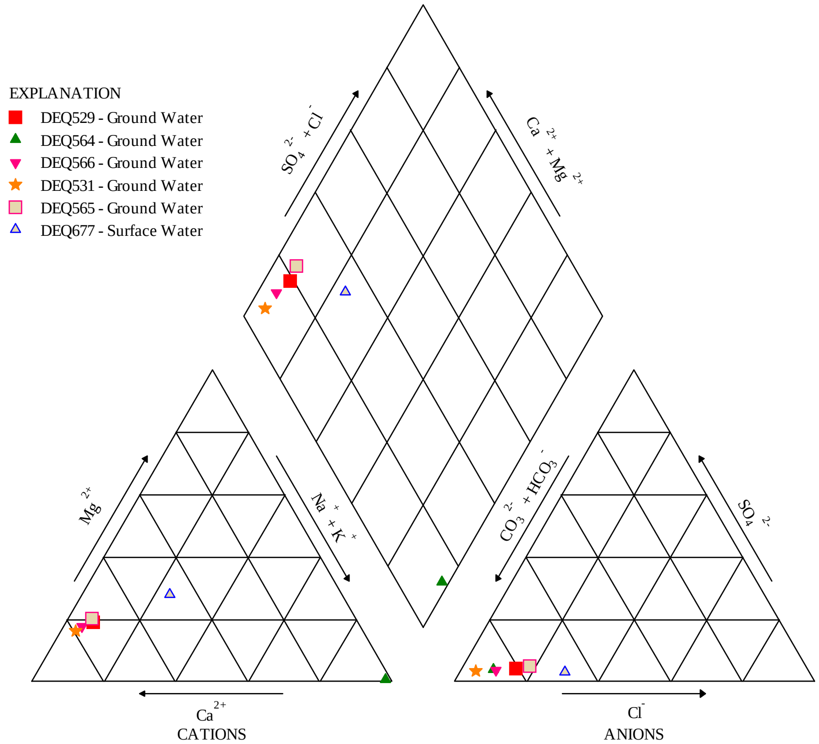

Figure 11. Piper trilinear diagram for water samples from selected wells within the Chilco study area (May 2009). Chemical symbols are defined in Appendix A.

Specific Conductivity Results

Specific conductivity was measured as part of the parameter stabilization measurements for each well. Specific conductivity is the measure of the electrical conductance potential of the total ions within a water sample. This parameter can be used to identify whether various water samples are subjected to the same ion source(s). If two relatively adjacent wells have significantly different specific conductivity measurements, then the wells may be in different ground water flow paths and not susceptible to the same recharge sources.

Based upon specific conductivity, the data from the water samples collected from September 2006 through May 2009 can be classified into four groups (see Table 3 in Appendix A):

- The first data group (Chilco Lake, labeled "DEQ677" in Figure 12) consisted of results from surface water samples that originated from Chilco Lake. The samples from this site had an average specific conductivity of 95.0 microsiemens per centimeter (µS/cm).
- The second data group (labeled "Group A" in Figure 12) consisted of sample analysis results from four wells (DEQ528, DEQ565, DEQ529, and DEQ570) located adjacent to Highway 95. These four wells had an average specific conductivity value of 262.5 µS/cm.
- The third group (a single surface water site at DEQ569) consisted of sample analysis results from log deck runoff water collected in the ditch along Chilco Road. These water samples had an average specific conductivity of 554.7 µS/cm.
- The fourth group (labeled "Group B" in Figure 12) consists of analytical data from five wells (DEQ531, DEQ532, DEQ564, DEQ566, and DEQ567) located along Chilco Road, approximately 0.5 to 0.75 miles west of Highway 95. Water samples from these five wells had average specific conductivity of 500.4 µS/cm (Figure 12).

Within Group A, water samples from the DEQ529 well had an average specific conductivity of 297.5 µS/cm (Figure 12) measured from September 2006 to February 2009. That value is approximately 7% greater than the specific conductivity average from a well that is up-gradient approximately 0.3 miles to the northeast (DEQ565), and 29% greater than the specific conductivity average from another up-gradient well approximately 0.75 miles to the northeast (DEQ528). The implication of the data within Group A is that specific conductivity is slightly increasing in the down-gradient direction.

Specific conductivity average values in samples from Group B wells located approximately 0.3 to 0.5 miles to the west of the DEQ529 well were 144% to 185% greater than the specific conductivity averages from the DEQ529 well. Specific conductivity averages at the DEQ569 surface water site were 186% greater than those from the DEQ529 well. This data illustrates that specific conductivity measured near the middle of the Chilco Channel is significantly greater than specific conductivity measured on the eastern margin of Chilco Channel.

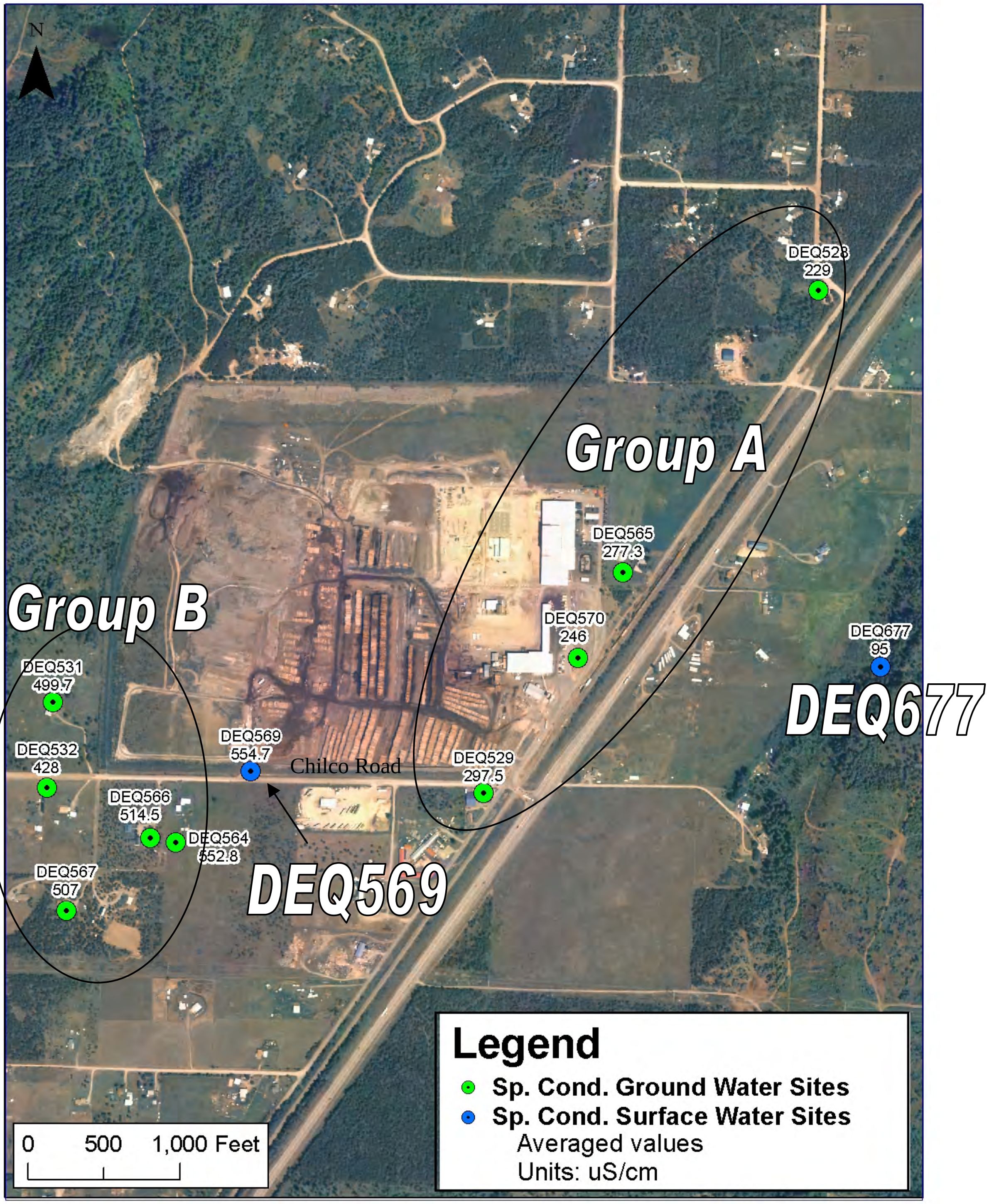

Figure 12. Averaged specific conductivity values for selected sampled wells and surface water sites. The specific conductivity values measured along Highway 95 (Group A sites) were almost one-half of those measured along Chilco Road (Group B sites). In a surface water sample taken along Chilco Road (DEQ569), specific conductivity measured only slightly higher than in nearby ground water samples.

Specific conductivity values recorded in Group B wells down-gradient of the mill (DEQ532, DEQ564, DEQ566, and DEQ567) are 1% to 24% lower than the values for samples at the surface water DEQ569 site, which consisted of log deck seepage water that collected in the ditch along Chilco Road. Water at the DEQ569 site is either pumped from the DEQ570 well (located in Group A) from May to mid-July, or piped from Chilco Lake (represented by sample site DEQ677) from mid-July to September. This implies that the runoff that collects as surface water in the ditch (DEQ569) shows increased specific conductivity concentrations which more closely resembles the down-gradient ground water wells than the source of water to the log decks.

Comparison of Specific Conductivity to Total Dissolved Solids

Whereas specific conductivity is the measure of the electrical conductance potential of ions within a sample, total dissolved solids (TDS) is a measure of the combined content of all microgranular or dissolved **inorganic** and **organic** substances contained in a liquid. Because the specific conductivity and TDS are similar, they generally plot with a high degree of correspondence on a graph, as in this case (Figure 13). The two largest influences upon specific conductivity and TDS in ground water are duration in the ground, and influence from nearby contaminant sources.

Of all the samples in this study, water from Chilco Lake (shown as the "DEQ677" group in Figure 13), has the lowest specific conductivity and TDS measurements. This is plausible because surface water generally does not interact with the subsurface materials and therefore typically does not absorb large concentrations of ions or microgranular material.

Group A wells show levels of specific conductivity and TDS that were intermediate between levels of Chilco Lake water and Group B wells. The ground water flow paths illustrated in Figure 3 also suggest that ground water flows from the eastern margin of the Chilco Channel (near Chilco Lake) to the central portion of the channel (near Group B wells), and likewise, the positions of the data on the graph are also intermediate.

Group B wells are the most down-gradient wells in the study area, and as expected because of down-gradient accumulation, they have the highest measurements of specific conductivity and TDS. Not only did Group B wells have the highest levels of both specific conductivity and TDS, but the TDS levels were disproportionately larger than specific conductivity. Higher than expected concentrations of TDS in ground water might also indicate it has been impacted by log deck runoff (McDougall, 2002). This implies that, based upon an evaluation of potential contaminant sources in the area, elevated levels of specific conductivity and TDS measured in Group B wells might be highly influenced by mill operations. For example, in July 2008 during a period of decreased production at the LP Mill, a Group B well (the DEQ531 well) had specific conductivity and TDS levels that were more similar to the levels in Group A than those in Group B.

The water found at the DEQ 569 sample site is assumed to be representative of all log deck runoff. Therefore, it can be assumed too that the chemistry of the water found at the

DEQ569 sample site represents the chemistry in all log deck runoff, which eventually infiltrates the ground surface. Samples from the DEQ569 sample site had both the highest specific conductivity and the highest concentrations of TDS. Interestingly, the specific conductivity/TDS ratio is less at the DEQ569 site than at other sites. One possible explanation for this unexpected result may be due to the laboratory method. The TDS concentration in a sample is determined by heating the sample to 180 degrees Celsius and measuring the residual (Standard Methods for the Examination of Water and Wastewater, 1999). This process has the potential of removing volatile solids, such as organic matter found in logs, and therefore introducing negative error into the reported TDS value.

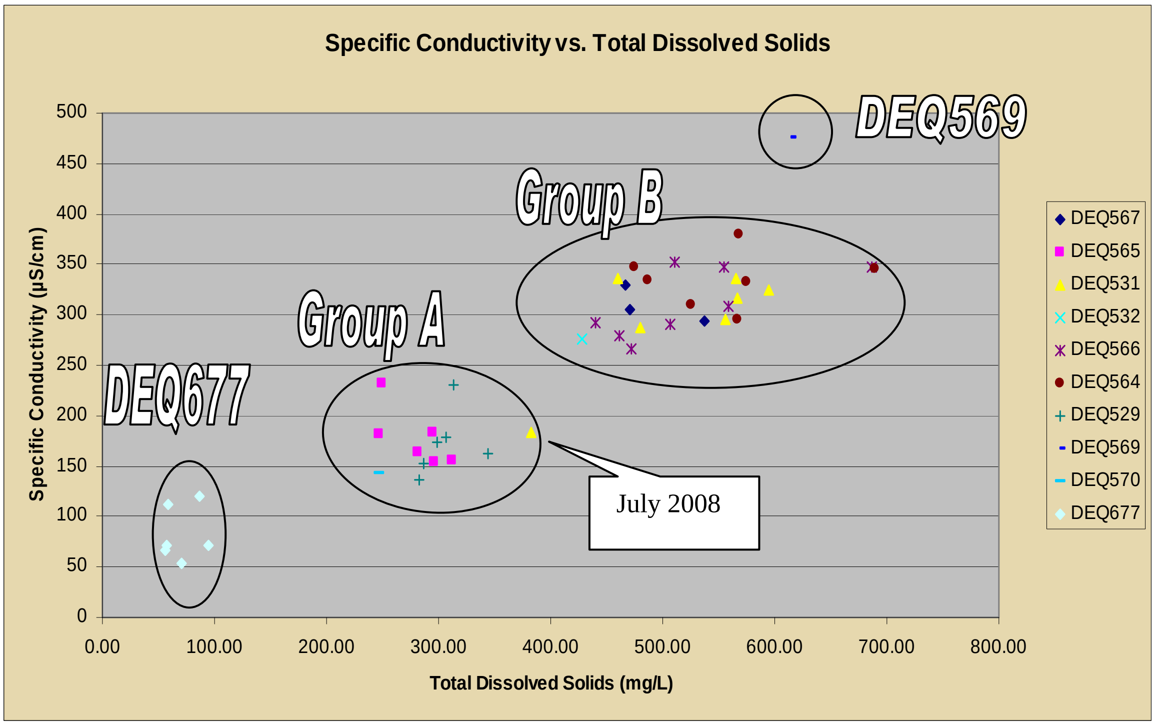

Figure 13. Specific conductivity and total dissolved solids sample results for each sampling event. The four groups of data represent distinct water chemistries. The July 2008 results for the DEQ531 well plotted near the Group A wells, suggesting a change in water chemistry as compared to all other results for that well.

Chloride Results

Chloride is not generally present in ground water at high concentrations within the study area. Chloride is a non-regulated contaminant, and in concentrations greater than 250 mg/L is considered a nuisance chemical that may cause cosmetic or aesthetic effects in ground water (US EPA, accessed November 2009). Sample results indicate that for those sampling points with enough data to establish a trend, chloride increased in five out of six sampling points over time. These elevated and increasing trends are most likely from **anthropogenic** (human-caused) sources. Potential sources of chloride in the study area could be from septic systems, road salt (de-icer), and fertilizer used on lawns and fields.

The data in Table 1 illustrates that chloride levels increased in ground water from September 2006 to May 2009, according to **Mann-Kendall trend analysis,** with a 90% confidence level. Between August 1993 and May 2009, chloride concentrations in the DEQ531 well increased from 1.8 mg/L (Buchanan and Graham, 1994) to a maximum of 8.76 mg/L. During the same time period, chloride concentrations in the DEQ565 well, located up-gradient of the LP Mill, increased from 2.6 mg/L to 17.2 mg/L. The DEQ677 surface water sampling location at Chilco Lake (which represents background conditions) has had statistically stable concentrations of chloride from September 2006 to May 2009. Only sampling locations with enough data to determine a trend were included in Table 1.

Table 1. Table illustrating increasing chloride concentrations, Chilco area aquifer. Concentrations are in mg/L. The 1993 data points are from Buchanan and Graham (1994).

Site Name = Chilco Study - Chloride		City = Chilco, Idaho		Site ID = various		Well Number = various	
		DEQ565	DEQ531	DEQ566	DEQ564	DEQ677	DEQ529
Event Number	Sampling Date (most recent last)	Concentration (leave blank if no data)	Concentration (leave blank if no data)	Concentration (leave blank if no data)	Concentration (leave blank if no data)	Concentration (leave blank if no data)	Concentration (leave blank if no data)
1	**8/4/1993**	2.6	1.8				
2	**9/6/2006**	8.44	3.84	10.80	13.10	2.97	8.640
3	**10/3/2006**					6.92	
4	**9/25/2007**	7.99	5.80	10.00		1.90	
5	**1/24/2008**		5.23	11.90	12.90		9.200
6	**4/29/2008**	11.30			17.10	8.03	11.700
7	**7/31/2008**	13.60	5.67	13.50	13.70	1.79	12.200
8	**11/5/2008**	11.00	8.53	13.40	13.20	5.18	9.940
9	**2/5/2009**	9.09	8.76	14.20	14.50	2.17	11.700
10	**5/20/2009**	17.200	6.670	18.000	17.300	5.400	14.700
Mann Kendall Statistic S =		16	20	17	11	0	14
Number of Rounds n =		8	8	7	7	8	7
Average =		10.15	5.79	13.11	14.54	4.30	11.15
Standard Deviation =		4.30	2.30	2.64	1.89	2.42	2.08
Coefficient of Variation (CV)		0.42	0.40	0.20	0.13	0.56	0.19
Trend ≥ 80% Confidence Level		**INCREASING**	**INCREASING**	**INCREASING**	**INCREASING**	No Trend	**INCREASING**
Trend ≥ 90% Confidence Level		**INCREASING**	**INCREASING**	**INCREASING**	**INCREASING**	No Trend	**INCREASING**
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	NA	NA	**CV <= 1 STABLE**	NA

Comparison of Chloride to Specific Conductivity

Chloride generally contributes to the overall ground water specific conductivity. Graphing chloride concentrations and specific conductivity measurements together illustrates the influence that chloride has on the specific conductivity (Figure 14). For a given sampling location, a tight cluster of sample results over time indicates that it has consistent specific conductivity and chloride levels . Likewise, as variance increases for chloride concentrations and specific conductivity, the plot becomes more scattered. Increased variability in sample results at a sample site can be directly proportional to a shorter travel distance from the source in that contaminants do not have time to disperse in the aquifer.

Within Group A samples (located adjacent to Highway 95), results from the DEQ565 well show a greater variability in chloride concentrations than results from the DEQ529 well (Figure 14). This may be due to the proximity of the DEQ565 well to a septic drainfield located approximately 120 feet up-gradient and a lawn (possibly fertilized) that surrounds its up-gradient side. The results from the DEQ529 well have a lower degree of variability in chloride concentrations, suggesting either a potential consistent nearby source that discharges low concentrations or chloride, or that the distance to chloride sources may not be as close as those impacting the DEQ565 well.

Samples from Group B wells appear to have elevated and somewhat more consistent chloride concentrations except for the samples from the DEQ531 well. Within the sampling sites represented by Group B, known potential sources of chloride include septic tanks and the usage of de-icers on roadways.

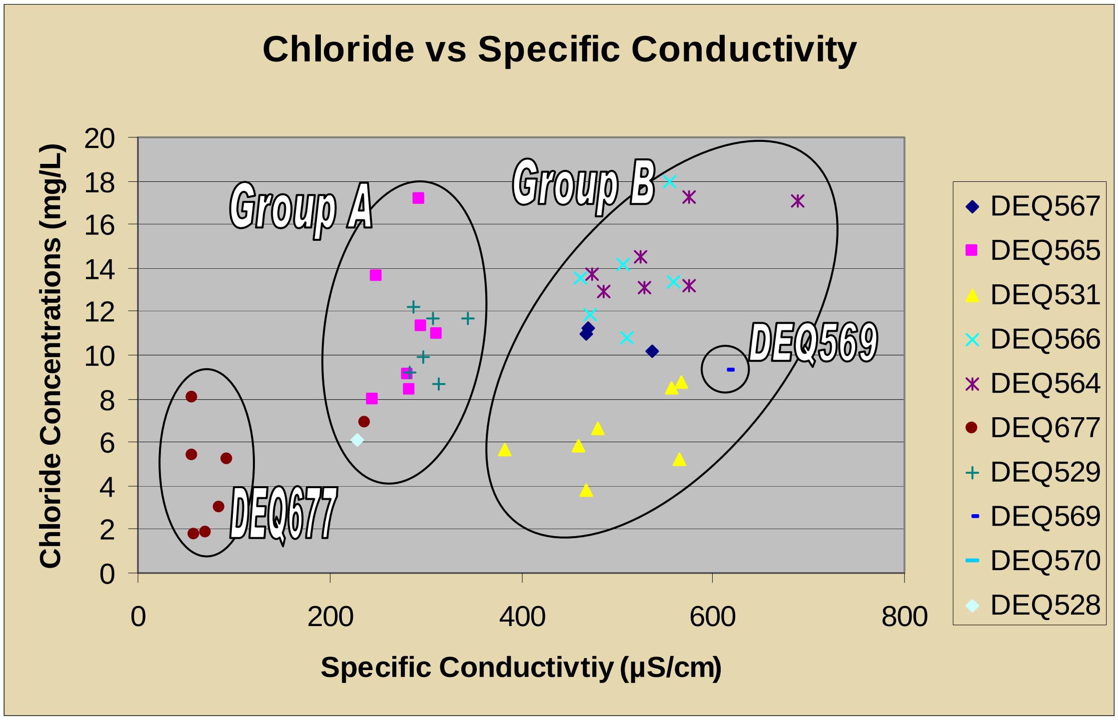

Figure 14. Graph comparing chloride concentrations (mg/L) to specific conductivity measurements (µS/cm) of selected wells for sampling events between September 2006 and May 2009.

Not included in Figure 14 are results for two samples from the DEQ569 sample site which contained chloride concentrations of 284 mg/L (December 2006) and 87 mg/L (March 2007). The two highest chloride measurements for both the DEQ564 well and the DEQ566 well were recorded in late spring or early summer, a timeframe when aquifer recharge from snow melt would have been the greatest (Figure 4). The time frame in which chloride concentrations are greatest in the DEQ569 well and also in the down-gradient wells suggests that de-icers may be the source of elevated chloride concentrations. In addition to the potential use of de-icer at the mill, road de-icer is only applied to Chilco Road where it crosses the train tracks, a location approximately 1,700 feet east of the DEQ569 site (Lakes Highway District, personal communication, September 2010).

Seasonal influxes of recharge to the aquifer may also affect chloride concentrations. Snowmelt can mobilize chloride downward from septic drainfields and the shallow subsurface into the aquifer, which can elevate chloride concentrations. Annual ground water levels can vary as much as 35 feet in the study area, which can potentially mobilize chloride that was in the ground but above the aquifer's saturated zone and thereby elevate chloride concentrations in the aquifer.

As mentioned earlier, the piper diagram for May 2009 (Figure 11) suggests that water softener effluent was being detected in water sampled from the DEQ 564 well. This would establish a direct link between that residence's septic waste and its well, despite the well being approximately 250 feet down-gradient of the septic drainfield. Additionally, as the DEQ566 well and the DEQ567 well are also down-gradient of septic systems, they too might be influenced by septic waste.

Although chloride concentrations in the Group B wells are lowest in the DEQ531 well, the plotted data has a relatively large scatter pattern (Figure 14). This well is located up-gradient of any potential road salting and is also up-gradient of the septic drainfield that services the residence where this well is located, and is located approximately one mile from the closest potential up-gradient septic drainfield. Therefore, the highly variable results may suggest that historic land use is affecting chloride concentrations in this well.

Nitrate Results

The presence of elevated nitrate concentrations in the ground water within the study area suggests an anthropogenic influence on nitrate concentrations in the aquifer. Due to the mobility of nitrate in ground water, it serves as an indicator that other contaminants may be potentially impacting the aquifer as well. Sources of nitrate in ground water include septic tank effluent, fertilizers, and animal waste. The highest recorded nitrate concentration amongst all sampling locations for this study was 2.03 mg/L, recorded at the DEQ565 well in March 2007. Nitrate is a regulated contaminant for public water system wells, and is considered potentially harmful if concentrations are greater than 10 mg/L, the EPA maximum contaminant level.

Table 2 shows nitrate trends using a **Mann-Kendall trend analysis** for sample sites with enough data to establish a trend if there is one. According to the data collected since March 2007, with a 90% confidence level, nitrate concentrations appear to be increasing within two Group B wells (the DEQ531 and DEQ564 wells) and stable at the DEQ566 well. Also at the 90% confidence level, concentrations are stable at two Group A wells (the DEQ565 and DEQ529 wells). Water sampled at the DEQ 677 sampling location also suggested a trend of increasing nitrate concentrations in the Chilco Lake area.

Table 2. Mann-Kendall analysis of last ten rounds of nitrate data results for selected sample sites within the Chilco Study area. Concentrations are in mg/L.

Site Name = Chilco Study - Nitrate		City = Chilco, Idaho		Site ID = various		Well Number = various	
		DEQ565	DEQ531	DEQ566	DEQ564	DEQ529	DEQ677
Event Number	Sampling Date (most recent last)	Concentration (leave blank if no data)	Concentration (leave blank if no data)	Concentration (leave blank if no data)	Concentration (leave blank if no data)	Concentration (leave blank if no data)	Concentration (leave blank if no data)
1	**3/5/2007**	2.03	0.641	0.974	0.88		0.020
2	**4/26/2007**	1.81	0.83	1.18	1.07	1.16	0.020
3	**7/10/2007**	1.54	0.53	0.99	0.85	1.27	0.020
4	**9/25/2007**	1.74	0.38	1.42			0.182
5	**1/24/2008**		0.66	0.97	0.99	1.32	
6	**4/29/2008**	1.72	1.44	1.27	1.12	0.81	0.043
7	**7/31/2008**	1.65	0.69	1.29	1.22	1.37	0.061
8	**11/5/2008**	1.74	0.71	1.16	1.15	1.16	0.479
9	**2/5/2009**	1.74	0.78	1.22	1.21	1.37	0.184
10	**5/20/2009**	1.740	1.050	1.130	1.100	1.000	0.050
Mann Kendall Statistic S =		-6	19	5	18	2	19
Number of Rounds n =		9	10	10	9	8	9
Average =		1.75	0.77	1.16	1.07	1.18	0.12
Standard Deviation =		0.13	0.29	0.15	0.13	0.20	0.15
Coefficient of Variation (CV)		0.08	0.38	0.13	0.12	0.17	1.28
Trend ≥ 80% Confidence Level		No Trend	**INCREASING**	No Trend	**INCREASING**	No Trend	**INCREASING**
Trend ≥ 90% Confidence Level		No Trend	**INCREASING**	No Trend	**INCREASING**	No Trend	**INCREASING**
Stability Test, If No Trend Exists at 80% Confidence Level		**CV <= 1 STABLE**	NA	**CV <= 1 STABLE**	NA	**CV <= 1 STABLE**	NA

Comparison of Nitrate to Specific Conductivity

The nitrate-specific conductivity graph in Figure 15 shows the relationship between nitrate concentration and specific conductivity.

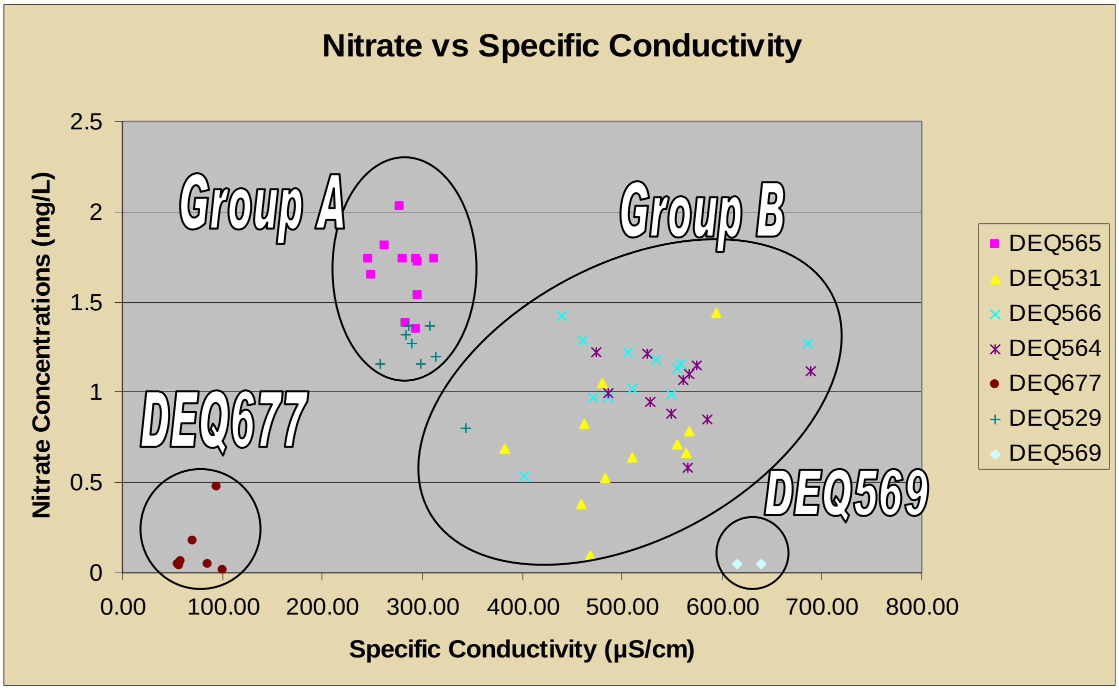

Figure 15. Graph illustrating the relationship between nitrate concentration and specific conductivity in selected wells.

The two non-seasonal-related aquifer recharge sources are discharge from Chilco Lake and log deck runoff. Chilco Lake discharge samples demonstrate a trend of increasing nitrate concentrations (Table 2), however, the concentrations are very low, and do not appear to be a significant source of nitrate to the aquifer. The log deck runoff samples from the ditch along Chilco Road (the DEQ569 sample site) show no detectable nitrate, despite some of the highest specific conductivity measurements in the study area. It appears that any nitrate in ground water or surface water that is applied to the log decks is utilized in the chemical decomposition of tree detritus at the mill, and therefore the nitrate input to the aquifer from log deck runoff is not significant.

Within Group A, the DEQ529 and DEQ565 wells appear to have similar specific conductivity; however, nitrate concentrations in the DEQ565 well are approximately 70% greater than those in the DEQ529 well. The DEQ565 well is located approximately 120 feet down-gradient of a septic drainfield, is at the edge of a horse corral, and is adjacent to a lawn. Nitrate concentrations and overall specific conductivity measured in the DEQ529 well are very consistent, suggesting that contaminant sources may be farther from the well, or may represent overall aquifer concentrations.

Plotted data from the Group B wells exhibit large variability in the nitrate-specific conductivity ratios, suggesting that nearby influences may be present. Nitrate-related land use immediately up-gradient of these wells consists of septic tanks and potentially fertilized lawns. Each house represented in Group B has a septic tank and a lawn, and the LP Mill has four septic tanks. Group B wells, except for the DEQ531 well, appear to be impacted by up-gradient septic systems, as previously described. Sampled water for the Group B wells generally contained lower nitrate concentrations than the DEQ529 well. Based upon the fact that log deck runoff appears to impact the Group B wells, the lower concentrations of nitrate could be attributed to either aquifer dilution or denitrification. Denitrification may be occurring when low nitrate concentrations are observed in reducing conditions (i.e., low dissolved oxygen) in the presence of an electron donor (such as dissolved organic carbon) (Esser, et al., 2009).

Bacteria Results

Tables in Appendix A present the analytical results for bacteria (total **coliform,** fecal coliform, and *E. coli*). During this study, at least one sample from each well has tested positive for total coliform, but no detections of *E. coli* have been identified. Both total coliform and *E. coli* have been detected on more than one occasion in the surface water at the DEQ569, DEQ571, DEQ572, and DEQ677 sampling sites. Known sources of bacteria in the Chilco area include a horse corral, septic tank effluent, and Chilco Lake surface water. Chilco Lake surface water **percolates** into the aquifer via Chilco Lake outfall or log deck runoff. There does not appear to be a trend or seasonality to the occurrences of bacteria in ground water.

Graham and Buchanan (1994) identified one well, CCM13, with total coliform contamination during their study. The CCM13 well is located directly east and across Highway 95 from the DEQ529 well (see Figure 7), approximately 600 feet distant. Graham and Buchanan (1994) suggested that Chilco Lake discharge was the bacterial source of that well due to water chemistry analysis, land use analysis, and ground water flow direction. This study confirmed the westerly ground water flow path direction using ground water information from both summer and winter (Figure 5). Additionally, the DEQ529 well has had the highest frequency of bacterial contamination during this study (Table 3). Therefore, based upon this study, DEQ concurs with Graham and Buchanan (1994) that bacteria contamination to the DEQ529 well appears to be coming from an easterly direction, possibly Chilco Lake.

Conclusions/Summary of Findings

This investigation concurs with Graham and Buchanan's (1994) findings that ground water within the Chilco Channel flows generally from the northeast to the southwest and, within the study area near the eastern margin of the channel, it flows in a westerly direction.

Area soils consist of coarse materials which sit on sands and gravels. As a result, travel time to the aquifer is short, as evidenced by comparing aquifer levels, average daytime temperatures, and precipitation between November 2004 and October 2006. This implies that any contamination can quickly impact the aquifer.

Potential contaminant sources within the study area include the LP Mill, septic systems, road de-icer salts, Chilco Lake, fertilizers, animal waste, well construction, and historic land use.

Both nitrate and chloride concentrations have been consistently increasing within the aquifer since 1993, based upon sample results at the DEQ531 and DEQ565 wells from this study and a study by Graham and Buchanan in 1994. Nitrate and chloride appear to be impacting each well in the study area to varying degrees based upon nitrate/specific conductivity and chloride/specific conductivity plots, and the concentration trends of these constituents.

Analytical results suggest that log deck runoff from the LP Mill may potentially influence the ground water chemistry, but the influence was not quantified in this study. Sample points up-gradient of the LP Mill are needed to distinguish potential impacts from the mill site to the aquifer. Log deck runoff as measured at the DEQ569 site was high in specific conductivity, TDS, and bacteria, but did not contain any detectable concentrations of nitrate.

Samples analyzed for total coliform and *E. coli* do not indicate a trend, although samples from the DEQ529 well contained bacteria more frequently than the other wells. Possible sources of bacteria include up-gradient septic tanks, surface water discharge from Chilco Lake, or both. Chilco Lake drains directly into the aquifer at a point approximately 0.5 miles northeast of the DEQ529 well. Water applied to the log decks from Chilco Lake may be a source of bacteria to the aquifer. Water at the DEQ569 sample site, located just south of the LP Mill, contained total coliform concentrations as high as 24,000 MPN/100mL.

Distance from potential contaminant sources to sample sites appears to have an influence on some sample results.

- The DEQ565 well is located approximately 120 feet down-gradient of a septic tank. Sample results show more variability and higher concentrations of both nitrate and chloride than those from the DEQ529 well, which is located further from any known septic tanks than the DEQ565 well.

- The DEQ531 well, located up-gradient of any known septic tanks and on the western edge of the LP Mill, contained highly variable and elevated concentrations of nitrate and TDS, and highly variable and elevated measurements of specific conductivity, but low concentrations of chloride. The water chemistry variations among samples from the DEQ531 well appear to be due to changes in seasonal flow direction, up-gradient impacts from the LP Mill, and possibly from other nearby historic land uses.

- The samples taken from the DEQ564, DEQ566, and DEQ567 wells contained elevated and highly variable concentrations of both nitrates and chloride, along with elevated and highly variable measurements of specific conductivity. These results may indicate that sources of these contaminants are located close to the sampled sites, possibly from nearby septic systems and/or the LP Mill.

Although bacteria were detected in samples from all wells within the study area, the highest reported number of *E. coli* and total coliform detections were in samples from the DEQ529 well. A crack in the DEQ529 well casing poses a great risk as a contamination pathway. An attempt to fix the problem by regrading the dirt around the casing did not appear to eliminate the problem. Ground water flow direction at this well is westerly, so it appears that ground water contamination in this well is not originating from the mill, but rather from an easterly to northeasterly source, possibly Chilco Lake. A 1993 sample from a well (CCM13) located approximately 600 feet east (and up-gradient) of the DEQ529 well contained bacteria, indicating that a persistent bacteria source has been present before many of the up-gradient residences (and septic tanks) were built.

Recommendations

Based upon the findings of this report, the following actions are recommended:

- Identify the locations of all septic tanks in the area.

- Identify wells that could serve as useful sampling points north (up-gradient) of the LP Mill site, and east of Highway 95 in the vicinity of Chilco Lake's outlet.

- Measure water levels in as many area wells as possible, on a monthly basis, to better define seasonal fluctuations, especially east of Highway 95.

- Delineate the perimeter of the log deck runoff at the LP Mill during each sampling event to determine if changes in recharge area and volume affect down-gradient sample results.

- Effectively repair or properly abandon the DEQ529 well so potential surface-related contamination does not enter the aquifer.

- Extract and analyze DNA samples from bacteria in ground water and surface water to help determine the origins of bacterial contamination.

- Evaluate historic land uses, especially those related to the disposal of waste.

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Glossary

Alluvial
Refers to soil or sediments deposited by a waterway (lake, river, etc.).

Aquifer
A thick, underground layer of rock that contains ground water. The top layer of an aquifer is permeable, allowing water from the surface of the earth to percolate into it. The lower layer of an aquifer, though, is impermeable, preventing the water from traveling any further down into the earth.

Background
The concentration of a substance in water, air, or soil that occurs naturally or is not the result of human activities.

Bedrock
The layer of solid rock that lies beneath the soil and loose rock found on the earth's surface.

Biological (or biochemical) oxygen demand (BOD)
A chemical procedure that measures how fast biological organisms in a sample of water use up oxygen.

Channel
A natural or artificial waterway that always or sometimes contains moving water. A channel has a definite bed and banks that confine the water.

Chloride
Any compound that contains a chlorine atom. A common example is sodium chloride (table salt).

Chemical oxygen demand (COD)
A measure of the oxygen required to oxidize (in other words, chemically add oxygen to) all compounds, both organic and inorganic, in water.

Coliform
Bacteria found in the digestive tracts of mammals. Their presence in water indicates fecal pollution. *E. coli* is one type of coliform bacteria.

Constituents
Specific chemicals that are identified for evaluation in a study.

Contour
A line drawn on a topographic map that connects points of the same height.

Dissolved oxygen (DO)
Oxygen that has dissolved in water and is available for fish and other aquatic animals to use. If the amount of dissolved oxygen in water is too low, aquatic animals will suffocate.

Down-gradient
The direction that groundwater flows; similar to "downstream" for surface water.

Drawdown
The drop in the level of water in the ground when water is being pumped from a well.

E. coli
Short for escherichia coliform, a type of bacteria found in the digestive tracts of warm-blooded animals.

Field parameters
The properties of or constituents (things contained) in collected water samples that are measured or analyzed.

Fluvial
Relating to rivers.

Hyrdaulic conductivity
The rate at which water can move through a permeable medium, such as soil.

Hyrdraulic gradient
In general, the direction of ground water flow due to changes in the depth of the water table.

IDAPA
A numbering designation for all administrative rules in Idaho promulgated in accordance with the Idaho Administrative Procedures act.

Infiltration
The penetration of water through the ground surface into subsurface soil.

Inorganic chemicals
Chemical substances of mineral origin, without carbon in their atomic structure.

Isotopes
A variation of an element that has the same atomic number of protons but a different weight because of the number of neutrons. Various isotopes of the same element may have different radioactive behaviors, and some are highly unstable.

Major ions	Ions are electrically charged atoms or groups of atoms. Major ions refer to the ions commonly found in a medium (in this study, ground water). In this study, major ions are Calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), carbonate (CO_3), bicarbonate (HCO_3), chloride (Cl), and sulfate (SO_4).
Most probable number (MPN)	An estimate of microbial density per unit volume of water sample, based on probability theory.
Nitrate	A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. A plant nutrient and inorganic fertilizer, nitrate is found in septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dumps.
Organic chemicals	Naturally occuring (animal- or plant-produced or synthetic) substances containing mainly carbon, hydrogen, nitrogen, and oxygen.
Paleochannel	An ancient stream bed or channel.
Per mil (‰)	One part per thousand
Percolation	The movement and filtering of water through the soil.
Permeable	A material that is permeable is porous and can transmit water.
Piper trilinear diagram (Piper diagram)	A diagram in which the results of multiple chemical analyses can be shown. Useful for visually depicting the chemistry from multiple water sources.
Point source	A source of pollutants that can be clearly identified, like the end of a pipe.

Potentiometric surface	The surface to which water in an aquifer can rise by hydrostatic pressure.
Public water system	A system for providing water to the public for human consumption through pipes or other constructed conveyances; to qualify as a public water system, the system must have at least 15 service connections or regularly serve an average of at least 25 individuals at least 60 days out of the year.
Recharge	Water that makes it way from the surface or possibly a storage area into the ground water, usually by infiltration through the soil.
Setback	The distance of a structure or other feature (as a well or septic system) from the property line or other feature
Specific conductivity	Rapid method of estimating the dissolved solid content of a water supply by testing its capacity to carry an electrical current.
Substrate	The layer of rock or soil beneath the surface soil.
Total dissolved solids (TDS)	The concentration of material dissolved in water.
Turbidity	A cloudy condition in water due to suspended silt or organic matter.
Unconfined aquifer	An aquifer containing water that is not under pressure. In an unconfined aquifer, the water level in a well is the same as the water table outside the well.
Up-gradient	Against the direction that groundwater flows; similar to “upstream” for surface water.
Vadose zone	Between the land surface and the water table.
Well casing	The tube or pipe placed inside a well to protect the water from contamination and prevent the well from caving in.

Appendix A. Analytical Methods, Field Parameters, and Results

The following abbreviations appear in the tables in this appendix:

BOD – biological (or biochemical) oxygen demand
Ca – calcium
$CaCO_3$ – calcium carbonate
Cl – chloride
COD – chemical oxygen demand
DO – dissolved oxygen
DOC – dissolved organic carbon
Fe – iron
HCO_3 –bicarbonate
K – potassium
Mg – magnesium
mg/L – milligrams per liter
mL – milliliter
Mn – manganese
MPN – most probable number
Na – sodium
TOC – total organic carbon
NO_3 – nitrate
SO_4 – sulfate
TDS – total dissolved solids
‰ – per mil
$\delta^{18}O$ - stable oxygen isotope ratio
$\delta^{2}H$ – stable deuterium isotope ratio
µg/L – micrograms per liter
µS/cm – microsiemens per centimeter

Table 3. Temperature, pH, Specific Conducitivity, Dissolved Oxygen, Total Coliform, *E. Coli*, Fecal Coliform, δ18O, and δ2H results

Sampling Location	Date	Temp (^{o}C)	pH	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Total Coliform (MPN/ 100mL)	*E. Coli* (MPN/ 100mL)	Fecal Coliform (MPN/100mL)	$\delta^{18}O$ (‰)	$\delta^{2}H$ (‰)
DEQ567	Sep-06					<2	<2			
DEQ567	Oct-06	9.4	7.35	537	7.56	2	2		-14.7	-109
DEQ567	Dec-06	8.8	7.73	507		<1	<1		-14.6	-111
DEQ567	Mar-07	8.7	7.69	488	6.89	<1	<1		-14.5	-108
DEQ567	Apr-07	8.8	6.96	511	7.19	<1	<1		-14.7	-108
DEQ567	Jul-07								-14.5	-107
DEQ567	Sep-07	9.5	7.03	467	5.66					
DEQ567	Jan-08	8.7	6.84	470	7.4					
DEQ565	Sep-06	9.4	8.17	284	10.8	<2	<2		-14.7	-108
DEQ565	Oct-06	8.9	7.71	294	3.72	<2	<2		-14.7	-109
DEQ565	Dec-06	8.6	7.92	278		<1	<1		-14.5	-112
DEQ565	Mar-07	8.7	7.83	234	8.78	<1	<1		-14.1	-105
DEQ565	Apr-07	8.5	7.16	263	8.63	<1	<1		-14.5	-106
DEQ565	Jul-07	8.8	7.28	296	13.01				-14.6	-109
DEQ565	Sep-07	9.2	7.46	246	9.9	<1	<1			
DEQ565	Apr-08	8.6	7.14	296	9.55	5	<1		-14.2	-108
DEQ565	Jul-08	9.1	7.48	249	11.13	<1	<1		-14.7	-112
DEQ565	Nov-08	8.6	7.79	312	12.32	<1	<1			
DEQ565	Feb-09	8	7.19	281	12.55	<1	<1		-14.5	-106
DEQ531	Sep-06	8.9	7.95	468	0.11	<2	<2		-13.3	-104
DEQ531	Dec-06	9.1	7.75	511		<1	<1		-13.8	-106

Sampling Location	Date	Temp (^{o}C)	pH	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Total Coliform (MPN/ 100mL)	*E. Coli* (MPN/ 100mL)	Fecal Coliform (MPN/100mL)	$\delta^{18}O$ (‰)	$\delta^{2}H$ (‰)
DEQ531	Mar-07	9.2	7.53	465	3.23	<1	<1		-14.7	-108
DEQ531	Apr-07	8.9	6.81	463	4.24	<1	<1		-14.9	-108
DEQ531	Jul-07	8.8	6.94	483	4.18	<1	<1		-14.2	-106
DEQ531	Sep-07	9.1	6.88	460	0.09	9.8	<1			
DEQ531	Jan-08	8.9	6.84	565	2.8	<1	<1			
DEQ531	Apr-08	8.9	6.91	595	8.1	<1	<1		-14.8	-111
DEQ531	Jul-08	9.6	7.88	383	9.51	<1	<1		-14.8	-112
DEQ531	Nov-08	8.8	7.54	556	6.83	<1	<1			
DEQ531	Feb-09	8.2	6.83	567	8.09	<1	<1		-14.4	-108
DEQ531	May-09	8.9	6.22	480	0.55	<1	<1		-14.8	-109
DEQ532	Sep-06	10.3	7.55	428	10.3	<2	<2		-14.5	-110
DEQ566	Sep-06	10.2	9.03	510	3.19	13	<2		-14.4	-107
DEQ566	Sep-06					2	<2			
DEQ566	Oct-06	13.6	7.71	403	2.36	<2	<2		-14.3	-107
DEQ566	Dec-06	12	7.67	526		<1	<1		-14.3	-110
DEQ566	Mar-07	8.9	7.56	486	3.31	<1	<1		-14.5	-107
DEQ566	Apr-07	8.8	6.79	535	4.72	<1	<1		-14.5	-107
DEQ566	Jul-07	11.2	6.8	549	12.62	<1	<1		-14.3	-106
DEQ566	Sep-07	9.5	7.16	440	3.3	<1	<1			
DEQ566	Jan-08	8.8	6.74	472	5.03	<1	<1			
DEQ566	Apr-08	8.2	6.9	686	7.3	<1	<1		-14.6	-110
DEQ566	Jul-08	10.3	8.09	461	5.21	<1	<1		-14.6	-112
DEQ566	Nov-08	9.4	7.39	559	5.39	1	<1			

Sampling Location	Date	Temp (°C)	pH	Specific Conductivity (μS/cm)	Dissolved Oxygen (mg/L)	Total Coliform (MPN/ 100mL)	*E. Coli* (MPN/ 100mL)	Fecal Coliform (MPN/100mL)	$\delta^{18}O$ (‰)	$\delta^{2}H$ (‰)
DEQ566	Feb-09	8.1	6.73	506	6.82	<1	<1		-14.8	-108
DEQ566	May-09	9	5.92	555	0.55				-14.7	-110
DEQ564	Sep-06	9.7	7.61	529	2.48	4	<2		-14.3	-109
DEQ564	Oct-06	9.8	7	566	1.26	4	<2		-14.1	-107
DEQ564	Dec-06	8.9	7.57	550		<1	<1		-14.3	-110
DEQ564	Mar-07	8.7	7.53	518	2.2	1	<1		-14.6	-108
DEQ564	Apr-07	8.7	6.88	561	3.23	<1	<1		-14.5	-106
DEQ564	Jul-07	9.8	6.84	586	6.37	<1	<1		-14.2	-108
DEQ564	Jan-08	8.7	6.55	486	3.2	<1	<1			
DEQ564	Apr-08	8.5	6.83	689	7.51	<1	<1		-14.6	-109
DEQ564	Jul-08	10	8.13	474	6.79	<1	<1		-14.5	-111
DEQ564	Nov-08	9.3	7.42	575	4.37	<1	<1			
DEQ564	Feb-09	7.9	6.87	525	5.22	<1	<1		-14.7	-109
DEQ564	May-09	9	5.97	575	0.55	<1	<1		-14.8	-108
DEQ677	Sep-06	19.8	10.71	86	11.39	110	<2		-9.9	-90
DEQ677	Oct-06	11.5	7.33	237	11.25	11	2		-13.9	-106
DEQ677	Dec-06					1100	2		-12.1	-98
DEQ677	Mar-07	5.5	6.53	100	2.6	575	<1		-13.6	-100
DEQ677	Apr-07					73.3	13.4		-13.9	-102
DEQ677	Jul-07	12.4	9.3	71	11.75	3653.5	4.1		-11.8	-93
DEQ677	Sep-07					46.1	2			
DEQ677	Jan-08					150				
DEQ677	Apr-08	7.7	6.36	57	14.5	150	38		-15.3	114

Sampling Location	Date	Temp (°C)	pH	Specific Conductivity (μS/cm)	Dissolved Oxygen (mg/L)	Total Coliform (MPN/ 100mL)	*E. Coli* (MPN/ 100mL)	Fecal Coliform (MPN/100mL)	$\delta^{18}O$ (‰)	$\delta^{2}H$ (‰)
DEQ677	Jul-08	17	8.39	59	9.16	2400	200		-12.8	-102
DEQ677	Nov-08	4.8	8.13	94	13.56	1700	2			
DEQ677	Feb-09					290	4		-13.8	-105
DEQ677	May-09	8.1	7.05	56	0.57	870	440		-15.5	-114
DEQ529	Sep-06	9	6.7	313	6.23	2	<2		-14.3	-106
DEQ529	Mar-07						<1			
DEQ529	Apr-07	8.5	6.58	258	7.53	<1	<1		-14.2	-104
DEQ529	Jul-07	9	6.61	290	7.43	<1	<1			
DEQ529	Jan-08	8.9	6.35	283	7.24	3	<1			
DEQ529	Apr-08	8.5	6.69	344	8.1	2	<1		-14.7	-109
DEQ529	Jul-08	9.2	7.94	287	0.616	<1	<1		-14.4	-110
DEQ529	Nov-08	8.8	7.26	298	10.2	2	<1			
DEQ529	Feb-09	8.6	6.61	307	8.65	<1	<1		-14.4	-107
DEQ529	May-09					15	<1			
DEQ571	Apr-07	11	7.8	240	6.92	365.4			-12.2	-94
DEQ572	Sep-06						<2			
DEQ572	Dec-06					250			-14.3	-109
DEQ572	Mar-07	4	5.99	42	15.51	331	<1		-14.3	-104
DEQ572	Apr-07					>1600	4	8	-13.4	-98
DEQ572	Jul-07					155310	16.9		-9.1	-86
DEQ572	Sep-07									
DEQ572	Apr-08	10	7.78	47	11.08	16	<1		-15.1	-111
DEQ569	Sep-06	18.9	8.06	615	1.85	170	13		-12.6	-102

Sampling Location	Date	Temp (°C)	pH	Specific Conductivity (μS/cm)	Dissolved Oxygen (mg/L)	Total Coliform (MPN/ 100mL)	*E. Coli* (MPN/ 100mL)	Fecal Coliform (MPN/100mL)	$\delta^{18}O$ (‰)	$\delta^{2}H$ (‰)
DEQ569	Oct-06	13.2	8.27	640	2.63	1600	<2		-12.2	-98
DEQ569	Dec-06					2400	6		-14.7	-108
DEQ569	Mar-07	9.8	7.82	409	4.68	24000	<1		-16.5	-119
DEQ569	Apr-07					2419	<1		-12.8	-97
DEQ569	Jul-07					9043	20.3		-4.4	-69
DEQ569	Sep-07									
DEQ570	Oct-06	8.9	7.23	246	12.37	23			-13.9	-106
DEQ570	Dec-06					3			-13.9	-108
DEQ570	Mar-07					3.1	<1		-14	-104
DEQ570	Apr-07								-14.3	-105
DEQ570	Jul-07								-14	-106
DEQ570	Sep-07									
DEQ528	Sep-06	7.3	8.87	229	11.63	<2	<2		-15.3	-113
DEQ528	Oct-06	7.3	8.87	229	11.63	<2	<2			

Table 4. Tannins/Lignins, Terpenes, Total Phenolics, Limonene, alphapinene, betapinene, 3-carene, and benzoic acid results

Sampling Location	Date	Tannins/Lignins (mg/L)	Terpenes (µg/L)	Total Phenolics (mg/L)	Limonene (µg/L)	alphapinene (µg/L)	betapinene (µg/L)	3-carene (µg/L)	benzoic acid (µg/l)
DEQ567	Sep-06								
DEQ567	Oct-06	<0.1	0	<0.005					
DEQ567	Dec-06								
DEQ567	Mar-07	<0.5		<0.05	<0.5	<0.5	<0.5	<0.5	
DEQ567	Apr-07	<0.5	0	<0.01	<0.5	<0.5	<0.5	<0.5	
DEQ567	Jul-07	<0.5		<0.01					
DEQ567	Sep-07	<0.5		0.0196	<0.1	<0.1	<0.1	<0.1	<0.1
DEQ567	Jan-08	<0.5							
DEQ567	Feb-09								
DEQ565	Sep-06	<0.1	0	<0.01	<0.1	<0.1	<0.1	<0.1	
DEQ565	Oct-06								
DEQ565	Dec-06								
DEQ565	Mar-07	0	0	0					
DEQ565	Apr-07								
DEQ565	Jul-07	<0.5		<0.01					
DEQ565	Sep-07								
DEQ565	Apr-08	<0.1		<0.01					
DEQ565	Jul-08	0.9							
DEQ565	Nov-08								
DEQ565	Feb-09								
DEQ565	May-09								
DEQ531	Sep-06	<0.1	0	<0.01	<0.1	<0.1	<0.1	<0.1	

Sampling Location	Date	Tannins/Lignins (mg/L)	Terpenes (µg/L)	Total Phenolics (mg/L)	Limonene (µg/L)	alphapinene (µg/L)	betapinene (µg/L)	3-carene (µg/L)	benzoic acid (µg/l)
DEQ531	Dec-06								
DEQ531	Mar-07								
DEQ531	Apr-07	<0.5	0	<0.01	<0.5	<0.5	<0.5	<0.5	
DEQ531	Jul-07	<0.5		<0.01					
DEQ531	Sep-07	<0.5		0.0147	<0.1	<0.1	<0.1	<0.1	<0.1
DEQ531	Jan-08	<0.5							
DEQ531	Apr-08	<0.1		<0.01					
DEQ531	Jul-08	<0.1		<0.1					
DEQ531	Nov-08	0.9							
DEQ531	Feb-09	<0.1							
DEQ531	May-09								
DEQ532	Sep-06	<0.1	0	<0.01	<0.1	<0.1	<0.1	<0.1	
DEQ566	Sep-06	0	0	0					
DEQ566	Sep-06								
DEQ566	Oct-06								
DEQ566	Dec-06								
DEQ566	Mar-07								
DEQ566	Apr-07	<0.5	0	<0.01	<0.5	<0.5	<0.5	<0.5	
DEQ566	Jul-07	<0.5		<0.01					
DEQ566	Sep-07	<0.5		0.0196	<0.1	<0.1	<0.1	<0.1	<0.1
DEQ566	Jan-08	<0.5							
DEQ566	Apr-08	<0.1		<0.01					
DEQ566	Jul-08	1.1		<0.1					

Sampling Location	Date	Tannins/Lignins (mg/L)	Terpenes (µg/L)	Total Phenolics (mg/L)	Limonene (µg/L)	alphapinene (µg/L)	betapinene (µg/L)	3-carene (µg/L)	benzoic acid (µg/l)
DEQ566	Nov-08	1							
DEQ566	Feb-09	<0.1							
DEQ566	May-09								
DEQ564	Sep-06	<0.1	0	<0.01	<0.1	<0.1	<0.1	<0.1	
DEQ564	Oct-06								
DEQ564	Dec-06								
DEQ564	Mar-07								
DEQ564	Apr-07								
DEQ564	Jul-07	<0.5		<0.01					
DEQ564	Jan-08	<0.5							
DEQ564	Apr-08	<0.1		<0.01					
DEQ564	Jul-08	1		<0.1					
DEQ564	Nov-08	1							
DEQ564	Feb-09	<0.1							
DEQ564	May-09								
DEQ677	Sep-06	0	0	0	<0.1	<0.1	<0.1	<0.1	
DEQ677	Oct-06								
DEQ677	Dec-06								
DEQ677	Mar-07	<0.5		<0.05	<0.5	<0.5	<0.5	<0.5	
DEQ677	Apr-07								
DEQ677	Jul-07	<0.5		<0.01					
DEQ677	Sep-07								
DEQ677	Jan-08								

Sampling Location	Date	Tannins/Lignins (mg/L)	Terpenes (µg/L)	Total Phenolics (mg/L)	Limonene (µg/L)	alphapinene (µg/L)	betapinene (µg/L)	3-carene (µg/L)	benzoic acid (µg/l)
DEQ677	Apr-08	<0.1		<0.01					
DEQ677	Jul-08	0.8							
DEQ677	Nov-08								
DEQ677	Feb-09	<0.1							
DEQ677	May-09								
DEQ529	Sep-06	0	0	0					
DEQ529	Mar-07								
DEQ529	Apr-07	<0.5	0	<0.01	<0.5	<0.5	<0.5	<0.5	
DEQ529	Jul-07	<0.5		<0.01					
DEQ529	Jan-08	<0.5							
DEQ529	Apr-08	<0.1		<0.01					
DEQ529	Jul-08	0.8							
DEQ529	Nov-08	1							
DEQ529	Feb-09	<0.1							
DEQ529	May-09								
DEQ571	Apr-07	0.59	0	<0.01	<0.5	<0.5	<0.5	<0.5	
DEQ572	Sep-06								
DEQ572	Dec-06	<0.1	0	<0.02	<0.1	<0.1	<0.1	<0.1	
DEQ572	Mar-07	<0.5		<0.05	<0.5	<0.5	<0.5	<0.5	
DEQ572	Apr-07	12.5	0	<0.01	<0.5	<0.5	<0.5	<0.5	
DEQ572	Jul-07	<0.5		<0.01					
DEQ572	Sep-07								
DEQ572	Apr-08	<0.1		<0.01					

Sampling Location	**Date**	**Tannins/Lignins (mg/L)**	**Terpenes (µg/L)**	**Total Phenolics (mg/L)**	**Limonene (µg/L)**	**alphapinene (µg/L)**	**betapinene (µg/L)**	**3-carene (µg/L)**	**benzoic acid (µg/l)**
DEQ569	Sep-06					<0.1	<0.1	<0.1	<0.1
DEQ569	Oct-06	2	0		0.006				
DEQ569	Dec-06								
DEQ569	Mar-07	8.7	2.8	0.06	1.26	<0.5	0.5	1.04	
DEQ569	Apr-07								
DEQ569	Jul-07	1.91		<0.01					
DEQ569	Sep-07	20		0.0491	<0.1	<0.1	<0.1	<0.1	<0.1
DEQ570	Oct-06	<0.1		0.006					
DEQ570	Dec-06	0	0.006						
DEQ570	Mar-07								
DEQ570	Apr-07								
DEQ570	Jul-07	<0.5		<0.01					
DEQ570	Sep-07	<0.5		<0.01	<0.1	<0.1	<0.1	<0.1	<0.1
DEQ528	Sep-06	<0.1	0	<0.01	<0.1	<0.1	<0.1	<0.1	
DEQ528	Oct-06	<0.1		nd	nd	nd	nd	nd	

Table 5. Chloride (Cl), Nitrate (NO_2+NO_3-N), Sulfate (SO_4), Total Dissolved Solids (TDS), Calcium (Ca), Chemical Oxygen Demand (COD), and Dissolved Organic Carbon (DOC) results.

Sampling Location	Date	Cl (mg/L)	NO_2+NO_3-N (mg/L)	SO_4 (mg/L)	TDS (mg/L)	BOD (mg/L)	Ca (mg/L)	COD (mg/L)	DOC (mg/L)
DEQ567	Sep-06								
DEQ567	Oct-06	10.20	0.81	7.69	294	<2.0	90.9	<5	
DEQ567	Dec-06	9.57	1.20	7.33	334				
DEQ567	Mar-07	10.30	1.51	7.53	336				
DEQ567	Apr-07	10.80	1.30	7.40	310				
DEQ567	Jul-07	11.70	1.15	7.55	324				
DEQ567	Sep-07	11.00	1.51	7.20	330				
DEQ567	Jan-08	11.20	1.27	7.91	306				
DEQ567	Feb-09								
DEQ565	Sep-06	8.44	1.38	5.65		<2.0	48.1	<5	<1
DEQ565	Oct-06		1.35		148				
DEQ565	Dec-06	7.08	1.56	5.42	188				
DEQ565	Mar-07	8.62	2.03	5.98	176				
DEQ565	Apr-07	10.20	1.81	5.66	165				
DEQ565	Jul-07	9.93	1.54	5.52	184				
DEQ565	Sep-07	7.99	1.74	5.03	182				
DEQ565	Apr-08	11.30	1.72	7.04	154				
DEQ565	Jul-08	13.60	1.65	6.01	232				
DEQ565	Nov-08	11.00	1.74	6.70	156				
DEQ565	Feb-09	9.09	1.74	6.03	164				
DEQ565	May-09	17.20	1.74	5.83	184		43.8		
DEQ531	Sep-06	3.84	0.10	3.83		<2.0	88.5	8	3.2

Sampling Location	Date	Cl (mg/L)	NO_2+NO_3-N (mg/L)	SO_4 (mg/L)	TDS (mg/L)	BOD (mg/L)	Ca (mg/L)	COD (mg/L)	DOC (mg/L)
DEQ531	Dec-06	8.26	0.07	4.76	342				
DEQ531	Mar-07	4.94	0.64	7.23	314				
DEQ531	Apr-07	4.91	0.83	6.30	290				
DEQ531	Jul-07	4.28	0.53	4.94	282				
DEQ531	Sep-07	5.80	0.38	3.55	336				
DEQ531	Jan-08	5.23	0.66	8.78	336				
DEQ531	Apr-08	4.70	1.44	10.00	324				
DEQ531	Jul-08	5.67	0.69	5.99	184				
DEQ531	Nov-08	8.50	0.67	7.02	296				
DEQ531	Feb-09	8.76	0.78	9.52	316				
DEQ531	May-09	6.67	1.05	7.09	288		86.3		
DEQ532	Sep-06	3.60	0.43	5.44	276	<2.0	77.3	11	1.4
DEQ566	Sep-06	10.80	1.02	7.39	352	<2.0	93.2	8	1.4
DEQ566	Sep-06								
DEQ566	Oct-06		0.53						
DEQ566	Dec-06	10.80	0.46	7.34	368				
DEQ566	Mar-07	11.70	0.97	7.73	336				
DEQ566	Apr-07	15.50	1.18	8.35	336				
DEQ566	Jul-07	11.60	0.99	7.46	318				
DEQ566	Sep-07	10.00	1.42	7.12	292				
DEQ566	Jan-08	11.90	0.97	8.53	266				
DEQ566	Apr-08	16.60	1.27	10.20	348				
DEQ566	Jul-08	13.50	1.29	9.15	280				

Sampling Location	Date	Cl (mg/L)	NO_2+NO_3-N (mg/L)	SO_4 (mg/L)	TDS (mg/L)	BOD (mg/L)	Ca (mg/L)	COD (mg/L)	DOC (mg/L)
DEQ566	Nov-08	13.40	1.16	9.76	308				
DEQ566	Feb-09	14.20	1.21	8.87	290				
DEQ566	May-09	18.00	1.13	8.86	348		97.7		
DEQ564	Sep-06	13.10	0.95	7.80		<2.0	99.1	<5.0	1
DEQ564	Oct-06		0.58		296				
DEQ564	Dec-06	14.80	0.68	8.10	350				
DEQ564	Mar-07	16.80	0.88	8.64	332				
DEQ564	Apr-07	19.00	1.07	9.24	355				
DEQ564	Jul-07	13.40	0.85	8.08	310				
DEQ564	Jan-08	12.90	0.99	9.70	334				
DEQ564	Apr-08	17.10	1.12	13.20	346				
DEQ564	Jul-08	13.70	1.22	10.20	348				
DEQ564	Nov-08	13.20	1.15	9.55	332				
DEQ564	Feb-09	14.50	1.21	9.68	310				
DEQ564	May-09	17.30	1.10	9.69	380		1.71		
DEQ677	Sep-06	2.97	<0.05	1.05	120	2.8	9.96	33	9.9
DEQ677	Oct-06	6.92	1.11	4.64					
DEQ677	Dec-06	2.62	0.16	3.10	108				
DEQ677	Mar-07	3.76	0.02	1.12	84				
DEQ677	Apr-07	2.61	0.02	1.71	54				
DEQ677	Jul-07	2.11	<0.020	1.12	58				
DEQ677	Sep-07	1.90	0.18	0.51	54				
DEQ677	Jan-08								

Sampling Location	Date	Cl (mg/L)	NO_2+NO_3-N (mg/L)	SO_4 (mg/L)	TDS (mg/L)	BOD (mg/L)	Ca (mg/L)	COD (mg/L)	DOC (mg/L)
DEQ677	Apr-08	8.03	0.04	2.08	72				
DEQ677	Jul-08	1.79	0.06	0.90	112				
DEQ677	Nov-08	5.18	0.48	2.76	72				
DEQ677	Feb-09	2.17	0.18	1.60	56				
DEQ677	May-09	5.40	0.05	0.66	66		5.34		
DEQ529	Sep-06	8.64	1.20	5.18	230	<2.0	52.8	8	1.3
DEQ529	Mar-07								
DEQ529	Apr-07	11.00	1.16	4.86	173				
DEQ529	Jul-07	9.04	1.27	5.17	184				
DEQ529	Jan-08	9.20	1.32	5.85	136				
DEQ529	Apr-08	11.70	0.81	6.67	162				
DEQ529	Jul-08	12.20	1.37	5.68	152				
DEQ529	Nov-08	9.94	1.16	5.88	174				
DEQ529	Feb-09	11.70	1.37	6.01	178				
DEQ529	May-09	14.70	1.00	5.30	180		45.8		
DEQ571	Apr-07	0.97	0.02	40.10	158				
DEQ572	Sep-06								
DEQ572	Dec-06	0.47	1.36	4.65	80				
DEQ572	Mar-07	0.45	1.26	3.84	62				
DEQ572	Apr-07	2.35	0.76	4.21	188				
DEQ572	Jul-07	2.39	0.16	5.34	560				
DEQ572	Sep-07	2.36	0.17	3.07	2670				
DEQ572	Apr-08	0.50	<0.02	2.04	64				

Sampling Location	Date	Cl (mg/L)	NO_2+NO_3-N (mg/L)	SO_4 (mg/L)	TDS (mg/L)	BOD (mg/L)	Ca (mg/L)	COD (mg/L)	DOC (mg/L)
DEQ569	Sep-06	9.25	<0.05	<0.3	476	17.8	92.9	171	
DEQ569	Oct-06		<0.05						
DEQ569	Dec-06	284.00	0.05	1.82	402				
DEQ569	Mar-07	87.70	0.02	3.15	342				
DEQ569	Apr-07	10.40	0.02	2.74	313				
DEQ569	Jul-07	16.20	<0.02	<0.3	344				
DEQ569	Sep-07								
DEQ570	Oct-06	6.88	1.10	4.62	143	<2	37.2	<5	
DEQ570	Dec-06	7.30	1.42	4.87	170				
DEQ570	Mar-07	6.01	0.52	3.02	108				
DEQ570	Apr-07	9.89	1.67	4.94	141				
DEQ570	Jul-07	7.04	1.29	4.32	126				
DEQ570	Sep-07	6.71	1.42	4.28	148				
DEQ528	Sep-06	6.08	0.56	4.49		<2.0	38.5	<5.0	<1.0
DEQ528	Oct-06	6.08	0.56	4.49		<2.0	38.5	<5.0	<1.0

Table 6. Total organic carbon (TOC), Total iron (Fe), Bicarbonate (HCO_3), Potassium (K), Magnesium (Mg), Total Manganese (Mn), Sodium (Na), Fluoride, and Carbonate Results.

Sampling Location	Date	TOC (mg/L)	Total Fe (mg/L)	Bicarbonate HCO3 (mg/L CaCO3)	K (mg/L)	Mg (mg/L)	Total Mn (mg/L)	Na (mg/L)	Fluoride (mg/L)	Carbonate (mg/L)
DEQ567	Sep-06									
DEQ567	Oct-06	<1.0	0.9	232	4.27	13.7	0.084	3.54		
DEQ567	Dec-06									
DEQ567	Mar-07									
DEQ567	Apr-07									
DEQ567	Jul-07									
DEQ567	Sep-07									
DEQ567	Jan-08									
DEQ567	Feb-09									
DEQ565	Sep-06	<1		121	2.69	7.7		3.4		
DEQ565	Oct-06		<0.06				<0.004			
DEQ565	Dec-06									
DEQ565	Mar-07									
DEQ565	Apr-07									
DEQ565	Jul-07									
DEQ565	Sep-07									
DEQ565	Apr-08								<0.1	
DEQ565	Jul-08								<0.1	
DEQ565	Nov-08								<0.1	
DEQ565	Feb-09								0.449	

Sampling Location	Date	TOC (mg/L)	Total Fe (mg/L)	Bicarbonate HCO3 (mg/L CaCO3)	K (mg/L)	Mg (mg/L)	Total Mn (mg/L)	Na (mg/L)	Fluoride (mg/L)	Carbonate (mg/L)
DEQ565	May-09			121	2.47	7.24		3.14		<1
DEQ531	Sep-06	3.1		238	3.23	10.6		3.23		
DEQ531	Dec-06									
DEQ531	Mar-07									
DEQ531	Apr-07									
DEQ531	Jul-07									
DEQ531	Sep-07									
DEQ531	Jan-08									
DEQ531	Apr-08								<0.1	
DEQ531	Jul-08								<0.1	
DEQ531	Nov-08								<0.1	
DEQ531	Feb-09								<0.1	
DEQ531	May-09			255	3.85	10.5		3.37		<1
DEQ532	Sep-06	1		215	2.95	10.6		3.15		
DEQ566	Sep-06	1		235	4.04	12.5		3.6		
DEQ566	Sep-06									
DEQ566	Oct-06		0.06				0.01			
DEQ566	Dec-06									
DEQ566	Mar-07									
DEQ566	Apr-07									
DEQ566	Jul-07									
DEQ566	Sep-07									

Sampling Location	Date	TOC (mg/L)	Total Fe (mg/L)	Bicarbonate HCO3 (mg/L CaCO3)	K (mg/L)	Mg (mg/L)	Total Mn (mg/L)	Na (mg/L)	Fluoride (mg/L)	Carbonate (mg/L)
DEQ566	Jan-08									
DEQ566	Apr-08								<0.1	
DEQ566	Jul-08								<0.1	
DEQ566	Nov-08								<0.1	
DEQ566	Feb-09								0.236	
DEQ566	May-09			280	4.36	13.5		4.98		<1.0
DEQ564	Sep-06	1		250	4.15	13.1		3.69		
DEQ564	Oct-06		0.11				<0.004			
DEQ564	Dec-06									
DEQ564	Mar-07									
DEQ564	Apr-07									
DEQ564	Jul-07									
DEQ564	Jan-08									
DEQ564	Apr-08								<0.1	
DEQ564	Jul-08								<0.1	
DEQ564	Nov-08								<0.1	
DEQ564	Feb-09								<0.1	
DEQ564	May-09			290	0.84	0.299		136		<1.0
DEQ677	Sep-06	8.6		31.5	2.67	2.19		3.05		
DEQ677	Oct-06		<0.06				<0.004			
DEQ677	Dec-06									
DEQ677	Mar-07									

Sampling Location	Date	TOC (mg/L)	Total Fe (mg/L)	Bicarbonate HCO3 (mg/L CaCO3)	K (mg/L)	Mg (mg/L)	Total Mn (mg/L)	Na (mg/L)	Fluoride (mg/L)	Carbonate (mg/L)
DEQ677	Apr-07									
DEQ677	Jul-07									
DEQ677	Sep-07									
DEQ677	Jan-08									
DEQ677	Apr-08								<0.1	
DEQ677	Jul-08								<0.1	
DEQ677	Nov-08								<0.1	
DEQ677	Feb-09								<0.1	
DEQ677	May-09			19.3	1.34	1.87		2.34		<1.0
DEQ529	Sep-06	1.2		140	3.25	7.85		3.78		
DEQ529	Mar-07									
DEQ529	Apr-07									
DEQ529	Jul-07									
DEQ529	Jan-08									
DEQ529	Apr-08								<0.1	
DEQ529	Jul-08								0.328	
DEQ529	Nov-08								<0.1	
DEQ529	Feb-09								<0.1	
DEQ529	May-09			134	3.03	7.17		3.54		<1.0
DEQ571	Apr-07									
DEQ572	Sep-06									
DEQ572	Dec-06									

Sampling Location	Date	TOC (mg/L)	Total Fe (mg/L)	Bicarbonate HCO3 (mg/L CaCO3)	K (mg/L)	Mg (mg/L)	Total Mn (mg/L)	Na (mg/L)	Fluoride (mg/L)	Carbonate (mg/L)
DEQ572	Mar-07									
DEQ572	Apr-07									
DEQ572	Jul-07									
DEQ572	Sep-07									
DEQ572	Apr-08								<0.1	
DEQ569	Sep-06	38.1		308	28.1	10.7		4.01		
DEQ569	Oct-06		2				3.39			
DEQ569	Dec-06									
DEQ569	Mar-07									
DEQ569	Apr-07									
DEQ569	Jul-07									
DEQ569	Sep-07									
DEQ570	Oct-06	<1.0	<0.06	98.7	2.56	6.18	<0.004	3.34		
DEQ570	Dec-06									
DEQ570	Mar-07									
DEQ570	Apr-07									
DEQ570	Jul-07									
DEQ570	Sep-07									
DEQ528	Sep-06	<1.0		102	2.29	6.48		3.35		
DEQ528	Oct-06	<1.0		124.36	2.29	6.48		3.35		

Appendix B. Available Well Drillers' Logs

Form 238-7
7/98
Starships Consulting and Management Services

IDAHO DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

Office Use Only
Inspected by____
Twp____ Rge____ Sec____
____1/4____1/4____1/4
Lat: : : Long: : :

1. WELL TAG NO. D0041132
Drilling Permit No: 837457
Other IDWR No. 95-9217

2. OWNER **Well Number:** 1087
Name NO KOOTENAI WATER DISTRICT
Address PO BOX 2290
City HAYDEN State ID Zip 83835

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

Twp. 52 ☑ North or ☐ South
Rge. 03 ☐ East or ☑ West
Sec. 18 NW 1/4 NW 1/4 SE 1/4
Gov't Lot County KOOTENAI
Lat: : : Long: : :
Address of Well Site WILLIAM ROAD
City HAYDEN
(Give at least name of road + Distance to Road or Landmark)
Lt. Blk. Sub. Name

4. USE:
☐ Domestic ☑ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other

5. TYPE OF WORK check all that apply (Replacement, etc.)
☑ New Well ☐ Modify ☐ Abandonment ☐ Other

6. DRILL METHOD
☑ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
3/8 HOLE PLUG	0	20	750 LBS	TEMP CASING
	20	60	2,500 LBS	TEMP CASING

Was drive shoe used? ☐ Y ☑ N Shoe Depth(s) RB
Was drive shoe seal tested? ☐ Y ☑ N How?

8. CASING/LINER:

Diameter	From	To	Gauge	Materi	Casing	Liner	Welded	Threaded
8	+2	215	.322	STEEL	☑	☐	☑	☐

Length of Headpipe 5' Length of Tailpipe 5'

9. PERFORATIONS/SCREENS
☐ Perforations Method
☑ Screens Screen Type JOHNSON STAINLESS

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
215	225	25		7	S/S	☐	☐

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
138 ft. below ground Artesian pressure lb.
Depth flow encountered ft. Describe access port or control devices: WELD ON CAP

52N 3W 18

11. WELL TESTS:
☐ Pump ☐ Bailer ☑ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
APPROX 50			5 HR

Water Temp. COLD Bottom Hole Temp COLD
Water Quality test or comments: CLEAR
Depth first Water encountered 180

12. LITHOLOGIC LOG:(Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
14	0	3	TOP SOIL		✓
14	3	24	SAND, GRAVELS & BOULDERS		✓
14	24	60	SAND & GRAVELS		✓
10	60	109	SAND & GRAVELS		✓
10	109	200	GRAVELS WITH CLAY		✓
10	200	204	BASALT GRAVEL WITH CLAY	✓	
10	204	212	BASALT		✓
10	212	231	BASALT, GRAVEL WITH CLAY	✓	
10	231	245	CLAY GRAY		

RECEIVED
DEC 12 2005
IDWR/North

Completed Depth 230 (Measurable)
Date: Started 11/21/2005 Completed 11/30/2005

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H20 WellService, Inc. Firm No. 448
Firm Official [signature] Date 12-05-05
and
Supervisor or Operator [signature] Date 12/02/05
TODD MORGAN (Sign Once if Firm Official and Operator)

Figure 16. Original well log for DEQ528 well

Form 238-7
7/98
Starships Consulting and Management Services

8/11/00 db

8/3/00 db

IDAHO DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

RECEIVED JUL 31 2000 IDWR/North

Office Use Only
Inspected by ____
Twp ____ Rge ____ Sec ____
____ 1/4 ____ 1/4 ____ 1/4
Lat: : : Long: : :

1. WELL TAG NO. D0013463
Drilling Permit No:
Other IDWR No. 765635

2. OWNER — Well Number: 69
Name North Kootenai Water District
Address PO Box 2290
City Hayden State ID Zip 83835

POSTED

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

Twp. 52 ☑ North or ☐ South
Rge. 03 ☐ East or ☑ West
Sec. 07 ____ 1/4 SE 1/4 NE 1/4
Gov't Lot ____ County KOOTENAI
Lat: : : Long: : :
Address of Well Site Chilco Estates
City Athol
(Give at least name of road + Distance to Road or Landmark)
Lt. ____ Blk. ____ Sub. Name ____

4. USE:
☐ Domestic ☒ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ____

5. TYPE OF WORK check all that apply (Replacement, etc.)
☐ New Well ☐ Modify ☐ Abandonment ☒ Other Repair

6. DRILL METHOD
☐ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD

Was drive shoe used? ☐ Y ☐ N Shoe Depth(s) ____
Was drive shoe seal tested? ☐ Y ☐ N How? ____

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded

Length of Headpipe ____ Length of Tailpipe ____

9. PERFORATIONS/SCREENS
☑ Perforations Method Air Perforator
☐ Screens Screen Type ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
135	145	1/8x4	100	12	steel	☑	☐

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
67 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____

52N 3W 7

11. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
100+			3 hours

Water Temp. cold Bottom Hole Temp cold
Water Quality test or comments: clear
Depth first Water encountered X

12. LITHOLOGIC LOG:(Describe repairs or abandonment)
* Repair

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
			Use down hole perforator	☐	☐
	135	145	10 rows of 10 perfs	☐	☐

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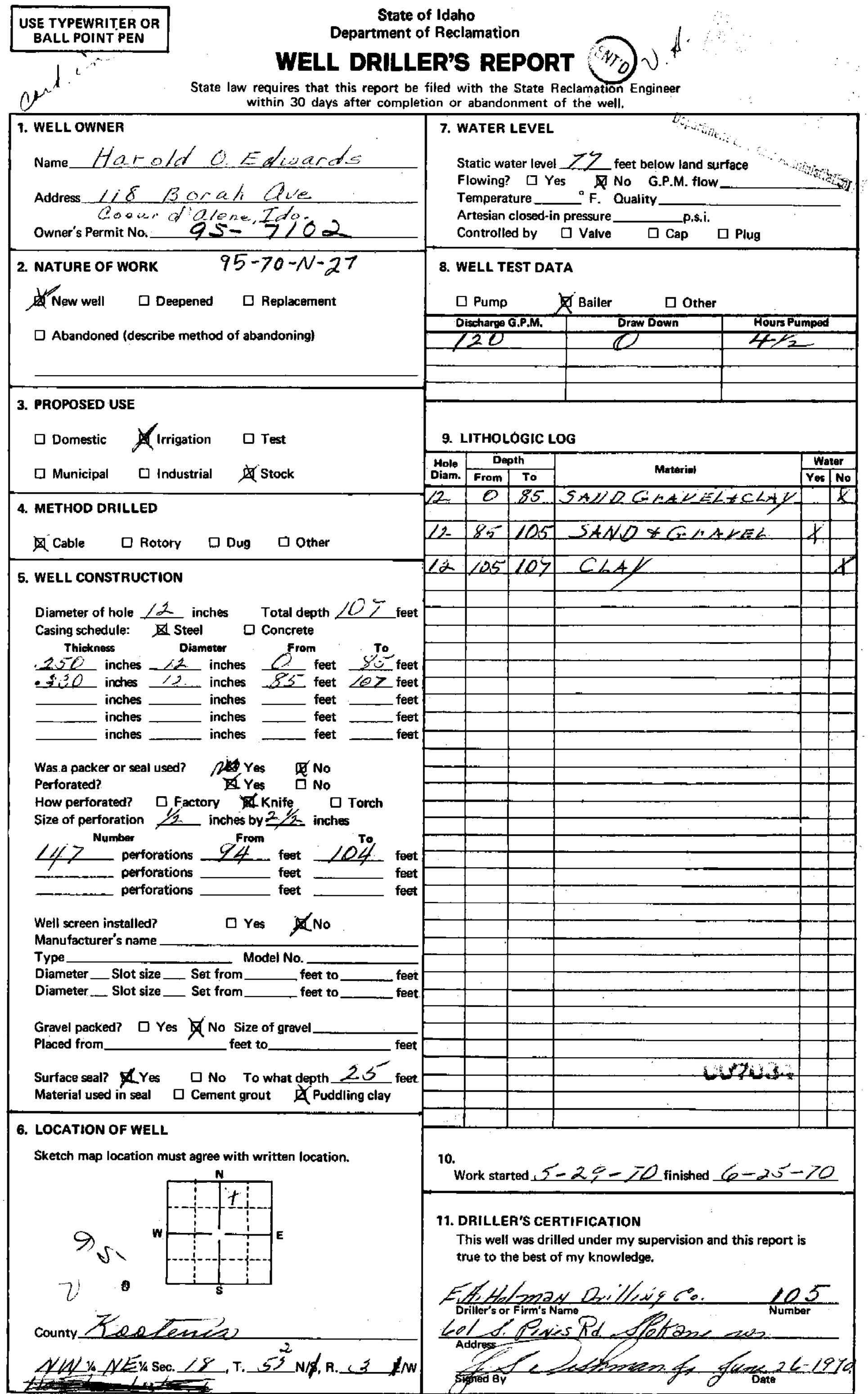
Completed Depth 147 (Measurable)
Date: Started 7/25/00 Completed 7/25/00

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H2O WellService Inc. Firm No. 448
Firm Official [signature] Date 8-2-00
and
Supervisor or Operator [signature] Date 7-26-00
(Sign Once if Firm Official and Operator) Todd Morgan

Figure 17. Log for modification to DEQ528 well



USE TYPEWRITER OR BALL POINT PEN

State of Idaho
Department of Reclamation

WELL DRILLER'S REPORT

State law requires that this report be filed with the State Reclamation Engineer within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name Harold O. Edwards

Address 118 Borah Ave
Coeur d'Alene, Ida.

Owner's Permit No. 95-7102

2. NATURE OF WORK 95-70-N-27

☒ New well ☐ Deepened ☐ Replacement

☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☐ Domestic ☒ Irrigation ☐ Test

☐ Municipal ☐ Industrial ☒ Stock

4. METHOD DRILLED

☒ Cable ☐ Rotory ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Diameter of hole 12 inches Total depth 107 feet

Casing schedule: ☒ Steel ☐ Concrete

Thickness	Diameter	From	To
.250 inches	12 inches	0 feet	85 feet
.330 inches	12 inches	85 feet	107 feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet

Was a packer or seal used? ☐ Yes ☒ No

Perforated? ☒ Yes ☐ No

How perforated? ☐ Factory ☒ Knife ☐ Torch

Size of perforation 1/2 inches by 2 1/2 inches

Number		From	To
147	perforations	94 feet	104 feet
	perforations	feet	feet
	perforations	feet	feet

Well screen installed? ☐ Yes ☒ No

Manufacturer's name

Type Model No.

Diameter Slot size Set from feet to feet

Diameter Slot size Set from feet to feet

Gravel packed? ☐ Yes ☒ No Size of gravel

Placed from feet to feet

Surface seal? ☒ Yes ☐ No To what depth 25 feet

Material used in seal ☐ Cement grout ☒ Puddling clay

6. LOCATION OF WELL

Sketch map location must agree with written location.

N / W / E / S

County Kootenai

NW ¼ NE ¼ Sec. 18, T. 52 N, R. 3 W

7. WATER LEVEL

Static water level 77 feet below land surface

Flowing? ☐ Yes ☒ No G.P.M. flow

Temperature °F. Quality

Artesian closed-in pressure p.s.i.

Controlled by ☐ Valve ☐ Cap ☐ Plug

8. WELL TEST DATA

☐ Pump ☒ Bailer ☐ Other

Discharge G.P.M.	Draw Down	Hours Pumped
120	0	4 1/2

9. LITHOLOGIC LOG

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
12	0	85	SAND GRAVEL & CLAY		X
12	85	105	SAND & GRAVEL	X	
12	105	107	CLAY		X

10. Work started 5-29-70 finished 6-25-70

11. DRILLER'S CERTIFICATION

This well was drilled under my supervision and this report is true to the best of my knowledge.

F.A. Holman Drilling Co. — Driller's or Firm's Name — 105 Number

601 S. Pines Rd. Spokane, Wn. — Address

Signed By — June 26-1970 Date

USE ADDITIONAL SHEETS IF NECESSARY

Figure 18. Original well log for DEQ529 well

Form 238-7
3/95-C96

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

Office Use Only
Inspected by ______
Twp ____ Rge ____ Sec ____
____ 1/4 ____ 1/4 ____ 1/4
Lat: : : Long: : :

1. DRILLING PERMIT NO. 837650
Other IDWR No. D0041123

2. OWNER:
Name Dale & Flora Morris
Address 3800 E Chilco Rd
City Athol State ID Zip 83801

3. LOCATION OF WELL by legal description:
Sketch map location must agree with written location

N / W / E / S

Twp. 52 North ☒ or South ☐
Rge. 3 East ☐ or West ☒
Sec. 18 1/4 (10 acres) NW 1/4 (40 acres) NW 1/4 (160 acres)
Gov't lot ____ County Kootenai
Lat:47:51:560 Long:116:45:591
Address of Well Site 3800 E Chilco Rd
City Athol
(Give at least name of road + Distance to Road or Landmark)
Lt. ____ Blk. ____ Sub. Name ____

4. USE:
☒ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other

5. TYPE OF WORK check all that apply (Replacement etc.)
☒ New Well ☐ Modify ☐ Abandonment ☐ Other

6. DRILL METHOD
☒ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
Bentonite	0	20	500 lbs.	Dry granular

Was drive shoe used? ☐ Y ☒ N Shoe Depth(s) ____
Was drive shoe seal tested? ☐ Y ☐ N How? ____

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
6"	+2	153	.250	Steel	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐

Length of Headpipe ____ Length of Tailpipe ____

9. PERFORATIONS/SCREENS
☐ Perforations Method ____
☒ Screens Screen Type johnson s.s.

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
158	153	20	Cont	6"	S.S.	☒	☐
						☐	☐
						☐	☐

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
90 ft. below ground Artesian Pressure ____ lb
Depth flow encountered ____ ft. Describe access port or control devices: ____

52N 3W 18

11. WELL TESTS:
☐ Pump ☐ Bailer ☒ Air ☐ Flowing Artesian

Yield gal/min.	Drawdown	Pumping Level	Time
30-35			8 Hrs.

Water Temp. ____ Bottom hole temp. ____
Water Quality test or comments: Very silty, then clearer.
Depth first Water Encountered 90'

12. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temp.	Water Y	Water N
10"	0	1	Top soil, cobbles		
	1	3	Gravel, silt, boulders		
	3	9	Cobbles, gravel		
	9	10	Boulder		
	10	16	Gravel, silt, cobbles		
	16	18	Boulder		
8"	18	33	Gravel, coarse, silt, brown		
	33	39	Cobbles, gravel		
	39	56	Gravel, coarse, silt, sand		
	56	61	Gravel, sand, silt, brown		
	61	87	Gravel, coarse, silt		
	87	105	Gravel, coarse, sand, coarse	☒	
	105	107	Clay, darker brown		
	107	112	Sand, gravel, silt	☒	
	112	125	Gravel, silt, sand	☒	
	125	127	Boulder, cobbles	☒	
	127	131	Gravel, cobbles	☒	
	131	139	Gravel, silt, brown	☒	
	139	143	Gravel, coarse	☒	
	143	147	Gravel, coarse, sand, coarse	☒	
	147	151	Gravel, coarse, 20 GPM	☒	
	151	152	Gravel, coarse, sand, coarse	☒	
	152	156	Gravel, coarse	☒	
	156	161	Gravel, coarse, sand, coarse	☒	
	161	169	Shale, decomposed	☒	
	169	170	Shale, grey, white	☒	
	170	175	Shale, hard, & soft layers	☒	

Completed Depth: 158 (Measurable)
Date: Started 11/28/05 Completed 12/1/05

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name McCarty Drilling & Pump Inc Firm No. 586
Firm Official [signature] Date 12-12-05
Supervisor or Operator ____ Date ____
(Sign once if Firm Official & Operator)

Date: 12/12/2005 Time:9:41:20 AM

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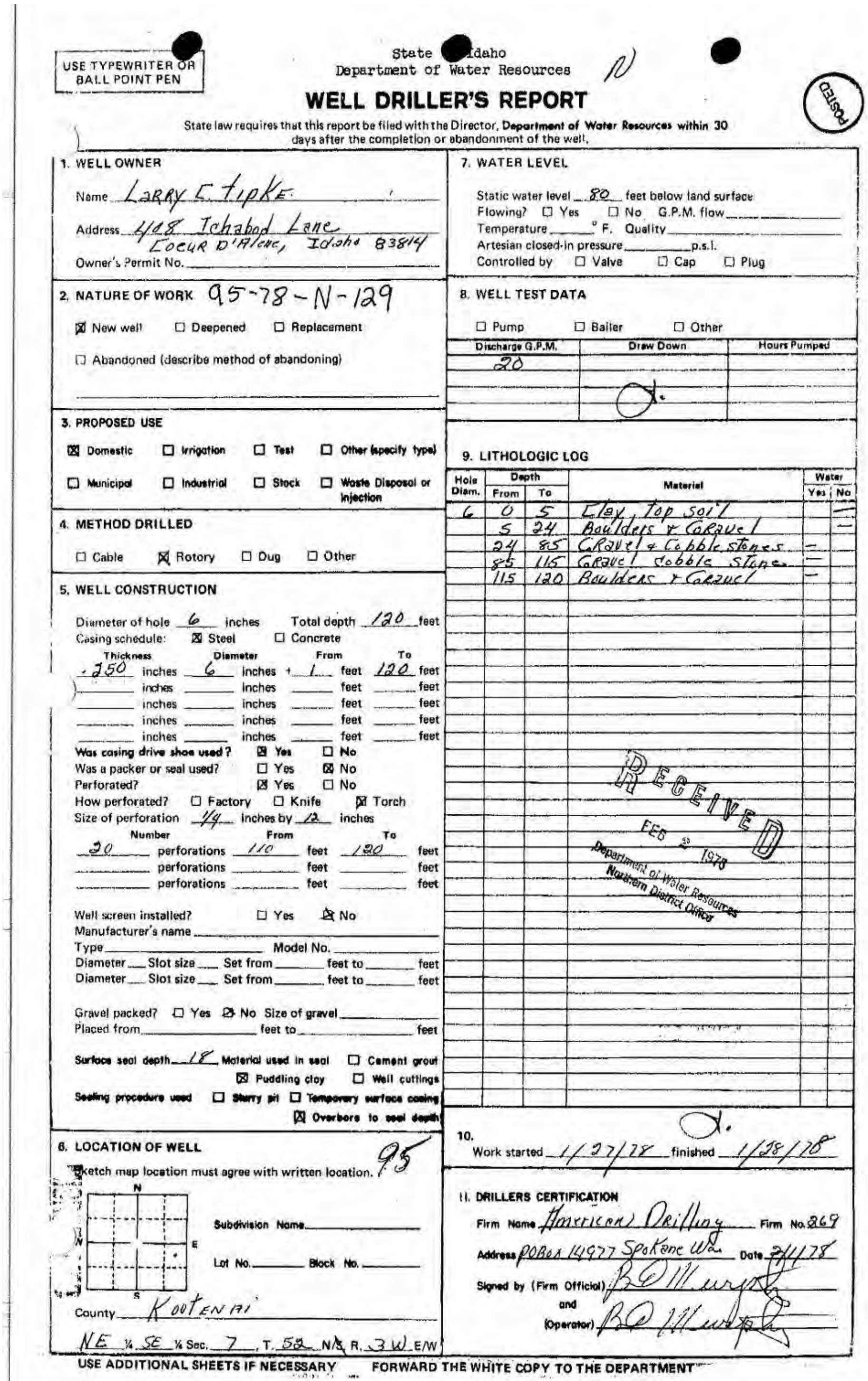
JAN 13 2006
IDWR/North

Figure 19. Original well log for DEQ564 well



USE TYPEWRITER OR BALL POINT PEN

State of Idaho
Department of Water Resources

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name: LARRY E. TIPKE
Address: 4108 Ichabod Lane, COEUR D'Alene, Idaho 83814
Owner's Permit No.

2. NATURE OF WORK 95-78-N-129

☒ New well ☐ Deepened ☐ Replacement

☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☒ Domestic ☐ Irrigation ☐ Test ☐ Other (specify type)
☐ Municipal ☐ Industrial ☐ Stock ☐ Waste Disposal or Injection

4. METHOD DRILLED

☐ Cable ☒ Rotary ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Diameter of hole 6 inches Total depth 120 feet
Casing schedule: ☒ Steel ☐ Concrete

Thickness	Diameter	From	To
.250 inches	6 inches	+1 feet	120 feet

Was casing drive shoe used? ☒ Yes ☐ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch
Size of perforation 1/4 inches by 12 inches

Number	From	To
30 perforations	110 feet	120 feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name
Type Model No.
Diameter Slot size Set from feet to feet
Diameter Slot size Set from feet to feet

Gravel packed? ☐ Yes ☒ No Size of gravel
Placed from feet to feet

Surface seal depth 18 Material used in seal ☐ Cement grout ☒ Puddling clay ☐ Well cuttings
Sealing procedure used ☐ Slurry pit ☐ Temporary surface casing ☒ Overbore to seal depth

6. LOCATION OF WELL

Sketch map location must agree with written location. 95

Subdivision Name
Lot No. Block No.

County KOOTENAI

NE ¼ SE ¼ Sec. 7, T. 52 N/S, R. 3 W E/W

7. WATER LEVEL

Static water level 80 feet below land surface
Flowing? ☐ Yes ☐ No G.P.M. flow
Temperature °F. Quality
Artesian closed-in pressure p.s.i.
Controlled by ☐ Valve ☐ Cap ☐ Plug

8. WELL TEST DATA

☐ Pump ☐ Bailer ☐ Other

Discharge G.P.M.	Draw Down	Hours Pumped
20		

9. LITHOLOGIC LOG

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
6	0	5	Clay, Top soil		—
	5	24	Boulders & Gravel		—
	24	85	Gravel & Cobblestones	—	
	85	115	Gravel cobble stone	—	
	115	120	Boulders & Gravel	—	

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FEB 2 1978
Department of Water Resources
Northern District Office

10. Work started 1/27/78 finished 1/28/78

11. DRILLERS CERTIFICATION

Firm Name American Drilling Firm No. 269
Address PO Box 14977 Spokane Wa. Date 2/1/78
Signed by (Firm Official) [signature]
and
(Operator) [signature]

USE ADDITIONAL SHEETS IF NECESSARY FORWARD THE WHITE COPY TO THE DEPARTMENT

Figure 20. Original well log for DEQ565 well

Form 238-7
7/98
Starships Consulting and Management Services

IDAHO DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

Office Use Only
Inspected by ____
Twp ____ Rge ____ Sec ____
____ 1/4 ____ 1/4 ____ 1/4
Lat: : : Long: : :

1. WELL TAG NO. D0044832
Drilling Permit No: 840138
Other IDWR No.

2. OWNER **Well Number:** 1169
Name HAROLD MARPLES
Address PO BOX 578
City HAYDEN State ID Zip 83835

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

Twp. 52 ☑ North or ☐ South
Rge. 03 ☐ East or ☑ West
Sec. 18 NE 1/4 NW 1/4 1/4
Gov't Lot County KOOTENAI
Lat: : : Long: : :
Address of Well Site 3762 CHILCO RD City ATHOL
(Give at least name of road + Distance to Road or Landmark)
Lt. Blk. Sub. Name

4. USE:
☑ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other

5. TYPE OF WORK check all that apply (Replacement, etc.)
☑ New Well ☐ Modify ☐ Abandonment ☐ Other

6. DRILL METHOD
☑ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
BENTONITE	0	18	350	OVERBORE

Was drive shoe used? ☐ Y ☑ N Shoe Depth(s) RB
Was drive shoe seal tested? ☐ Y ☑ N How?

8. CASING/LINER:

Diameter	From	To	Gauge	Materl	Casing	Liner	Welded	Threaded
6	2	102	.250	STEEL	☑	☐	☑	☐

Length of Headpipe Length of Tailpipe

9. PERFORATIONS/SCREENS
☐ Perforations Method
☐ Screens Screen Type

From	To	Slot Size	Number	Diameter	Material	Casing	Liner

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
75 ft. below ground Artesian pressure lb.
Depth flow encountered ft. Describe access port or control devices: WELD ON CAP

52N 3W 18

11. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
20			2.5

Water Temp. COLD Bottom Hole Temp COLD
Water Quality test or comments: CLOUDY
Depth first Water encountered 90

12. LITHOLOGIC LOG:(Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
8	0	2	TOPSOIL		☑
8	2	77	SAND AND GRAVEL		☑
8	77	90	SAND AND GRAVEL W/ CLAY	☑	
8	90	105	BROKEN SHALE	☑	

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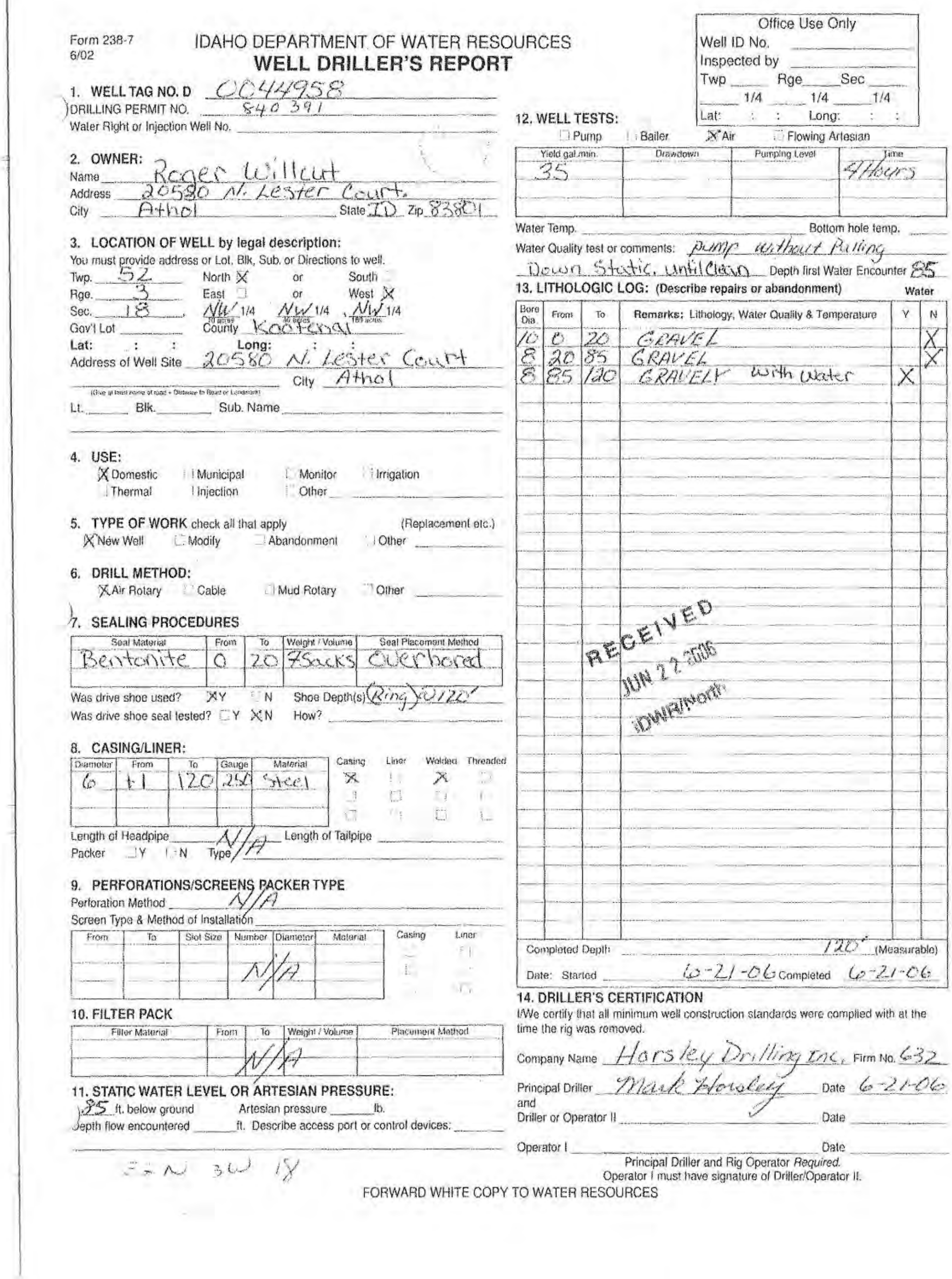
JUN 29 2006
IDWR/North

Completed Depth 105 (Measurable)
Date: Started 6/7/2006 Completed 6/8/2006

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H2O WellService, Inc. Firm No. 448
Firm Official [signature] Date 6-14-06
and
Supervisor or Operator [signature] Date 06/09/06
TODD MORGAN (Sign Once if Firm Official and Operator)

Figure 21. Original well log for DEQ566 well


Form 238-7
6/02

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

Office Use Only
Well ID No. ______
Inspected by ______
Twp ____ Rge ____ Sec ____
____ 1/4 ____ 1/4 ____ 1/4
Lat: : : Long: : :

1. WELL TAG NO. D 0044958
DRILLING PERMIT NO. 840 391
Water Right or Injection Well No. ______

2. OWNER:
Name Roger Willcut
Address 20580 N. Lester Court
City Athol State ID Zip 83801

3. LOCATION OF WELL by legal description:
You must provide address or Lot, Blk, Sub. or Directions to well.
Twp. 52 North X or South
Rge. 3 East or West X
Sec. 18 NW 1/4 NW 1/4 NW 1/4
Gov't Lot ____ County Kootenai
Lat: : : Long: : :
Address of Well Site 20580 N. Lester Court
City Athol
Lt. ____ Blk. ____ Sub. Name ______

4. USE:
X Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ____

5. TYPE OF WORK check all that apply (Replacement etc.)
X New Well ☐ Modify ☐ Abandonment ☐ Other ____

6. DRILL METHOD:
X Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

Seal Material	From	To	Weight / Volume	Seal Placement Method
Bentonite	0	20	7Sacks	Overbored

Was drive shoe used? X Y ☐ N Shoe Depth(s) (Ring) @ 120'
Was drive shoe seal tested? ☐ Y X N How? ____

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
6	+1	120	250	Steel	X		X	

Length of Headpipe N/A Length of Tailpipe ____
Packer ☐ Y ☐ N Type

9. PERFORATIONS/SCREENS PACKER TYPE
Perforation Method N/A
Screen Type & Method of Installation ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
			N/A				

10. FILTER PACK

Filter Material	From	To	Weight / Volume	Placement Method
	N/A			

11. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
85 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____

52N 3W 18

12. WELL TESTS:
☐ Pump ☐ Bailer X Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
35			4 Hours

Water Temp. ____ Bottom hole temp. ____
Water Quality test or comments: pump without Pulling Down Static, until Clean Depth first Water Encounter 85

13. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
10	0	20	GRAVEL		X
8	20	85	GRAVEL		X
8	85	120	GRAVELY With Water	X	

RECEIVED
JUN 22 2006
IDWR/North

Completed Depth 120' (Measurable)
Date: Started 6-21-06 Completed 6-21-06

14. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Company Name Horsley Drilling Inc. Firm No. 632
Principal Driller Mark Horsley Date 6-21-06
and
Driller or Operator II ____ Date ____
Operator I ____ Date ____
Principal Driller and Rig Operator *Required.*
Operator I must have signature of Driller/Operator II.

FORWARD WHITE COPY TO WATER RESOURCES

Figure 22. Original well log for DEQ567 well

RECEIVED
JUN 13 1969
Department of Reclamation

ENT'D

REPORT OF WELL DRILLER
State of Idaho

State law requires that this report shall be filed with the State Reclamation Engineer within 30 days after completion or abandonment of the well.

WELL OWNER:
Name Hedlund Lumber Co.
Address 808 North Boyer
Sandpoint, Idaho 95-69-N-39
Owner's Permit No. 95-7033
NATURE OF WORK (check): Replacement well [ ] New well [✓] Deepened [ ] Abandoned [ ]
Water is to be used for: Fire Protection
METHOD OF CONSTRUCTION: Rotary [ ] Cable [x] Dug [ ] Other ______ (explain)
CASING SCHEDULE: Threaded __ Welded x
12" "Diam. from +1 ft. to 170 ft.
"Diam. from ft. to ft.
"Diam. from ft. to ft.
"Diam. from ft. to ft.
Thickness of casing: .375 Material:
Steel [x] concrete [ ] wood [ ] other [ ]
(explain)
PERFORATED? Yes [x] No [ ] Type of perforator used: Mills Knife
Size of perforations: 3/8" " by 2 1/2 "
276' perforations from 106' ft. to 129' ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
WAS SCREEN INSTALLED? Yes [ ] No [x]
Manufacturer's name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.
CONSTRUCTION: Well gravel packed? Yes [ ] No. [x] size of gravel Gravel placed from ft. to ft. Surface seal provided? Yes [x] No [ ] To what depth? 20' ft. Material used in seal: cement
Did any strata contain unusable water? Yes [ ] No. [x] Type of water: Depth of strata ft. Method of sealing strata off: Clay layers of natural construction & Bedrock (?)
Surface casing used? Yes [x] No. [ ]
Cemented in place? Yes [x] No [ ]
Locate well in section

Sec.

LOCATION OF WELL: County Kootenai
SW ¼ SE ¼ Sec. 31 T. 52 N/S R. 3 E/W

Size of drilled hole: 12" Total depth of well: ~~270'~~ 172 Standing water level below ground: 85' Temp. Fahr. ° Test delivery: gpm or cfs Pump? [✓] Bail [ ]
Size of pump and motor used to make test: 250hP 1800 RPM 8" Column 10' Bowls
Length of time of test: 8 Hrs. 0 Min. 0
Drawdown: 5 ft. Artesian pressure: ft. above land surface Give flow cfs or 1200 gpm. Shutoff pressure:
Controlled by: Valve [ ] Cap [ ] Plug [ ]
No control [ ] Does well leak around casing? Yes [ ] No [✓]

DEPTH FROM FEET	DEPTH TO FEET	MATERIAL	WATER YES OR NO
0'	38'	Large gravel & clay	no
38'	83'	Sand, gravel & clay	no
83'	129'	Sand & gravel	yes
129'	135'	Clay, sand & gravel	yes
135'	139'	Blue clay & gravel	no
139'	141'	Pea gravel & clay	water
141'	162'	Brown clay & gravel	no
162'	164'	Fine sand & water	water
164'	183'	Brown clay	no
183'	200'	Clay, grey	no
200'	220'	Sandy grey clay	no
220'	240'	Blue clay & sand	no
240'	253'	Blue clay	no
253'	270'	Granite hard	no

Work started: 2/12/69
Work finished: 3/15/69
Well Driller's Statement: This well was drilled under my supervision and this report is true to the best of my knowledge.
Name: E.A. Holman Drilling Co.
Address: 601 So. Pines
Signed by: J.A. Holman Jr.
License No. 105 Date: 6-2-69

Use other side for additional remarks

95

Figure 23. Original well log for DEQ570 well