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HYDROGEOLOGICAL ASSESSMENT

Doty-Dryad Area
Lewis County, Washington

Prepared for: Lewis County Department of Public Works

Project No. 080192-001-03 • December 1, 2008

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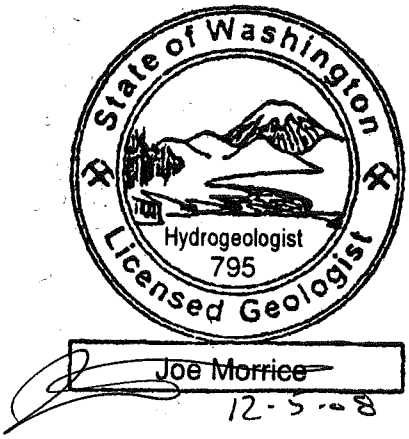

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1 Introduction

This report presents a hydrogeologic assessment of the Doty-Dryad area of Lewis County, Washington. The study area considered in this report is shown on Figure 1, and includes the communities of Doty and Dryad, which are located approximately 15 miles west of Chehalis, Washington. The Chehalis River runs through the middle of the study area, forming an approximately 1 mile wide valley. Most residences in the study area are located in the relatively flat valley bottom. Residences in the study area are supplied by onsite domestic wells and utilize individual septic systems.

In December 2007, a major flood occurred on the Chehalis River, flooding a number of residences in Doty, Dryad, and the surrounding area. Following the flood, water quality samples collected from wells of flooded residences tested positive for total coliform, and in some cases, E. Coli, likely due to contact with floodwaters.

The County has expressed a desire to develop a community supply well in the Doty-Dryad area to serve as an emergency source of supply for area residents in the event of future floods or other natural disasters. The primary goal of this assessment is to identify potential areas and aquifer target zones for development of a future emergency water supply well. Major considerations in selecting a potential well site include the potential aquifer yield, avoiding areas of potential coliform contamination, and avoiding potential future contamination of the well.

The following sections discuss data sources used in this assessment; hydrogeologic conditions in the study area, including typical well yields; the occurrence, distribution, and likely sources of coliform detections in residential wells; and recommendations for siting of a potential community supply well.

2 Data Sources and GIS Database

The following data sources were used in developing this hydrogeologic assessment:

- Well log files downloaded from the Department of Ecology website;
- Published geologic reports and maps, including Water Supply Bulletin 17 (Weigle and Foxworthy, 1962) and the Washington Department of Natural Resources digital geologic mapping Geographic Information System (GIS) files;
- Coliform test data collected from area residences before and after the December 2007 flood;
- Nitrate data collected from area residences between 1994 and 2008; and
- County GIS files, including tax parcel locations, estimated extents of the 20067 flood, aerial images, and topographic elevation data.

Ecology's well log files contain 173 well log records in the Doty-Dryad study area. Of these, 147 were successfully located and assigned to individual tax parcels by Lewis County GIS staff, based on information provided on the well log forms (i.e., tax parcel number, well address, owner address, or owner name, as available). The remaining 26 well logs were located based on the quarter-quarter section locations listed on the logs. Figure 1 shows assigned well log locations, and the basis on which the assignment was made. Well logs that could only be located to the closest quarter-quarter section were not used in the interpretation of hydrogeologic conditions described in Section 3.

Coliform and nitrate sample results were also assigned to individual tax parcels by Lewis County GIS staff. Approximately 180 coliform samples collected from 88 locations collected prior to the flood, and 140 coliform samples from 90 locations collected after the flood were assigned to tax parcels based on the address at which the samples were collected. This does not include an additional 135 coliform samples collected before and after the flood from the Rainbow Falls State Park Group A Public Water System.

The water quality and well log data sets were joined based on parcel number. Eighty-one well logs that have associated coliform data were identified. A total of 116 coliform samples (pre- and post-flood) are associated with 68 of the well logs. There are 60 coliform samples collected from 44 wells before the flood, and 56 coliform samples from collected 37 wells after the flood.

A data gaps memorandum (Aspect 2008) identified the need for wellhead inspections and additional coiliform and nitrate sampling. County staff inspected the wellheads of 16 wells on November 12, 2008. Deficiencies in wellhead construction that could allow coliform to enter the well or distribution system were noted in these inspections. Five wells were also sampled for coliform and nitrate. These samples are included in the post-flood sample counts discussed above.

3 Hydrogeologic Conditions

The following descriptions of geologic and hydrogeologic conditions in the study area are based on a review of Ecology well logs, a geologic report that includes the study area (Weigle and Foxworthy, 1962), and the DNR geologic map for the area (Harris and Schuster, 2000). Figure 2 presents the surficial geology in the study area taken from the DNR geologic map. Two geologic cross sections (Figures 3 and 4) were developed to depict subsurface geologic conditions. Cross section locations and the locations of well logs used to construct the cross sections are shown on Figure 2.

3.1 Geologic Setting

The geology of the Doty-Dryad study area consists of a thin layer of recently deposited unconsolidated sediments overlying consolidated sedimentary bedrock (sandstone and siltstone) and basalt. The major geologic units encountered in the study area are shown in plan view on Figure 2 and in profile in Figures 3 and 4. The geologic units, from youngest to oldest, include:

- Quaternary age alluvium (Qa), landslide (Qls), and terrace (Qt) deposits. The alluvium is limited to the Chehalis River floodplain and the drainages of the larger tributary creeks. The landslide deposits occur along steep slopes of the valley walls. The terrace deposits are limited to the north side of the valley, and may include older alluvial or glacial deposits. These units consist of unconsolidated mixtures of sand, gravel, silt, and clay. Where encountered these units are about 10 to 20 feet thick. For purposes of evaluating hydrogeologic conditions and constructing the cross sections, these units were combined as a single unit described as unconsolidated deposits. The unconsolidated deposits overlie older sedimentary units (sandstone and siltstone) and the Grande Ronde Basalt.
- Middle to upper Miocene age continental (Mc(w)) and marine (Mm(2m)) sedimentary rocks of the Wilkes and Montesano Formations. These units occur at or near ground surface along the north side of the valley and overlie either the Grande Ronde Basalt (Mv(gN2)), where present, or older lower to middle Miocene age marine sedimentary rocks of the Astoria Formation. These sedimentary rocks consist of sandstone with interbedded siltstone. Based on the well logs, these units are up to about 100 to 150 feet thick in the study area.
- The middle Miocene age Grande Ronde Basalt. This unit occurs at or near ground surface along the Chehalis River drainage and the south side of the valley. North of the river this unit is encountered starting at depths of about 100 to 150 feet. Based on the few wells that fully penetrate this unit, the Grande Ronde Basalt is about 100 feet thick in the study area.
- Lower to middle Miocene age marine sedimentary rocks of the Astoria Formation (Mm(1a) and Mm(1al)). These units are generally not exposed at ground surface, except in the western part of the study area. Where not exposed, these units underlie the Grande Ronde Basalt, where present, or the younger continental and marine sedimentary rocks of the Wilkes and Montesano Formations. These sedimentary rocks consist of sandstone with interbedded siltstone. Based on descriptions in the well logs it is difficult to distinguish between the sedimentary rocks of the Wilkes, Montesano, and Astoria Formations. These three formations are not differentiated on the cross sections, and are described simply as sandstone with interbedded siltstone.

Based on the available information, there are no major geologic structures (e.g., faults or folds) in the study area that would affect hydrogeologic conditions. Immediately south of the study area a northeast-southwest trending fault is mapped in the Grande Ronde Basalt. It is unclear if this fault line extends into the study area, although no evidence of it could be identified based on a review of the well log information.

3.2 Hydrogeology

3.2.1 Aquifers and Well Yields

The geologic units can be characterized as aquifers or aquitards, based on their ability to store and transmit water. An aquifer can be defined as a water-bearing unit with sufficient permeability to yield usable quantities of water. An aquitard can be defined as a water bearing unit that does not yield usable quantities of water. Aquitards also generally act as barriers to groundwater flow.

The sedimentary bedrock units act as the primary water supply aquifer in the study area. Virtually all of the wells in the study area tap these units, rather than the basalt or unconsolidated deposits. Water within the sandstones is stored and transmitted via fracture permeability. Of the 173 well logs reviewed, only five are for wells that tap the unconsolidated deposits, and only two wells appear to be completed entirely in the basalt.

The basalt likely acts as an aquitard, although it may locally produce usable quantities of water. This unit it typically described on well logs as “hard” drilling and is not noted as being water bearing. The unconsolidated deposits likely act as an aquifer, at least where they are saturated, sufficiently thick, and comprised predominantly of coarser-grained materials such as sands and gravels.

Air lift or bailer test data indicating approximate well yield is listed on 161 of the well logs. Wells for which well yield data are available are summarized on Table 1 and shown on Figure 5. Well location symbols also indicate the range of completion depths for the wells. Well yields from the sedimentary bedrock ranging from about 1 to 70 gallons per minute (gpm), with an average yield of about 10 gpm. Average yield for each of the depth intervals on Figure 5 does not vary significantly, ranging from about 10 to 13 gpm. Based on these data, there does not appear to be a pattern relating well yield to either total depth or horizontal location. Variations in well yield are likely due to a combination of differences in well construction and local variations in the number and continuity of fractures in the bedrock.

Specific capacity is defined as the well yield divided by the drawdown of the water level in the pumping well, and has units of gallons per minute per foot (gpm/ft). Fifty-four well logs provided both well yield and drawdown data. Specific capacities in the study area range from less than 0.1 to about 1.1 gpm/ft, with an average value of 0.2 gpm/ft. These are generally low values for specific capacity, and are indicative of a relatively unproductive aquifer.

3.2.2 Groundwater Elevations

Groundwater elevations were estimated based on approximate ground surface elevations and depth to water measurements listed on the well logs. Due to uncertainties in well locations and ground elevations and the different dates of the depth to water measurements in the wells, accuracy of the estimated water level data is expected to be plus or minus 20 feet. There does not appear to be significant differences in groundwater elevations for wells completed at different depths, therefore all the groundwater elevation data were used to develop the groundwater elevation contour map shown on Figure 6.

Based on the groundwater elevation contours, groundwater flow appears to follow ground surface topography, with flow from the higher elevations toward the valley bottom. Groundwater in the valley bottom generally parallels the direction of river flow (i.e., eastward in the study area), and likely ultimately discharges to the Chehalis River. In Doty, groundwater elevations show an apparent depression, indicated by the closed 275-foot elevation contour. This area of lower groundwater levels may be an artifact of elevation errors or could be the result of pumping drawdown from the relatively large number of domestic wells in this area.

4 Coliform Occurrence

Coliform and nitrate data provided by the County were reviewed to:

- Assess whether groundwater in the study area was impacted by coliform associated with releases from domestic septic systems prior to the December 2007 flood;
- Evaluate whether wells with coliform detected after the flood represent wide-spread aquifer impacts or are related to individual well construction issues; and
- Identify areas that are not impacted by coliform and are suitable for future groundwater development.

Coliform and nitrate data were matched to well logs and tax parcels, as described in Section 2. The locations of wells with nitrate data and associated nitrate concentrations are shown on Figure 7 and summarized in Table 2. The coliform data were divided into pre-flood and post-flood data, and are show on Figures 8 and 9. Tables 3 and 4 summarize the pre-flood and post-flood coliform data and that were matched to well logs. These data are discussed in the following sections.

In general there appear to be persistent coliform impacts to wells tapping shallow groundwater in the more densely developed community of Doty, with scattered detections of coliform in shallow and deep wells throughout the rest of the study area. Shallow groundwater in the community of Dryad may also be impacted by coliform, although the evidence is less clear. The persistent detections of coliform in shallow wells in Doty, and to a lesser extent Dryad, indicate that wells tapping shallow groundwater in these locations are susceptible to contamination with coliform from septic system discharges. Although coliform has been detected in wells tapping deeper groundwater in these areas, the detections are not as persistent or wide-spread. The more scattered detections are not indicative of coliform contamination of groundwater, and are more likely related to construction and maintenance problems with individual wells and distribution systems.

4.1 Nitrate Data

Elevated nitrate concentrations in groundwater can be an indication of infiltration of septic system leachate, in turn indicating the potential for coliform from septic systems to contaminate groundwater. As shown on Figure 7 and Table 2, nitrate concentrations are uniformly low in the study area. Only three wells had nitrate concentrations greater than or equal to 1 milligram per liter (mg/L), with a maximum detected concentration of 2.7 mg/L. These three wells are not located near each other and two of the wells are located outside the relatively densely developed towns of Doty and Dryad, where impacts to groundwater from septic systems would be most likely to occur. Based on the uniformly low concentrations and the large separation between locations with concentrations greater than or equal to 1 mg/L, it appears that infiltration of leachate from septic systems has not resulted in a widespread nitrate impacts to groundwater tapped by domestic supply wells in the area.

4.2 Pre-Flood Coliform Data

Coliform data collected prior to the December 2007 flood are presented on Figure 8 and in Table 3. Table 5 presents a statistics summary for coliform detections pre- and post-flood. About 180 coliform samples were collected from 88 domestic wells in the study area prior to the flood. Well logs were identified for approximately half the sample locations. These coliform sample totals do not include the large number of samples collected from the Rainbow Falls State Park Group A Water System, all of which were non-detect for coliform. Total coliform was detected in 37 of the 88 domestic wells sampled, with E. coli detected at 8 locations. Coliform was not detected at ten of these 37 locations in subsequent sampling, indicating the previous detections were probably due to localized contamination of the well or distribution system, rather than coliform contamination of the aquifer.

As shown on Table 3, coliform detections occur over a broad range of well depths. There appears to be some correlation of coliform occurrence with well depth. Coliform was detected in 8 of 14 wells completed at depths less than 100 feet, and only 6 of 29 wells completed at depths greater than 100 feet (Table 5).

The locations of coliform detections are scattered throughout the study area, although a cluster of nine detections (without subsequent nondetect samples) are located in the more densely developed town of Doty. Well logs were identified for three of the locations with detected coliform. These wells with detected coliform are completed at depths of 80 to 155 feet. Other pre-flood samples from Doty collected from wells completed nearby at similar depths (80 to 160 feet) did not show detections of coliform.

Coliform was detected in six samples from residences in Doty for which well logs were not identified. Notes in the coliform database provided by the County indicate that a number of residences in Doty are served by shallow (less than 20 feet deep), dug wells. It is not clear if the pre-flood coliform detections are associated with dug wells or not; however as discussed in the post-flood data, these shallow, dug wells were disproportionately impacted by the flood.

One location in Dryad (the Dryad Baptist Church, 112 Olive Street) appears to have a persistent coliform problem. The well log identified for this location indicates it is completed at a depth of 40 feet. Deeper wells in Dryad did not show persistent detections of coliform. This implies that any coliform contamination of the aquifer in Dryad is limited to shallow groundwater.

Coliform data were identified for two wells (362124 and 470199) completed beneath the basalt. These wells are located near the east end of the study area. Coliform was not detected in either of these wells.

Based on these data, the coliform detections do not appear to indicate an aquifer contamination problem, except for shallow groundwater contamination that is affecting shallow wells completed near the water table in Doty and, to a lesser extent, Dryad. The scattered nature of the pre-flood coliform detections outside of Doty and Dryad implies problems with individual wells and distribution systems, rather than coliform contamination of the aquifer.

Table 5

Summary of Coliform Detections

Pre-Flood Coliform Data	**Wells Sampled**	**Wells Coliform Present**	**% of wells Coliform Present**
All Samples	88	37	42%
Resampling after detection	24	14	58%
Wells <100 ft depth	14	8	57%
Wells >100 ft depth	29	6	21%
Unknown Depth	41	23	56%
Post-Flood Coliform Data			
All Samples	90	44	49%
Resampling after detection	28	14	50%
Dug Wells	11	10	91%
Drilled Wells	37	13	35%
Deficient Wellhead	5	4	80%
Non-Deficient Wellheads	10	1	10%

4.3 Post-Flood Coliform Data

Coliform data collected after the December 2007 flood are presented on Figure 9 and in Table 4. A total of 140 coliform samples were collected from 90 domestic wells in the study area after the flood. Well logs were identified for 37 of the sample locations. These coliform sample totals do not include samples collected from the Rainbow Falls State Park Group A Water System, all of which were non-detect for coliform. Total coliform was detected in 44 of the 90 domestic wells sampled after the flood, with E. coli detected at 12 locations. This represents an increase in wells with detected coliform of about 7 percent over pre-flood conditions.

Of the 44 locations with initial coliform detections, coliform was not detected at 15 locations in subsequent sampling, indicating the previous detections were probably due to localized contamination of the well or distribution system, rather than coliform contamination of the aquifer. Fifteen locations with initial detections of coliform were not resampled (Figure 9), and it is unknown if coliform persists at these locations. Notes in the post-flood coliform data provided by the County indicate that at least 11 wells in the study area are shallow, dug wells. Coliform was detected in 10 out of 11 dug wells, while only 13 out of 37 deeper, drilled wells for which well logs were identified were affected. Based on these data, coliform contamination of the aquifer, either preexisting or due to the flood, is likely limited to shallow groundwater near ground surface, and does not appear to impact deeper groundwater.

The 13 locations with associated well logs where coliform was detected in the initial sample were resampled (Table 4). Coliform was not detected in subsequent samples from eight of these locations, but was detected at five locations. These wells with confirmed detections are completed at depths of 80 to 200 feet. Samples collect from nearby locations with well logs had no coliform detected, either in the initial sample or in subsequent samples. As discussed in the following section, four of these five locations with continued coliform detections have some form of wellhead deficiency that could act as a route for coliform to enter the well or distribution system.

Post-flood coliform data were identified for four wells (428058, 387171, 470199, and 14841) completed in the sandstone beneath the basalt. These wells are located east of Dryad. Coliform was not detected in any of these wells. Coliform data were not identified for three other wells completed beneath the basalt.

The post-flood coliform data do not appear to indicate an aquifer contamination problem. Wells where coliform detections have persisted are located near wells where coliform were never detected or where subsequent sampling indicated that well disinfection had been successful, implying contamination of individual wells rather than contamination of the aquifer. The correlation between wellhead construction and maintenance problems and detection of coliform further implies that coliform occurrence is related to localized problems with individual wells and distribution systems, rather than coliform contamination of the aquifer.

4.4 Wellhead Inspection

County staff completed inspections of 16 wells in the study area to identify well construction issues that could be contributing to coliform detections. Results of the wellhead inspections and a summary of coliform testing results for each well are presented on Table 6.

Six wells were identified as having some form of wellhead deficiency (e.g., broken conduit, loose well cap, etc.) that could provide a route for coliform or other contaminants to enter the well. Five of the deficient wellheads had coliform detected in at least one post-flood sample. Of these five wells, only one subsequently tested as free of coliform, while coliform was detected in the most recent samples from the other four wells.

No apparent deficiencies were noted at the ten other wellheads. Nine of these ten were sampled for coliform after the flood, and only one had a coliform detection (130 Cedar Street). Coliform was not detected in a subsequent sample from this well.

4.5 Conclusions

Based on the above data, there does not appear to be wide-spread coliform contamination of the aquifer in the Doty-Dryad study area. Except for the more densely developed communities of Doty and Dryad, coliform detections are localized in nature, and appear to be due to individual wellhead construction and maintenance problems. There are areas of groundwater that appear to be contaminated with coliform in Doty and Dryad, although the contamination appears to be limited to shallow groundwater near land surface. These conclusions are based on the following observations:

- Nitrate concentrations in groundwater are generally low, indicating that loading from septic systems to groundwater, a potential source of coliform contamination, is not contributing significantly to groundwater tapped by domestic wells in the study area.
- Except in Doty and Dryad, coliform detected in samples collected prior to the December 2007 flood are from locations scattered throughout the study area. This implies pre-flood detections of coliform are related to problems with individual wells and distribution systems, rather than coliform contamination of the aquifer.
- In the more developed communities of Doty and Dryad, shallow wells are disproportionately impacted by coliform in both the pre- and post-flood data sets. Deeper, drilled wells in these areas are impacted by coliform at far lower rates than the shallow wells. This implies that shallow groundwater may be contaminated with coliform from septic systems or floodwaters in these areas.
- The correlation between coliform detection and wellhead deficiencies indicates that coliform impacts are likely due to well construction and maintenance problems, rather than coliform contamination of the aquifer.

5 Well Siting

The County has expressed a preference for drilling a potential community supply well in the Dryad area, near where the emergency command center was established during the 2007 flood. The goal would be for this well to produce about 30 gpm for use as an emergency supply during future flooding events or other natural disasters. The major considerations for selecting a well site include potential yield of the target aquifer, presence of existing coliform contamination, and susceptibility to future contamination. These considerations are discussed in the following sections, followed by a recommendation for well siting.

5.1 Target Aquifer

Reported yields from the sandstone aquifer (Wilkes, Montesano, and Astoria Formations) in the study area are variable, ranging from about 1 to 70 gpm, with an average yield of about 10 gpm. Reported yields do not appear to vary systematically with depth or horizontal location. Instead the variability in well yields are likely due to a combination of differences in well construction and local variations in the number and continuity of fractures in the bedrock. Therefore, regardless of where the well is sited, the uncertainty in the potential yield is high, although a yield of at least 10 gpm is reasonable to expect.

In the vicinity of Dryad, The Grande Ronde Basalt is present at depths of about 150 to 200 feet below ground surface. The basalt is not a productive source, and should not be considered for well development. A well in this area could either be completed above the basalt at a total depth of about 150 feet, or below the basalt at depths of greater than 200 feet.

5.2 Existing Contamination

Existing coliform contamination of the aquifer does not appear to be a significant problem in the study area, except for shallow groundwater in Doty and Dryad. Detections of coliform in deeper, drilled wells are scattered and appear to be related to problems with construction and maintenance of individual wells. To avoid the apparent shallow groundwater contamination, a community supply well completed in Doty or Dryad should not tap shallow groundwater, and should instead be completed deeper in the sandstone aquifer. Based on the relatively high occurrence of coliform in domestic wells less than 100 feet deep, a future supply well should only be open to the aquifer below depths of 100 feet.

5.3 Susceptibility to Future Contamination

Potential sources of future contamination include surface sources, such as flooding or poorly maintained septic systems, and poorly constructed and maintained wells that could act as conduits for contaminants to reach the aquifer. To avoid contamination from surface sources, the well should be located a minimum of 100 feet from any septic tanks or drainfields (Chapter 246-272A-0210 WAC). The well should also be located outside the 100 year floodplain, or have the wellhead elevated at least 2 feet above the floodplain (Chapter 173-160-291(2) WAC).

As discussed below, one advantage of completing a well in the sandstone beneath the basalt is that relatively few wells in the area are completed in this unit. A well completed in this unit would be less susceptible to contamination entering the aquifer through poorly constructed or maintained domestic wells.

5.4 Well Siting Recommendation

We recommend completing a future community supply well in one of two locations:

- **Location 1** - About a ½ mile northwest of Dryad along on Chandler Road between Dunn Creek and Marcuson Creek; and
- **Location 2** - Midway between Doty and Dryad at approximately 268 Doty Dryad Road near the intersection of Sections 1 and 2;
- Each of these locations lie outside the concentrated areas of coliform detections associated with possible shallow groundwater contamination in the Doty and Dryad areas and therefore, reduces the probability of coliform contamination occurring in the well. In addition, both locations are outside of the 2007 flood zone. Considerations for each of these locations are discussed below. The County had expressed interest in a well at the emergency command center in Dryad. Considerations are also provided for a well at this location.

Considerations for Location 1

Of the two locations, Location 1 (Chandler Road location) is preferred as well yields appear somewhat greater in this area than at Location 2. Location 1 is also topographically higher than Location 2, significantly reducing chances of the wellhead being inundated during future flooding. A target aquifer depth between 150 and 250 feet should be anticipated with completion in the Montesano Sandstone above the Grande Ronde Basalt. Deeper completions will minimize the chances for coliform contamination and increase the available drawdown in the well, leading to higher well yields. To minimize chances for coliform contamination, the well should be completed at a minimum depth of 150 feet. At this depth, the well will likely be completed in the Montesano Sandstone, above the Grande Ronde Basalt.

Considerations for Location 2

At location 2, the well should be completed in the Astoria Formation sandstone lying beneath the Grande Ronde Basalt with a target depth of about 200 to 250 feet below ground surface. Although it will be more expensive than drilling a shallower well, there are two advantages to completing a well in the sandstone below the basalt. The first reason is that the basalt will act as an aquitard, reducing the potential for surface contamination to migrate to the underlying sandstone tapped by the well. Although coliform data from wells completed beneath the basalt are limited, coliform was not detected in any of the five wells for which data are available. Similarly, only seven domestic wells were identified that tap the sandstone below the basalt, such that a well completed below the basalt would be less susceptible to contamination introduced through poorly maintained domestic wells.

The second advantage is that a deeper well will have a longer water column above the well screen and pump, allowing for more available drawdown during pumping. For example, using the average specific capacity for wells in the area of 0.2 gpm/ft, a 100-foot increase in the available drawdown would translate into an increased yield of about 20 gpm.

Considerations Common to Both Locations

At either location, the wells should be located outside the flood plain and protected to avoid exposure to floodwaters and potential introduction of contaminants to the wellhead. The well should also be located at least 100 feet from any septic system tanks and drainfields.

Emergency Command Center Location

The County indicated a preferred location near the Dryad emergency command center. However, because of persistent coliform detections in the nearby Baptist Church well and other coliform detections in the Dryad area, we have concerns that coliform may be present in the shallow aquifer in this area and not related to isolated occurrences. If a well were drilled at the Dryad emergency command center, the following steps should be taken to minimize the chances for coliform contamination:

- Disinfect throughout the drilling process to minimize the opportunity for drag-down of coliform contamination during drilling.
- Increase the length of the surface seal from 18 to at least 50 feet. The surface seal should be terminated in a non-water bearing portion of the sandstone. A surface seal constructed in this manner will minimize the opportunity for creating a conduit for coliform impacted water to migrate downward outside the well casing.
- Complete the well beneath Grand Ronde Basalt (nominal depth 200 feet) as described above for Location 2.

6 References

Aspect Consulting, LLC, 2008, Data Summary and Recommended Data Collection, Memorandum to Shirley Kook and Sue Kennedy, Lewis County, November 5.

Harris, C. and Schuster, J.E., 2000, 1:100,000-Scale Digital Geology of Washington State, Washington State Department of Natural Resources, Division of Geology and Earth Resources.

Weigle, J.M. and Foxworthy, B. L., 1962, Geology Ground-Water Resources of West-Central Lewis County, Washington, Water Supply Bulletin No. 17, State of Washington Department of Conservations, Division of Water Resources.

Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Lewis County Department of Public Works for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

Table 1 - Well Yield and Drawdown Data

Project No. 080192
Doty-Dryad Hydrogeological Assessment
Lewis County, WA

Ecology Well ID	Township	Range	Section	Well Yield (gpm)	Drawdown (feet)	Specific Capacity (gpm/ft)
11074	13N	4W	4	7	140	0.05
15217	13N	4W	4	20	80	0.3
18406	13N	4W	5	11	115	0.1
13433	13N	4W	5	8	75	0.1
17516	13N	4W	5	6	26	0.2
13624	13N	4W	6	10	100	0.1
19694	13N	4W	7	11	70	0.2
19695	13N	4W	7	25	47	0.5
272005	13N	4W	7	34	30.3	1.1
10918	13N	4W	8	5.5	60	0.09
17830	13N	4W	8	5	20	0.3
522603	13N	4W	9	1	110	0.009
16501	13N	4W	9	6	130	0.05
18599	13N	4W	9	6	100	0.06
521646	13N	4W	9	4	62	0.06
16499	13N	4W	9	10	20	0.5
15175	13N	4W	10	3	220	0.01
18843	13N	4W	10	75	150	0.5
16346	13N	5W	1	4	90	0.04
12539	13N	5W	1	15	120	0.1
13014	13N	5W	1	11	88	0.1
13361	13N	5W	1	15	100	0.2
18238	13N	5W	1	12	60	0.2
16609	13N	5W	1	13	51.5	0.3
14502	13N	5W	1	10	35	0.3
19099	13N	5W	1	6	20	0.3
14308	13N	5W	1	24	40	0.6
14662	13N	5W	2	5	70	0.07
14667	13N	5W	2	10	105	0.1
16427	13N	5W	2	14	143	0.1
13814	13N	5W	2	8	74	0.1
12877	13N	5W	2	6.5	60	0.1
17633	13N	5W	2	11	100	0.1
191393	13N	5W	2	4	34	0.1
12618	13N	5W	2	10	36	0.3
12125	13N	5W	2	9	20	0.5
527176	13N	5W	3	5	75	0.07
375986	13N	5W	3	5	71	0.07
336241	13N	5W	3	5	70	0.07
19644	13N	5W	3	20	95	0.2
18783	13N	5W	3	2	8	0.3
16301	13N	5W	3	10	40	0.3
19937	13N	5W	4	6	10	0.6
251801	13N	5W	8	2	75	0.03
527160	13N	5W	9	2.5	55	0.05
271671	13N	5W	9	8	120	0.07
11107	13N	5W	9	5	40	0.1

Table 1 - Well Yield and Drawdown Data

Project No. 080192
Doty-Dryad Hydrogeological Assessment
Lewis County, WA

Ecology Well ID	Township	Range	Section	Well Yield (gpm)	Drawdown (feet)	Specific Capacity (gpm/ft)
11106	13N	5W	9	20	19	1.1
59956	13N	5W	11	6	40	0.2
11035	13N	5W	12	1.7	155	0.01
15633	13N	5W	12	6	243	0.02
13793	13N	5W	12	5	185	0.03
19685	13N	5W	12	30	220	0.1
375988	13N	5W	12	20	85	0.2

Table 2 - Nitrate in Groundwater Data

Project No. 080192
Doty-Dryad Hydrogeological Assessment
Lewis County, WA

Ecology Well ID	Address	Parcel Number	Township	Range	Section	Date Collected	Nitrate Concentration (mg/L)
326654	224 LEUDINGHAUS RD	19235000000	13N	4W	4	10/9/2002	<0.2
358968	120 LEUDNGHAUS RD	19230001000	13N	4W	4	1/20/2003	0.3
10987	508 LEUDINGHAUS RD	19242001008	13N	4W	5	3/29/1999	<0.2
423956	478 LEUDINGHAUS RD	19242001013	13N	4W	5	10/3/2006	<0.2
455505	380 LEUDINGHAUS RD	19243014000	13N	4W	5	2/7/2007	0.2
495039	0 LEUDINGHAUS RD	19243020000	13N	4W	5	8/29/2007	<0.5
495039	0 LEUDINGHAUS RD	19243020000	13N	4W	5	10/31/2007	<0.5
313913	582 LEUDINGHAUS RD	19254001008	13N	4W	6	3/19/2002	0.3
10918	239 HATCHERY RD	19268007000	13N	4W	8	12/8/1998	0.4
16632	449 LEUDINGHAUS RD	19272011003	13N	4W	8	7/19/1999	<0.2
19040	3484 ST HWY 6	19301003000	13N	4W	8	5/19/1998	0.3
19397	3883 ST HWY 6	19273005003	13N	4W	8	9/9/1998	<0.2
21507	239 HATCHERY RD	19268007000	13N	4W	8	12/8/1998	0.4
123392	449 LEUDINGHAUS RD	19272011003	13N	4W	9	7/19/1999	<0.2
521646	186 LEUDINGHAUS RD	19226002000	13N	4W	9	5/6/2008	<0.5
18414	481 RIVER RD	19301007000	13N	4W	10	7/22/2008	1.3
12539	197 5TH ST DRYAD	19824000000	13N	5W	1	9/6/2005	<0.2
249407	740 A LEUDINGHAUS RD	19735002000	13N	5W	1	5/31/2005	0.5
250714	702 LEUDINGHAUS RD	19751001000	13N	5W	1	10/30/2000	<0.2
387544	316 CHANDLER RD	19695001001	13N	5W	1	3/29/2004	0.3
14662	109 1ST ST	10247001000	13N	5W	2	9/4/2003	0.9
20338	178 DOTY ST	19772001001	13N	5W	2	6/15/1998	0.3
336107	471 CHANDLER RD	19770008000	13N	5W	2	3/9/2004	0.2
344714	105 & 166 TRUMAN LN	19772001002	13N	5W	2	10/21/2002	<0.2
362671	166 TRUMAN LN	19772002000	13N	5W	2	9/15/2003	0.3
370809	146 TRUMAN LN	19765000000	13N	5W	2	8/5/2003	<0.2
387173	266 DOTY DRYAD RD	19822002002	13N	5W	2	6/6/2007	<0.5
477475	129 5TH ST	19820000000	13N	5W	2	5/16/2007	<0.5
14072	468 CHANDLER RD	19768001000	13N	5W	3	6/16/1998	<0.2
336241	747 22 CHANDLER RD	19912003006	13N	5W	3	8/23/2006	<0.2
344716	792 CHANDLER RD	19909000000	13N	5W	3	10/21/2002	<0.2
527160	213 BAGSHAW RD	19971001001	13N	5W	9	1/22/2007	0.3
12729	4133 ST RTE 6	20038000000	13N	5W	12	12/18/2002	0.2

Notes:
mg/L - milligrams per liter
< - not detected at indicated detection limit

Table 3 - Pre-Flood Coliform Data with Associated Well Logs

Project No. 080192
Doty-Dryad Hydrogeological Assessment
Lewis County, WA

Ecology Well ID	Address	Parcel Number	Well Depth (feet)	Township	Range	Section	Date Collected	Total Coliform	E coli
362124	158 LEUDINGHAUS RD	19227000000	230	13N	4W	4	5/11/1994	a	
362124	158 LEUDINGHAUS RD	19227000000	230	13N	4W	4	8/6/2007	a	
358968	120 LEUDINGHAUS RD	19230001000	300	13N	4W	4	1/20/2003	a	
16674	406 LEUDINGHAUS RD	19242001005	100	13N	4W	5	10/9/2001	a	
423956	478 LEUDINGHAUS RD	19242001013	80	13N	4W	5	10/3/2006	a	
17516	397 LEUDINGHAUS RD	19243010000	48	13N	4W	5	2/21/1995	a	
455505	380 LEUDINGHAUS RD	19243014000	59	13N	4W	5	2/7/2007	p	a
455505	380 LEUDINGHAUS RD	19243014000	59	13N	4W	5	2/13/2007	a	
13433	346 LEUDINGHAUS RD	19243033001	105	13N	4W	5	8/6/1996	a	
13433	346 LEUDINGHAUS RD	19243033001	105	13N	4W	5	11/9/1999	a	
430098	652 LEUDINGHAUS RD	19250001000	100	13N	4W	6	3/5/2007	a	
13624	600 C LEUDINGHAUS RD	19252005002	130	13N	4W	6	3/24/1998	a	
367708	3956 A ST HWY 6	19256003000	100	13N	4W	7	3/19/1997	a	
19397	3883 ST HWY 6	19273005003	52	13N	4W	7	1/27/1998	p	a
13826	4149 ST HWY 6	20039000000	167	13N	4W	7	7/26/1999	p	a
13826	4149 ST HWY 6	20039000000	167	13N	4W	7	8/9/1999	a	
21507	239 HATCHERY RD	19268007000	100	13N	4W	8	1/4/1994	a	
21507	239 HATCHERY RD	19268007000	100	13N	4W	8	3/11/1996	a	
21507	239 HATCHERY RD	19268007000	100	13N	4W	8	12/8/1998	a	
21507	239 HATCHERY RD	19268007000	100	13N	4W	8	4/6/1999	a	
19040	3484 ST HWY 6	19301003000	95	13N	4W	8	6/14/1995	a	
521646	186 LEUDINGHAUS RD	19226002000	80	13N	4W	9	3/17/1998	a	
521646	186 LEUDINGHAUS RD	19226002000	80	13N	4W	9	1/18/2000	p	p
522603	204 LEUDINGHAUS RD	19282003000	130	13N	4W	9	8/14/2006	a	
470199	491 RIVER RD	19205007002	160	13N	4W	10	3/14/2007	a	
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	4/6/1998	p	
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	7/26/1999	a	
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	1/8/2001	a	
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	10/24/2001	p	a
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	11/13/2001	p	a
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	1/2/2002	a	
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	1/9/2002	a	
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	1/26/2003	a	
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	3/16/2004	a	
12922	112 OLIVE STREET	010201000000	40	13N	5W	1	8/23/2005	a	
11980	222 KOBE RD	19683000000	200	13N	5W	1	6/1/1998	p	a
11980	222 KOBE RD	19683000000	200	13N	5W	1	6/8/1998	p	a
441015	361 CHANDLER RD	19693001004	80	13N	5W	1	9/18/2006	a	

Table 3 - Pre-Flood Coliform Data with Associated Well Logs

Project No. 080192
Doty-Dryad Hydrogeological Assessment
Lewis County, WA

Ecology Well ID	Address	Parcel Number	Well Depth (feet)	Township	Range	Section	Date Collected	Total Coliform	E coli
14308	324 CHANDLER RD	19695001003	64	13N	5W	1	8/1/1994	a	
12539	197 RAILROAD AVE	19824000000	138	13N	5W	1	8/22/2005	a	
399492	212 STEVENS RD	10242000000	115	13N	5W	2	3/17/2005	a	
14662	109 1ST ST	10247001000	80	13N	5W	2	9/3/2003	p	a
19767	185 STEVENS RD	10264000000	120	13N	5W	2	10/11/1994	p	a
370809	146 TRUMAN LN	19765000000	155	13N	5W	2	8/5/2003	p	a
123730	0 CHANDLER RD	19766001000	318	13N	5W	2	6/19/1996	p	a
14667	499 CHANDLER RD	19770006000	180	13N	5W	2	10/6/1999	a	
14667	499 CHANDLER RD	19770006000	180	13N	5W	2	4/16/2002	a	
336107	471 CHANDLER RD	19770008000	180	13N	5W	2	3/9/2004	a	
362671	166 TRUMAN LN	19772002000	160	13N	5W	2	9/15/2003	a	
252645	368 DOTY DRYAD RD	19815001000	90	13N	5W	2	1/20/1998	p	a
252645	368 DOTY DRYAD RD	19815001000	90	13N	5W	2	1/27/1998	a	
477475	129 5TH ST	19820000000	180	13N	5W	2	5/16/2007	a	
387173	266 DOTY DRYAD RD	19822002002	163	13N	5W	2	6/11/2007	a	
350814	115 STODDARD RD	19834001000	103	13N	5W	2	12/28/2004	a	
15245	156 ELK CREEK RD	19901001000	140	13N	5W	3	10/22/2001	a	
19406	760 CHANDLER RD	19907003000	36	13N	5W	3	9/6/1995	a	
19406	760 CHANDLER RD	19907003000	36	13N	5W	3	12/1/1997	p	a
344716	792 CHANDLER RD	19909000000	90	13N	5W	3	10/31/1995	p	a
344716	792 CHANDLER RD	19909000000	90	13N	5W	3	5/4/1998	p	a
18783	751 CHANDLER RD	19912001001	20	13N	5W	3	6/6/2005	p	p
18783	751 CHANDLER RD	19912001001	20	13N	5W	3	6/20/2005	p	a
18783	751 CHANDLER RD	19912001001	20	13N	5W	3	7/5/2005	a	
336241	747 22 CHANDLER RD	19912003006	125	13N	5W	3	8/23/2006	a	
527160	213 BAGSHAW RD	19971001001	65	13N	5W	9	1/22/2007	a	
500023	515 ELK CREEK RD	19974005001	160	13N	5W	9	9/13/2006	a	
11035	4149 ST HWY 6	20039000000	193	13N	5W	12	7/26/1999	p	a
11035	4149 ST HWY 6	20039000000	193	13N	5W	12	8/9/1999	a	
375988	829 LEUDINGHAUS RD	20043001000	143	13N	5W	12	5/18/1994	a	
272101	205 DOTY DRYAD RD	20058001000	105	13N	5W	12	3/14/1994	a	

Notes:
"a" indicates total coliform or E Coli absent in sample, "p" indicates total coliform or E. Coli present in sample
Samples with total coliform or E. coli present are shaded gray.

Table 4 - Post-Flood Coliform Data with Associated Well Logs

Project No. 080192
Doty-Dryad Hydrogeological Assessment
Lewis County, WA

Ecology Well ID	Address	Parcel Number	Well Depth (feet)	Township	Range	Section	Date Collected	Total Coliform	E coli
15176	707 MESKILL RD	19204001000	265	13N	4W	3	1/16/2008	a	
326654	224 LEUDINGHAUS RD	19235000000	97	13N	4W	4	5/5/2008	a	
428058	508-10 LEUDINGHAUS RD	19242001011	243	13N	4W	5	12/15/2007	a	
455505	380 LEUDINGHAUS RD	19243014000	59	13N	4W	5	12/17/2007	a	
495039	146 LABARRE RD	19243020000	100	13N	4W	5	12/15/2007	p	a
495039	146 LABARRE RD	19243020000	100	13N	4W	5	12/27/2007	a	
16753	120 LABARRE RD	19243025001	120	13N	4W	5	12/7/2007	p	a
16753	120 LABARRE RD	19243025001	120	13N	4W	5	12/20/2007	a	
13433	346 LEUDINGHAUS RD	19243033001	105	13N	4W	5	12/14/2007	p	a
13433	346 LEUDINGHAUS RD	19243033001	105	13N	4W	5	1/2/2008	p	a
13433	346 LEUDINGHAUS RD	19243033001	105	13N	4W	5	1/15/2008	a	
430098	652 LEUDINGHAUS RD	19250001000	100	13N	4W	6	4/29/2008	a	
313914	582 LEUDINGHAUS RD	19254001008	160	13N	4W	6	12/7/2007	p	p
313914	582 LEUDINGHAUS RD	19254001008	160	13N	4W	6	3/5/2008	p	a
313914	582 LEUDINGHAUS RD	19254001008	160	13N	4W	6	3/5/2008	p	a
14841	3935 STATE HIGHWAY 6	19256002000	242	13N	4W	7	1/8/2008	a	
367708	3956 A STATE ROUTE 6	19256003000	100	13N	4W	7	1/3/2008	a	
272341	4008 STATE ROUTE 6	19262000000		13N	4W	7	4/15/2008	a	
19695	4102 STATE HIGHWAY 6	19263003000	89	13N	4W	7	12/27/2007	p	a
19695	4102 STATE HIGHWAY 6	19263003000	89	13N	4W	7	11/12/2008	p	a
20029	3796-A ST HWY 6	19268001007	160	13N	4W	8	12/18/2007	a	
21507	239 HATCHERY RD	19268007000	100	13N	4W	8	12/12/2007	a	
13850	433 LEUDINGHAUS RD	19272010000	81	13N	4W	8	7/15/2008	p	a
13850	433 LEUDINGHAUS RD	19272010000	81	13N	4W	8	7/21/2008	a	
19040	3484 HIGHWAY 6	19301003000	95	13N	4W	8	12/30/2007	p	a
19040	3484 ST HWY 6	19301003000	95	13N	4W	8	7/6/2008	a	
521646	186 LEUDINGHAUS RD	19226002000	80	13N	4W	9	5/6/2008	a	
13683	296 LEUDINGHAUS RD	19234001000	205	13N	4W	9	1/2/2008	a	
18599	237 HATCHERY RD	19270000000	126	13N	4W	9	12/27/2007	a	
387171	167 LEUDINGHAUS RD	19282002002	300	13N	4W	9	1/8/2008	a	
470199	491 RIVER RD	19205007002	160	13N	4W	10	1/2/2008	a	
470199	491 RIVER RD	19205007002	160	13N	4W	10	4/14/2008	a	
11980	222 KOBE RD	19683000000	200	13N	5W	1	1/23/2008	p	a
11980	222 KOBE RD	19745000000	200	13N	5W	1	11/12/2008	p	a

Table 4 - Post-Flood Coliform Data with Associated Well Logs

Project No. 080192
Doty-Dryad Hydrogeological Assessment
Lewis County, WA

Ecology Well ID	Address	Parcel Number	Well Depth (feet)	Township	Range	Section	Date Collected	Total Coliform	E coli
15058	337 CHANDLER RD	19693001003	125	13N	5W	1	12/19/2007	a	
249407	740A LEUDINGHAUS RD	19735002000	103	13N	5W	1	12/27/2007	p	a
249407	740A LEUDINGHAUS RD	19735002000	103	13N	5W	1	11/12/2008	p	a
386656	124 KOBE RD	19744000000	83	13N	5W	1	12/13/2007	a	
18238	134 KOBE RD	19745000000	111	13N	5W	1	12/6/2007	p	p
18238	134 KOBE RD	19745000000	111	13N	5W	1	12/19/2007	p	p
18238	134 KOBE RD	19745000000	111	13N	5W	1	12/31/2007	a	
250714	702 LEUDINGHAUS RD	19751001000	63	13N	5W	1	3/3/2008	a	
539558	264 DOTY DRYAD RD	19823001000	80	13N	5W	1	12/12/2007	a	
271205	130 CEDAR ST	10229001000		13N	5W	2	12/19/2007	p	a
271205	130 CEDAR ST	10229001000		13N	5W	2	11/12/2008	a	
362671	166 TRUMAN LN	19772002000	160	13N	5W	2	12/13/2007	a	
12877	200 STEVENS RD	19793006000	80	13N	5W	2	12/17/2007	p	a
12877	200 STEVENS RD	19793006000	80	13N	5W	2	12/28/2007	p	a
12877	200 STEVENS RD	19793006000	80	13N	5W	2	11/12/2008	p	a
12125	346 DOTY DRYAD RD	19818001000	82	13N	5W	2	12/13/2007	p	a
12125	346 DOTY DRYAD RD	19818001000	82	13N	5W	2	12/20/2007	p	a
12125	346 DOTY DRYAD RD	19818001000	82	13N	5W	2	12/27/2007	a	
350814	115 STODDARD RD	19834001000	103	13N	5W	2	1/15/2008	a	
19216	117 FOWLER RD	19859000000	140	13N	5W	2	12/14/2007	a	
15245	156 ELK CREEK RD	19901001000	140	13N	5W	3	3/17/2008	a	
272101	205 DOTY DRYAD RD	20058001000	105	13N	5W	12	12/17/2007	a	

Notes:
"a" indicates total coliform or E Coli absent in sample, "p" indicates total coliform or E. Coli present in sample
Samples with total coliform or E. coli present are shaded gray.

Table 6 - Wellhead Inspection

Project No. 080192
Doty-Dryad Hydrogeological Assessment
Lewis County, WA

Ecology Well ID	Address	Parcel Number	Inspection Notes	Coliform Sampling Results
11980	222 KOBE RD	019683000000	**Broken conduit**	Coliform detected in all pre- and post-flood samples.
12877	200 STEVENS RD	019793006000	**Broken conduit, open wiring**	Coliform detected in all post-flood samples.
249407	740A LEUDINGHAUS RD	019735002000	**Broken conduit, open wiring**	Coliform detected in all post-flood samples.
13433	346 LEUDINGHAUS RD	019243033001	**Open wiring**, secondary treatment softening & filtration	Coliform not detected in pre-flood samples. Coliform detected in initial post-flood samples, but not in final sample.
19695	4102 ST HWY 6	019263003000	Well in garage, no disinfection since last sample, **open wiring**	Coliform detected in all post-flood samples.
272101	205 DOTY DRYAD RD	020058001000	**Missing bolts at well cap, loose conduit**	Coliform not detected in pre- or post-flood samples.
271205	130 CEDAR ST	010229001000	Same well as 240 Stevens Rd	Coliform detected in initial post-flood sample, but not in final sample.
350814	115 STODDARD RD	019834001000	No observed well deficiency	Coliform not detected in pre- or post-flood samples.
15245	156 ELK CREEK	019901001000	No observed well deficiency	Coliform not detected in pre- or post-flood samples.
521646	186 LEUDINGHAUS RD	019226002000	Pitless adapter exposed but intact, elect conduit intact, no well deficiencies observed	Coliform detected in one of two pre-flood samples; not detected in post-flood sample.
455505	380 LEUDINGHAUS RD	019243014000	No observed well deficiency	Coliform detected in one of two pre-flood samples; not detected in post-flood sample.
362124	158 LEUDINGHAUS RD	019227000000	Well under pressure, one way vent	Coliform not detected in pre-flood samples. No post-flood samples collected.
430098	653 LEUDINGHAUS RD	019250001000	No observed well deficiency	Coliform not detected in pre- or post-flood samples.
470199	491 RIVER RD	019205007002	Well under pressure, one way vent, did not sterilize	Coliform not detected in pre- or post-flood samples.
21507	239 HATCHERY RD	019268007000	No observed well deficiency	Coliform not detected in pre- or post-flood samples.
367708	3956 A ST HWY 6	019256003000	No observed deficiency at well, poly storage tank above grd in roofed leanto	Coliform not detected in pre- or post-flood samples.

Well deficiencies that could act as routes for coliform to enter a well are shown in **bold.**

Study Area

Estimated Flood Extent

Watercourses

Well Logs

(Placement Description)

- Parcel ID Number
- Well Address
- Owner Address
- Mix of possible clues from owner name, road name, and general location
- Least confident matches due multiple possibilities or limited info
- Qtr-Qtr Section

Deer Creek
Capps Creek
Absher Creek
Dunn Creek
Marcuson Creek
Dell Creek
Garret Creek
Prairie Creek
Bunker Creek
Elk Creek
Nine Creek
Chehalis River
Hope Creek
Fronia Creek
Katula Creek
Doty
Dryad
Mutinen
CERES HILL

0 1,500 3,000 6,000 9,000 12,000 Feet

Aspect consulting
earth + water
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Study Area and Well Location Map

Doty-Dryad Hydrogeologic Assessment
Lewis County, WA

DATE: Nov 2008	PROJECT NO. 080192
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 1
REVISED BY: -	

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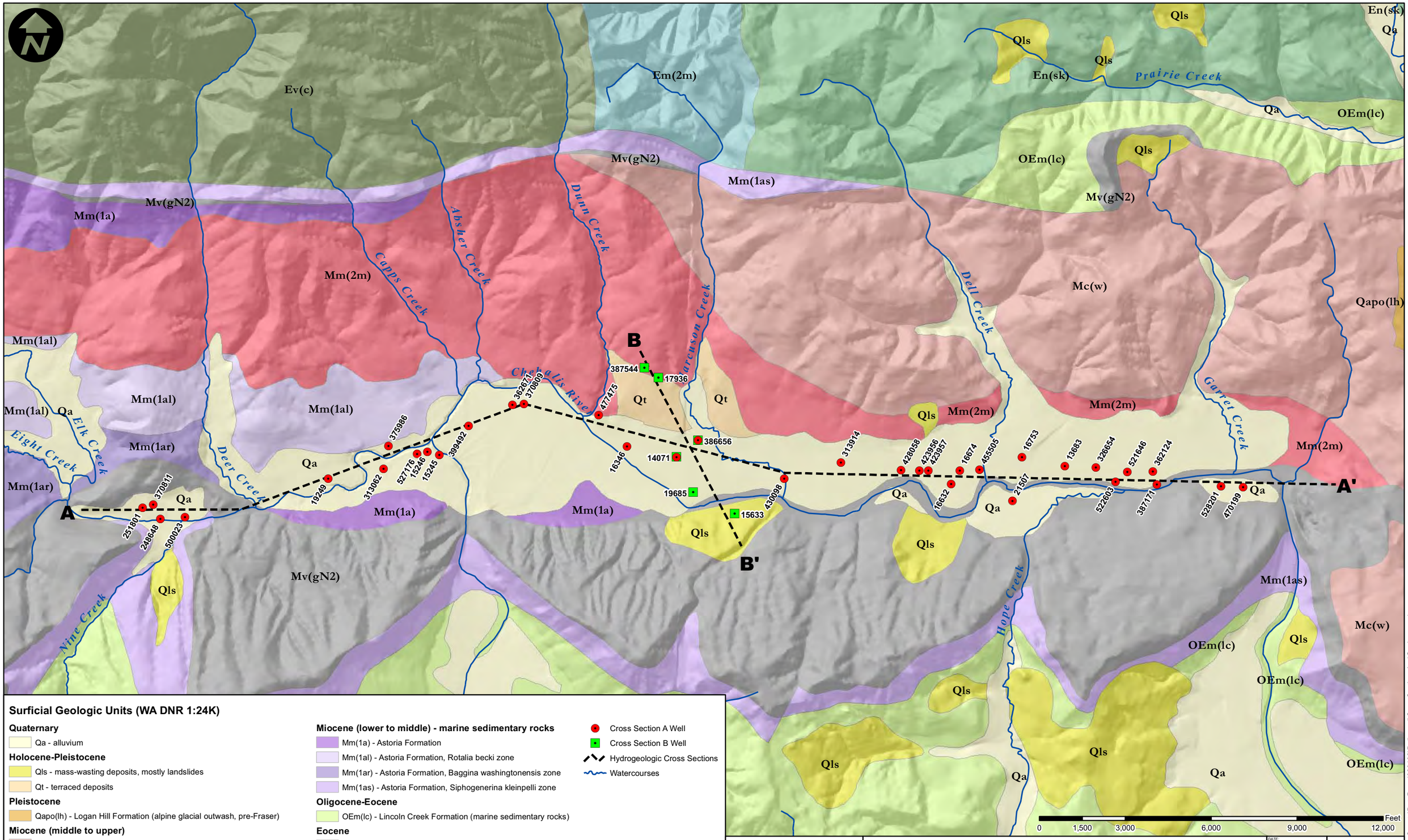

Surficial Geologic Units (WA DNR 1:24K)

Quaternary
- Qa - alluvium

Holocene-Pleistocene
- Qls - mass-wasting deposits, mostly landslides
- Qt - terraced deposits

Pleistocene
- Qapo(lh) - Logan Hill Formation (alpine glacial outwash, pre-Fraser)

Miocene (middle to upper)
- Mc(w) - Wilkes Formation (continental sedimentary deposits or rocks)
- Mm(2m) - Montesano Formation (marine sedimentary rocks)

Miocene (middle)
- Mv(gN2) - Grande Ronde Basalt (basalt flows (upper flows of norm.mag.pol.)

Miocene (lower to middle) - marine sedimentary rocks
- Mm(1a) - Astoria Formation
- Mm(1al) - Astoria Formation, Rotalia becki zone
- Mm(1ar) - Astoria Formation, Baggina washingtonensis zone
- Mm(1as) - Astoria Formation, Siphogenerina kleinpelli zone

Oligocene-Eocene
- OEm(lc) - Lincoln Creek Formation (marine sedimentary rocks)

Eocene
- Em(2m) - McIntosh Formation (marine sedimentary rocks)
- En(c) - Cowlitz Formation (nearshore sedimentary rocks)
- En(sk) - Skookumchuck Formation (nearshore sedimentary rocks)
- Ev(c) - Crescent Formation (basalt flows and flow breccias)

- Cross Section A Well
- Cross Section B Well
- Hydrogeologic Cross Sections
- Watercourses

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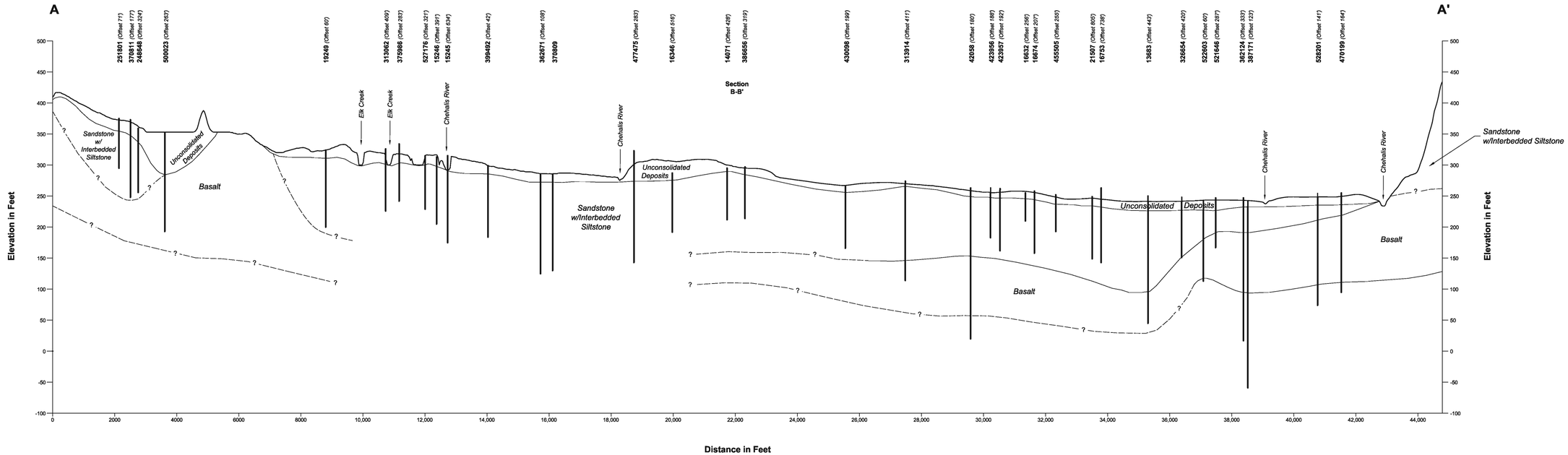
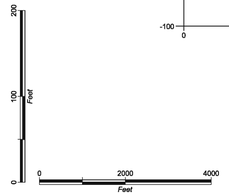
Cross Section Location Map

Doty-Dryad Hydrogeologic Assessment
Lewis County, WA

DATE: Nov 2008	PROJECT NO. 080192
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 2
REVISED BY: -	

T:\projects_8\Lewis_County\DotyDryad080192\Delivered\CrossSectionsAndGeology.mxd





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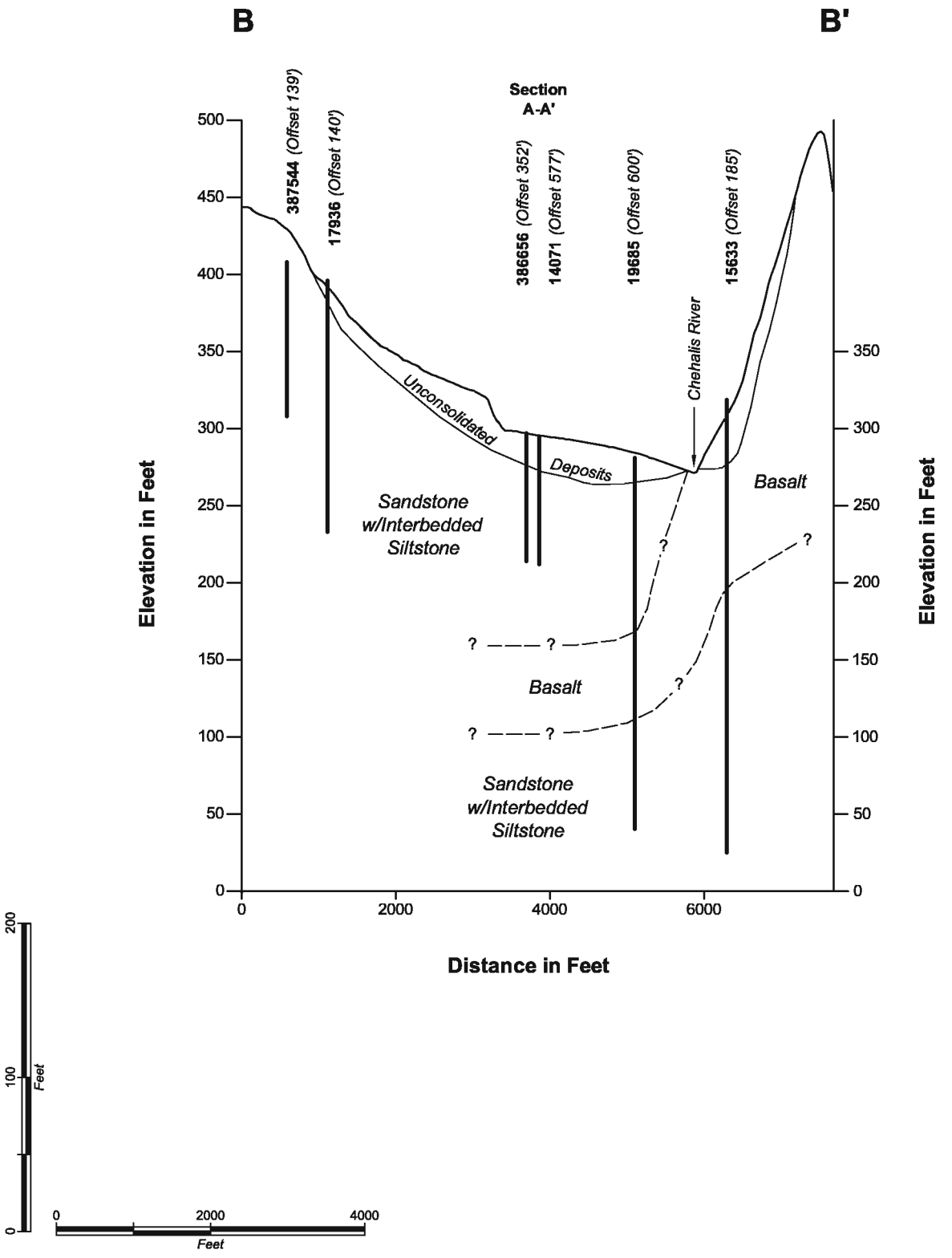
Cross Section A-A'

Doty-Dryad Hydrogeological Assessment
Lewis County, Washington

DATE: November 2008	PROJECT NO. 080192
DESIGNED BY: JM	
DRAWN BY: SCC	FIGURE NO. 3
REVISED BY: -	

Q:\Doty-Dryad\080192 Doty-Dryad hydrogeologic Assessment\2008-11 Hydrogeologic Assessment\080192-BB.dwg



Cross Section B-B'

Doty-Dryad Hydrogeological Assessment
Lewis County, Washington

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DATE: November 2008	PROJECT NO. 080192
DESIGNED BY: JM	
DRAWN BY: SCC	FIGURE NO. 4
REVISED BY: -	

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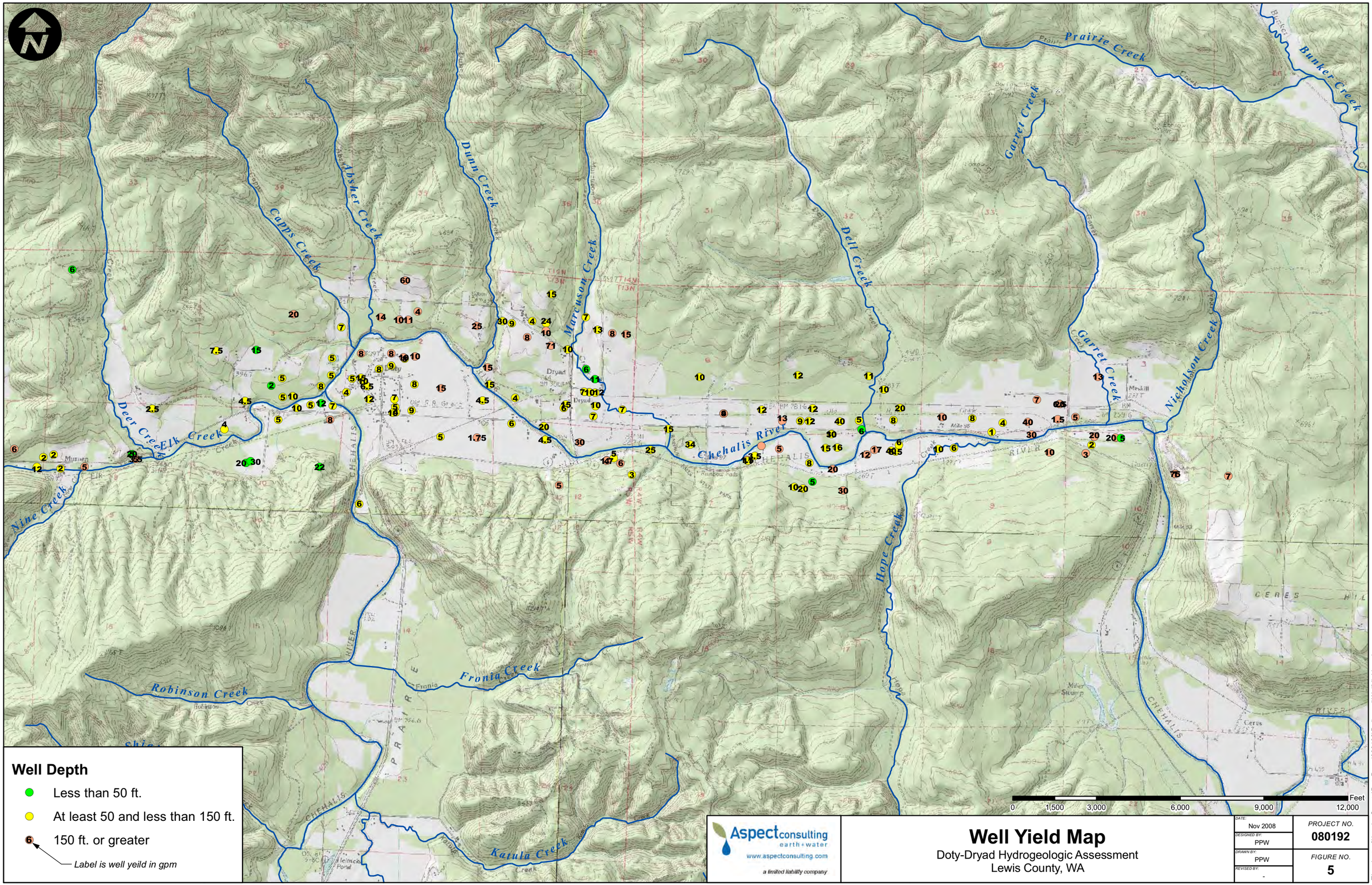

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Well Yield Map

Doty-Dryad Hydrogeologic Assessment
Lewis County, WA

DATE: Nov 2008	PROJECT NO. 080192
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 5
REVISED BY: -	

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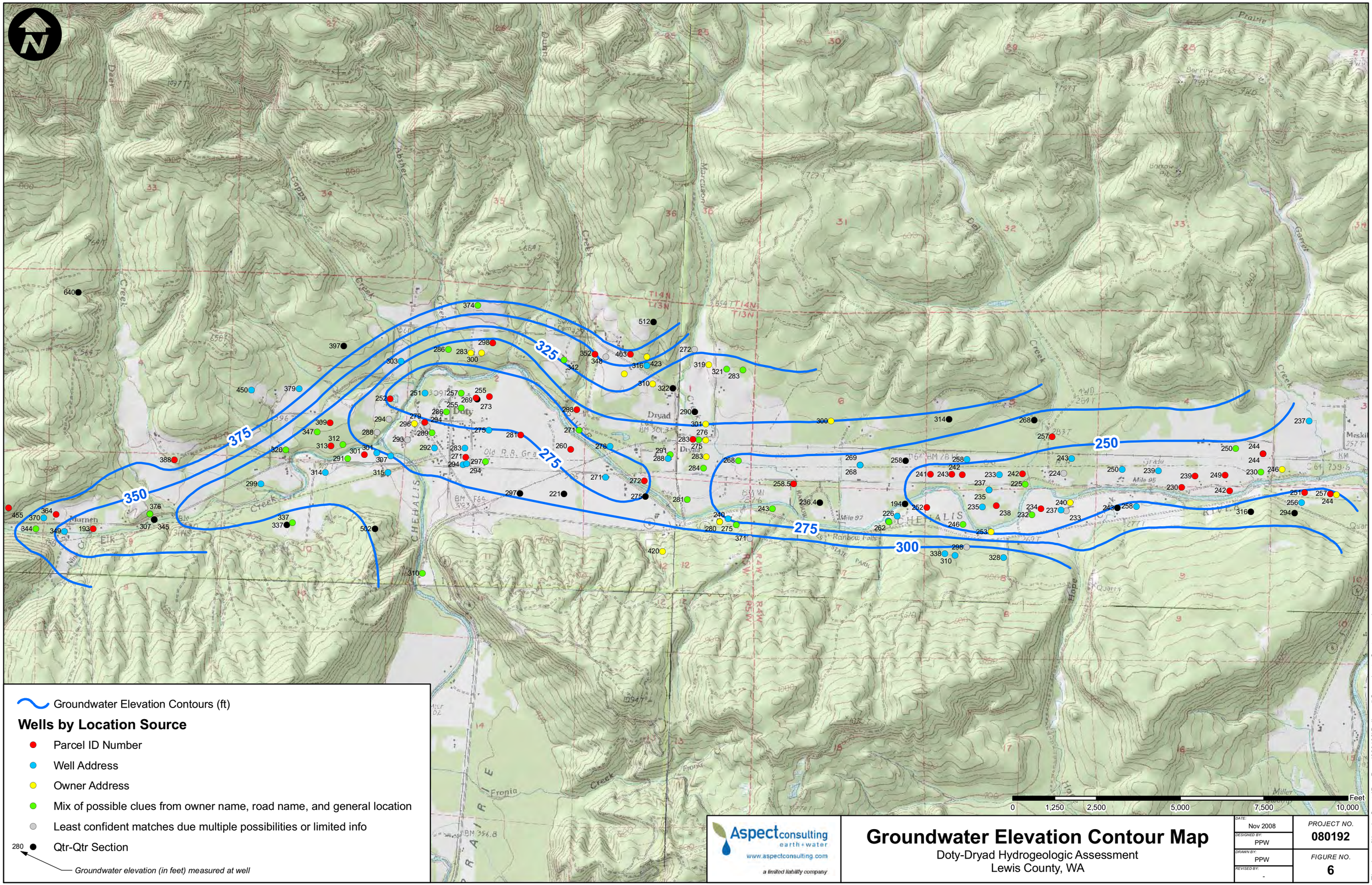

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Groundwater Elevation Contour Map

Doty-Dryad Hydrogeologic Assessment
Lewis County, WA

DATE: Nov 2008	PROJECT NO. 080192
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 6
REVISED BY: -	

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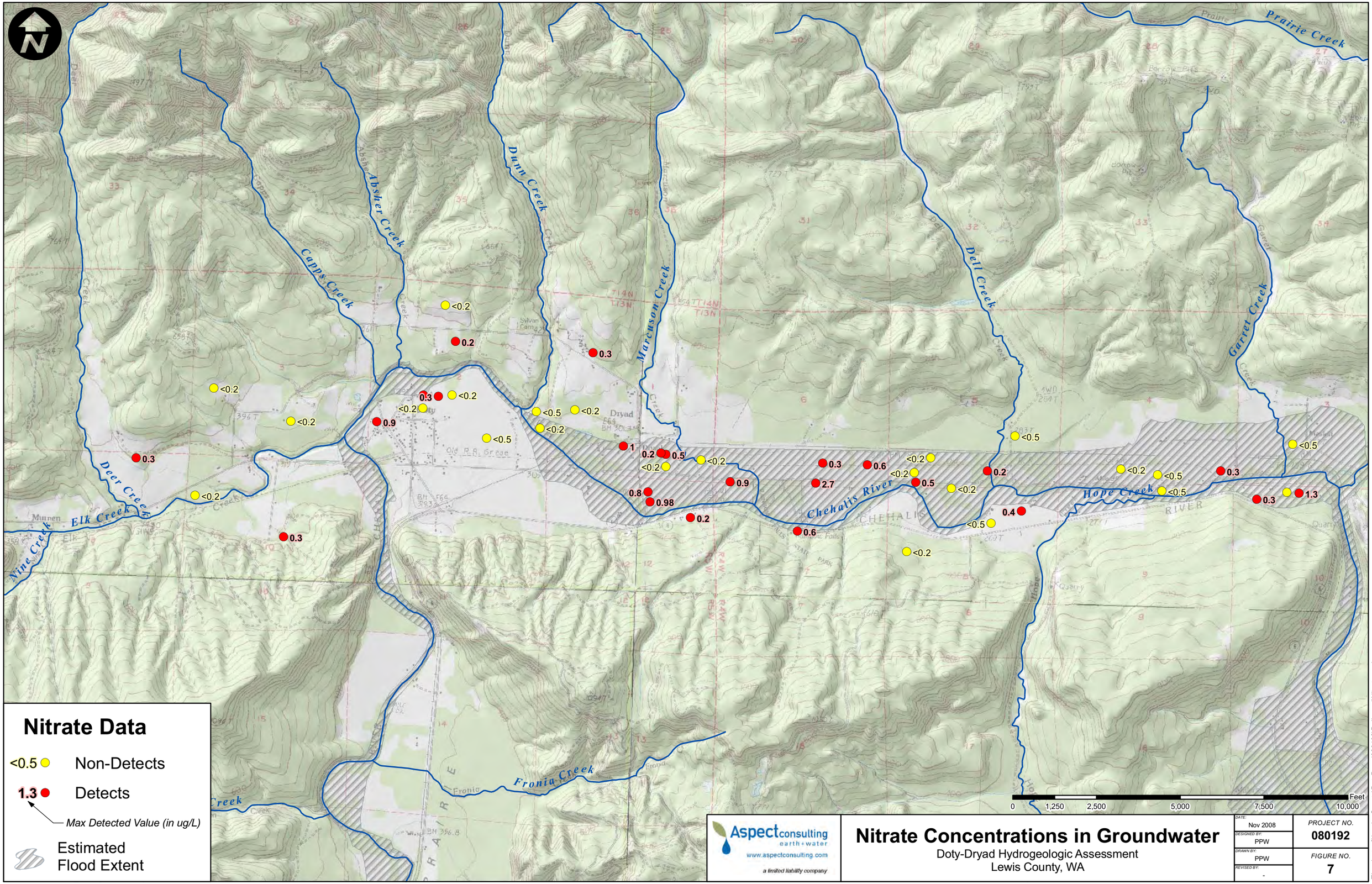

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Nitrate Concentrations in Groundwater

Doty-Dryad Hydrogeologic Assessment
Lewis County, WA

DATE: Nov 2008	PROJECT NO. 080192
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 7
REVISED BY: -	

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Pre-Flood Coliform Data

- Never detected
- Detected, re-sampled, subsequent clean (coliform absent)
- Initially clean, then detect, then last result clean
- Initially clean, then last result detect
- Detected and not re-sampled
- Detected, re-sampled, detected

Label indicates number of samples at given location

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Pre-Flood Coliform Data

Doty-Dryad Hydrogeologic Assessment
Lewis County, WA

DATE: Nov 2008	PROJECT NO. 080192
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REVISED BY: -	

0 1,250 2,500 5,000 7,500 10,000 Feet

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Post-Flood Coliform Data

- Never Detected
- Detected, re-sampled, subsequent clean (coliform absent)
- Initially clean, then detect, then last result clean
- Detected and not re-sampled
- Detected, re-sampled, detected

Label indicates number of samples at given location

- Well with observed wellhead deficiency
- Estimated Flood Extent

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Post-Flood Coliform Data

Doty-Dryad Hydrogeologic Assessment
Lewis County, WA

DATE: Dec 2008	PROJECT NO. 080192
DESIGNED BY: PPW	
DRAWN BY: PPW	FIGURE NO. 9
REVISED BY: -	

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