HYDROLOGIC INFORMATION REPORT SUPPORTING WATER AVAILABILITY ASSESSMENT

Dallesport Peninsula Study Area, WRIA 30

Prepared for: WRIA 30 Water Resource Planning & Advisory Committee

Project No. 070024-013-01 • June 17, 2011

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1 Project Objectives and Report Organization

Within Water Resource Inventory Area 30 (WRIA 30), aka the Klickitat River basin, there are several areas with potential for substantial future growth, including portions of the Swale Creek, Little Klickitat, Lower Klickitat, and Columbia Tributaries subbasins. The WRIA 30 Watershed Management Plan [WPN and Aspect Consulting, LLC (Aspect), 2004] identified data gaps that needed to be addressed in order to help determine the quantities of water available for appropriation, including:

- Refine estimates of actual water use; and
- Delineate specific aquifer zones within the subbasins.

The WRIA 30 Watershed Management Plan calls for conducting water availability studies and collecting data that will facilitate the processing of water rights. Washington State Department of Ecology (Ecology) has provided funding (Grant No. G1000101) to complete water availability studies in priority areas of WRIA 30, including High Prairie (straddling western Swale Creek and eastern Lower Klickitat subbasins), the Fisher Hill/Appleton area (northwestern Lower Klickitat subbasin), and, the subject of this report, the Dallesport area (western Columbia Tributaries subbasin). Figure 1.1 depicts the various subbasins of WRIA 30 and the Dallesport study area within the Columbia Tributaries subbasin.

For previous water availability studies of the Little Klickitat and Swale Creek subbasins in WRIA 30 (Aspect, 2007), the PAC coordinated with John Kirk, hydrogeologist for Ecology Central Regional Office, regarding additional information required prior to Ecology’s processing of new water right applications. Based on these discussions, the following information was determined to be needed for the Dallesport area:

1. Determine how much additional water could be appropriated without exceeding the average annual recharge to the aquifer. Document uncertainty in that estimate.
2. Assuming all the water available was appropriated, quantitatively determine the pumping impact (magnitude and timing/duration) on the Columbia River, if any, and document uncertainty.
3. Obtain information about the aquifer hydraulic properties to allow assessment of interference\impairment to existing wells from the approval of new water rights.

Item 1 is related to water available for appropriation of new water rights. Items 2 and 3 are related to potential for impairment associated with new appropriations. It was previously agreed with Ecology that a quantitative assessment of pumping impacts is beyond the scope of this assessment; impairment can also depend on the quantity and location of new water rights being applied for. It was therefore decided that the best value from this assessment can be obtained by refining the hydrogeologic conceptual site model including collection of field data within the subbasin.

Therefore, the objectives of this assessment for the Dallesport study area include:

1. Creation of a hydrogeologic conceptual model, including the most definitive interpretation of the hydrostratigraphy and groundwater flow system to date;
2. Establishment of a groundwater level monitoring network; and
3. Creation of a study area-scale water balance, assisting in the determination of water availability for the study area.

1.1 Report Organization

The following sections of this report include:

- Water Level Monitoring
- Conceptual Model of Hydrogeologic Conditions
- Water Balance
- Conclusions and Recommendations

2 Water Level Monitoring

An important element of the study is establishment of a well network in which groundwater levels can be monitored. The water level data are used to evaluate groundwater flow directions within the aquifer system and, with continued long-term measurements, document aquifer response to short-term conditions (e.g. seasonal and pumping stresses) and longer-term trends that can provide empirical information regarding sustainable levels of groundwater withdrawal. This study established the well monitoring network and initiated three rounds of monitoring, which is hoped to be extended over the long term if funding remains available. The water level monitoring activities are described below.

2.1 Establishment of Well Monitoring Network

The primary area of focus for the groundwater level monitoring network was the Dallesport Peninsula, including both the Murdock and Fivemile Creek areas (Figure 1.1). The establishment of the water level monitoring network was conducted in accordance with a Quality Assurance Project Plan (QAPP) prepared for the project (Aspect, 2010a). Members of the PAC and local community assisted in the effort by contacting local well owners to request permission to access their well and inform them of the study objective.

The first step for establishing the network of wells in which to monitor groundwater levels involved compilation of addresses of prospective wells based on well locations from Ecology’s on-line well log database (http://apps.ecy.wa.gov/welllog/). Additional wells were added to the prospective water level monitoring network list based on personal contacts of local community members.

The prospective water level monitoring network wells were prioritized in order to (1) provide spatial coverage of the basin and (2) provide a representative number of wells completed in the various basalt aquifers to allow for potential differentiation of water levels within respective hydrostratigraphic units. For wells completed in the interflow zones between the basalt units, water levels were considered to be representative of the underlying basalt aquifer. Within the Dallesport study area, the alluvium, eolian, and Missoula Flood deposits are not considered to be significant aquifers due to the limited number of wells completed within the respective units. Therefore, for the purposes of this assessment, these aquifers (collectively termed unconsolidated aquifer) were not included in the water level monitoring network.

Once the list of prospective water level monitoring network wells was established, local well owners were contacted to request permission to access their wells as part of the field reconnaissance. Only wells for which owner permission was granted were visited as part of the field reconnaissance. If permission was not granted for a well in an area of needed spatial coverage, the well owner of a lower priority prospective water level monitoring network well was contacted in its place. If a well owner granted permission to access their well, but wanted to be present during the measurements, personnel from Aspect or

Klickitat County Natural Resources Department called and set up a time with the respective owner in which to do so.

Personnel from Aspect and Klickitat County Natural Resources Department conducted a field reconnaissance the week of April 12-16, 2010, with the objective of identifying accessible existing wells to include in the monitoring network. During the field reconnaissance, each wellhead was examined in the field to determine whether an access port was available for the respective water level measurements. If suitable access existed, the depth to water in the well was measured. Because most of the wells measured had pumps installed, care was taken to avoid getting the electric water level indicator, if used, caught on pump wiring or other items in the well. Only wells for which water levels could be readily measured were retained as part of the water level monitoring network. The location of the wells retained for the water level monitoring network were documented with field notes, photographs, and surveyed locations so that subsequent water level measurements can be taken if owner permission is received.

Following completion of the field reconnaissance, the water level monitoring network for the Dallesport study area consisted of 25 wells. This includes 11 wells in the Dallesport area, 9 wells in the Murdock area, and 5 wells in the Fivemile Creek area, as depicted on Figure 2.1. Table 2.1 summarizes information regarding wells in the network, including address, date of construction, depth, inferred aquifer unit of completion, and survey data.

Several wells were included in the monitoring network even though no water level measurements were initially taken during the April 2010 event. This includes wells T02/R13-16K2 and T02/R13-25N1, which had air lines that could not be operated reliably; and well T02/R13-13B1, which was obstructed for access of the water level sounder so did not provide an accurate water level measurement. Attempts to collect water level measurements from these wells were made during subsequent water level monitoring events. In addition, there were two wells in which we received owner permission to monitor, but water level measurements could not be collected due to the lack of an access port at the wellhead, or an obstruction within the well (T02/R13-27G1 and T02/R13-33J2, respectively). These wells were not included in the water level monitoring network.

During the second round of water level measurements, during the week of November 30 - December 3, 2010 (described below), it was determined that it would not be possible to collect water levels from well T02/R13-13B1, which had previously been obstructed. This well was thus removed from the water level monitoring network.

During third round of water level measurements in April-May 2011 the owner of well T02/R13-21C1 asked to no longer be included in the water level monitoring network. This well was thus removed from the water level monitoring network.

2.2 Well Survey

Prior to the field reconnaissance, locations and groundwater levels for wells in the study area were based on Ecology's on-line well log database. Wells in the well log database are located based on the center of the quarter-quarter section listed on the well log. Errors in identifying the appropriate quarter-quarter section on the well logs are relatively common. In addition, the well elevation is assumed to be the elevation at the center of the respective quarter-quarter section as indicated by the USGS' Digital Elevation Model (DEM). In areas of relatively large vertical relief, this can cause significant errors in the well elevation and thus the calculated groundwater elevations. Therefore, to provide a more accurate and representative picture of groundwater elevations (and thus flow directions), it is necessary to obtain accurate (surveyed) well locations and elevations for wells included in the water level monitoring network.

As part of the field reconnaissance, wells included in the water level monitoring network were surveyed by a Klickitat County Public Works surveyor using a high-resolution Global Positioning System (GPS), with a base station at a known control point to allow for real-time differential correction. Because of the distances over which the wells were spread, the surveyor established additional control points throughout the study area. The location (Washington State Plane South Coordinates, NAD 83 datum) and elevation (NAVD 88 datum) of the water level measuring point for each well was surveyed to a reported precision of plus or minus 1.0 and 0.1 foot, respectively. Table 2.1 presents the survey data for wells within the monitoring network.

2.3 Water Level Measurements

Three rounds of water level measurements were collected from the monitoring network wells during this study: April 2010 and April-May 2011 generally representing pre- or early-irrigation conditions, and November-December 2010 generally representing post-irrigation conditions.

In order to provide an accurate "snapshot" of pre-irrigation and post-irrigation groundwater levels, an attempt will be made during subsequent monitoring events to collect the water level measurements for the Dallesport area within a 1-week period of time if possible.

2.3.1 Water Level Measurement Procedures

Depth-to-water measurements were conducted using either an electric water level indicator (tape) or a sonic water level indicator (sounder)[1], depending on well access. The former provides greater precision, but has the significant disadvantage of potentially becoming permanently caught on wiring or other appurtenances within the well casing. The latter has less precision but is much faster to use and, more importantly, does not have the risk of becoming caught in the well. During the initial round of water level measurements (April 2010), field personnel used both the electric tape and the well sounder for all wells which had suitable access in order to establish instrument accuracy and suitability for each well. A quality control (QC) evaluation of the sonic sounder performance, using actual data from WRIA 30 monitoring efforts, is provided in the QAPP (Aspect, 2010a).

All depth-to-water measurements were made relative to the top of well casing or other defined measuring point at the wellhead. The selected measuring point for each well was marked in magic marker, if possible, and was documented in the field form so that it can be reproduced in subsequent measurement rounds.

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[1] Global Water WL600 or equivalent instrument.

When the electric water level indicator was used, each depth-to-water measurement was made to a precision of 0.01 foot. The water level indicator was lowered to contact the water in the well casing (contact determined by a light or beep on the indicator) and the reading noted. The indicator was then immediately withdrawn out of the water and the measurement repeated. If the two readings were consistent, the reading was recorded on a field form along with the measurement date and time. If the two readings were not consistent, measurements were repeated until a reproducible result was obtained. If repeated water level measurements indicated the presence of rising/falling water levels due to pumping influences, it was noted as such on the respective field form. Other pertinent information regarding the well or the depth-to-water measurement were also recorded in the field notes.

When the sonic water level indicator was used, each depth-to-water measurement was made to a precision of 0.1 ft. The sonic water level indicator was programmed with the regional monthly temperature setting suggested by the manufacturer. The sonic water level indicator was placed flush with the top of the casing, and the depth-to-water was displayed on a LCD screen. The measurement was repeated until a reproducible result was obtained. If the two readings were consistent, the reading was recorded in the field notes along with measurement date and time. If the two sonic water level readings were not consistent, or the water level appeared to be incorrect based on well construction or regional hydrologic information, then the depth-to-water was measured solely with an electric water level indicator.

If an electric water level indicator was used for the depth-to-water measurement, the lower couple of feet of tape was rinsed and wiped with a clean paper towel. Any rust or other visible material on the water level indicator after a measurement was also wiped off using a clean paper towel prior to the next measurement.

A table of static water level measurements from the respective wells logs was carried in the field. Measurements that varied greatly from previous measurements in a given well (accounting for differences between pre- and post-irrigation) were repeated for confirmation.

3 Conceptual Model of Hydrogeologic Conditions

3.1 Hydrostratigraphy

A generalized geologic history of the WRIA 30 subbasins, including the Columbia Tributaries subbasin within which the Dallesport study area occurs, is provided in the WRIA 30 Level 1 watershed assessment (WPN and Aspect, 2004). Based on that information and subsequent evaluation, hydrostratigraphic units within this study area include (from youngest to oldest):

- Alluvium (Qa);
- Eolian, i.e. wind-deposited (Qd);
- Missoula Flood (Qfg);
- Dalles Formation (Mc[d]);
- Wanapum basalt (Priest Rapids (Mv[wpr]), Roza (Mv[wr]), and Frenchman Springs (Mv[wfs]) members); and
- Grande Ronde basalt (Mv[g]).

Both the Wanapum and the Grande Ronde basalts are formations of the Columbia River Basalt Group (CRBG), which consisted of widespread extrusion of numerous basalt flows originating from vents located in the Pasco area (Bauer and Hansen, 2000). Sedimentary interbeds deposited between the individual basalt flows are collectively referred to as the Ellensburg Formation (Mc[e]).

The surface geology and geologic structures from Washington Department of Natural Resources (WDNR) 1:100,000 scale digital mapping are shown on Figure 3.1. A detailed hydrogeologic cross section (Figure 3.2) was developed to better define the depth and distribution of the local hydrostratigraphic units, the presence of geologic structures (faults and folds), and the occurrence of water-bearing zones within the study area. The cross section was developed using well logs from Ecology’s well log database, the WDNR geologic mapping, and available information from other studies.

The location of cross section A-A’ is illustrated on Figure 3.1, and was determined based on available well log coverage and features with the greatest hydrologic interest within the study area, such as geologic structures. Cross section A-A’ extends southwest-northeast, from Dallesport to Fivemile Creek. The cross section intersects an east-west trending syncline, normal fault, and a second syncline in the vicinity of the Dallesport area; an inferred northwest-southeast trending normal fault in the central region of the Dallesport Peninsula; and a northwest-southeast trending normal fault in the vicinity of the Fivemile Creek area.

A total of 22 well logs were selected from the nearly 250 available well logs for the Dallesport Peninsula in order to create cross section A-A’. Appendix A provides a summary table of the well completion details from the well logs in the study area. The cross section integrates the following data from each well log: location of well to the nearest quarter-quarter section; well depth; cased interval; static water level; depth and thickness of geologic units encountered; water-bearing zones, if reported; and the surface elevation from the USGS DEM, assuming the well is located at the center of the quarter-quarter section (see Well Survey section above).

3.1.1 Groundwater Occurrence

Groundwater in the study area generally occurs within the bedrock units of the Columbia River Basalt Group (CRBG). Although the Dallesport Peninsula has pockets of unconsolidated deposits (e.g., alluvium (Qa), eolian deposits (Qd), Missoula Flood deposits (Qfg), and the Dalles Formation (Mc[d])) found at the surface (Figure 3.1), these units are not expected to be a significant source of water due to the limited continuity and thickness.

Groundwater in the CRBG occurs primarily within the tops of the individual flows (flow tops) that became vesicular (porous) as gas bubbles escaped the flows during cooling, and/or within the fractured flow bottoms (sometimes referred to as pillows). Flow tops and bottoms – collectively referred to as interflow zones – are usually porous and permeable, and therefore transmit water more readily than the intervening massive portions of the basalt flow interior, which generally constitute flow barriers, except where fractured. A permeable flow top is normally present for each flow, while permeable flow bottoms range from relatively thick units to completely absent.

In addition, terrestrial sediments can be deposited between the underlying flow top and overlying flow bottom during time periods between basalt flows. These sediments are collectively considered part of the Ellensburg Formation (Mc[e]) and can be either relatively permeable or impermeable; depending on composition, thickness, and lateral extent (Brown, 1979). Based on the cross section (Figure 3.2) and individual well logs, the interflow zones in the study area have thicknesses ranging between 10 and 80 feet. However, both the lateral continuity and thickness of the water-bearing interflow zones are highly variable.

3.1.2 Hydrostratigraphic Unit Descriptions

The younger hydrostratigraphic units overlying the Columbia River Basalt Group (CRBG) in the study area include (Figure 3.1): alluvium (Qa), eolian (Qd) deposits, Missoula Flood (Qfg) deposits, and the Dalles Formation (Mc[d]). As discussed above, these units – collectively termed the unconsolidated aquifer – are not expected to be a significant source of groundwater on the scale of the study area.

Within the study area, the alluvium can be highly variable in composition (from clay to gravel), with groundwater occurrence limited to the coarse-grained (sand and gravel) portions. The only occurrence of alluvium on the Dallesport Peninsula is in the vicinity of The Dalles Dam, and no wells are known to be completed in this unit.

The eolian deposits consist primarily of dune sand, and are found in the southwestern portion of the Dallesport Peninsula. Based on the cross section (Figure 3.2), this unit can be as much as 80 feet thick in the study area. A single well (T02/R13-28G1) is known to be completed in this unit, which based on the well log, had a static water level of 65 feet below ground surface (February 2, 1953) and a yield of 160 gallons per minute (gpm).

The Missoula Flood deposits consist of gravel and coarse sand (Korosec, 1987) and can be found at the surface in the central region of the Dallesport Peninsula. This unit can be as much as 90 feet thick in the study area (see Figure 3.2). A single well (T02/R13-22J1) is completed in this unit, which, based on the well log, had a static water level of 25 feet below ground surface (May 1991) and a yield of 20 gpm with 50 feet of drawdown. The water-bearing sands of the eolian deposits and the sands and gravels of the Missoula Flood deposits are likely in hydraulic continuity due to their proximity and the absence of any type of stratigraphic or structural barriers (Figure 3.1). Since these are the only water-bearing units overlying the CRBG in the study area that have wells completed in the respective units, they are grouped together hydrostratigraphically, constituting the unconsolidated aquifer.

The Dalles Formation can be found in the study area along an unnamed east-west trending thrust fault located in the northern portion of the Dallesport Peninsula (within sections 12, 14, 15, and 16). This unit consists of thickly bedded, gray, volcaniclastic and sedimentary deposits (Korosec, 1987). No wells within the study area are known to be completed in this unit.

The Columbia River Basalt Group units in the study area have a collective thickness of several thousand feet. With the exception of the northwestern corner of the Dallesport Peninsula, the Wanapum basalt is consistently present across the study area (Figure 3.1). Except for the northwestern region of the Dallesport Peninsula (Murdock area), the Wanapum basalt is estimated to be at least between 500 (T02/R13-14P1) and 700 (T02/R13-12Q2) feet thick in the study area (see Figure 3.2). The Wanapum basalt consists of three separate members (from youngest to oldest): the Priest Rapids (Mv[wpr]), Roza (Mv[wr]), and Frenchman Springs (Mv[wfs]):

- The Priest Rapids member ranges from being absent along the eastern and western edges of the Dallesport Pennisula, to a maximum thickness of approximately 200 feet in both the Dallesport and Fivemile Creek areas of the Dallesport Peninsula.
- Except for being absent along the eastern and western edges of the Dallesport Peninsula, the Roza member ranges from a minimum thickness of 70 feet in the Dallesport area to a maximum thickness of 150 feet in the central portion of the Dallesport Peninsula.
- The Frenchman Springs member is estimated to be at least between 310 (T02/R13-22Q1) and 430 (T02/R13-12Q2) feet thick in the study area (Figure 3.2).

Underlying the Wanapum basalt is the Grande Ronde basalt, which is the most laterally extensive and thickest of the CRBG formations, constituting 85 to 88 percent of the total volume of the CRBG (Vaccaro, 1999). Because of its great depth across most of the study area, there are relatively few wells completed in the Grande Ronde basalt in the study area. The wells completed in the Grande Ronde basalt are primarily located along Highway 14, to the northwest of Murdock (Figure 3.1). These wells have static water levels ranging between 20 and 130 feet below ground surface, with yields between 8 and 35 gallons per minute. In this area, the Grande Ronde basalt can be found at the surface adjacent to the Columbia River. In this area, it is possible that the water-bearing zones of the Grande Ronde basalt may be in hydraulic continuity with the Columbia River.

As previously discussed, sediments deposited between the various basalt flows are part of the Ellensburg formation. Where sediments interbedded between basalt flows are coarse grained (sand/gravel), the interbeds may transmit groundwater in usable quantity. However, because the composition, thickness, and extent of the interbeds is highly variable, groundwater production from these units is correspondingly variable. In many localities, the productivity of the interbeds is often low because of limited lateral extent and changes in composition. Within the study area, the interbeds (Mc[e]) can be absent, as observed between the Roza (Mv[wr]) and Frenchman Springs (Mv[wfs]) members of the Wanapum basalt in the Dallesport area, or can be as much as 40 feet thick, as observed between the Priest Rapids (Mv[wpr]) and Roza (Mv[wr]) members of the Wanapum basalt (Figure 3.2). As previously discussed, water levels from the interflow zone are considered to be representative of the underlying basalt aquifer; therefore, for the purposes of this study the interflow zone is also considered to be part of the underlying basalt aquifer.

3.2 Geologic Structures

The major geologic structures (faults and folds) in the project area, taken from WDNR geologic mapping, are identified on both the geologic map (Figure 3.1) and the cross section (Figure 3.2). The Columbia Tributaries subbasin is structurally bound to the north of the project area (does not appear on Figures 3.1 or 3.2) by the Columbia Hills anticline (Newcomb, 1969). The Columbia Hills anticline is part of the Yakima Fold Belt, which formed from regional north-south compression that began during the deposition of the Grand Ronde basalt approximately 16 million ybp (Reidel et al., 1989). This compression resulted in the formation of the southwest-northeast trending folds (synclines and anticlines) and the associated reverse and thrust faults (older rocks are slid upward over younger rocks) found in the region. There is a southwest-northeast trending thrust fault in the northern region of the Dallesport Peninsula, with several hundred feet of displacement, which is likely associated with the formation of the Columbia Hills anticline.

Superimposed upon the major southwest-northeast trending structures within the study area are numerous northwest-southeast trending normal faults (younger rocks are slid downward over older rocks), likely created from a rotational component of the same north-south compression that resulted in the southwest-northeast trending folds and faults (Reidel et al., 1989). Two of these faults occur within the project area. One of the faults, an unnamed normal fault with several hundred feet of vertical displacement (Figure 3.2), is located in the northeast portion of the study area. The second, a northwest-southeast trending normal fault associated with the Quarry fault (Newcomb, 1969), does not show nearly as much displacement (between 40 and 100 feet, based on Figure 3.2), and is located in the southeastern region of the project area. There is some uncertainty to how far this normal fault extends to the northwest, across the Dallesport Peninsula. However, based on a month of continuous groundwater level monitoring previously conducted in wells T02/R13-22Q1 and T02/R13-22Q2, located on opposite sides of the northwestern extension of the fault trace (Figure 2.1), it was determined that the wells were not in hydraulic continuity, even though they were completed in a similar member of the Wanapum basalt (Flynn, 2007). It is therefore hypothesized that this fault extends to the northwest between T02/R13-22Q1 and T02/R13-22Q2.

Within the study area, the individual members of the Wanapum basalt (Priest Rapids, Roza, and Frenchman Springs) are generally dipping to the southeast or southwest between 1 and 14 degrees (Bela and Hull, 1982), towards The Dalles syncline, which is an asymmetric southwest-northeast trending fold located in the southern region of the Dallesport Peninsula. In addition, there are also several other smaller unnamed folds (anticlines and synclines) in the project area, primarily located in the western and northwestern regions of the Dallesport Peninsula (Figure 3.1).

In the subsurface, folds and faults may represent partial or complete barriers to groundwater flow, laterally compartmentalizing flow within the study area. Newcomb (1961 and 1969) theorized that tight anticlinal folding of basalt forms breccia (broken rock) and fault gouge between the individual flows near the axis of an anticline, which decreases the transmissivity of the basalt and impedes groundwater flow across the anticlinal crest. In addition, due to the folding and upwarping of the individual flows in the creation of the anticlinal crest, higher heads are needed for groundwater to flow over this crest. Fault gouge may also decrease the transmissivity of the basalt units in the vicinity of both normal and reverse faults. If significant displacement occurs across these faults to offset the water-bearing interflow zones, the faults may act as impermeable barriers to lateral groundwater flow.

3.3 Groundwater Conditions

3.3.1 Unconsolidated Aquifer

As previously discussed, the unconsolidated deposits are not expected to be a significant source of groundwater. Only two wells within the study area (T02/R13-28G1 and T02/R13-22J1) were found to be completed within this aquifer. Based on the well logs, these wells had static water levels of 65 feet and 25 feet below ground surface and yields of 160 gpm and 20 gpm, respectively. These wells were not included in the groundwater level monitoring network.

Due to the limited continuity and thickness of the unconsolidated aquifer and the limited number of wells completed within this aquifer, it is not possible to accurately determine groundwater flow directions within this aquifer. The scattered locations of the unconsolidated aquifer wells relative to the basalt aquifer wells also do not allow for a reliable determination of vertical gradients between the unconsolidated aquifer and the underlying basalt aquifer. However, in areas where the underlying bedrock of the CRBG is relatively impermeable due to the presence of a relatively massive flow interior, it is expected that groundwater flow will follow the topography of the bedrock, with springs often occurring at the downgradient extents of the unconsolidated aquifer (Piper, 1932). In areas where the underlying units of the CRBG consists of relatively permeable interflow zones, it is expected that there is a downward gradient, especially during the early part of the year when there is significant precipitation. During these instances, recharge from the unconsolidated aquifer to the underlying basalt aquifers is expected.

3.3.2 Basalt Aquifers

Of the 25 wells originally included in the water level monitoring network, 4 wells are completed in the Priest Rapids member, 2 wells are completed in Roza member, and 19 wells are completed in the Frenchman Springs member of the Wanapum basalt. The Frenchman Springs member appears to be the primary aquifer for a majority of the study area and, accordingly, a majority of the wells included in the monitoring network are completed in it, Most of the wells completed within the Priest Rapids or Roza members are found in the southwestern region of the Dallesport Peninsula. No wells were found on the Dallesport Peninsula that were completed in the Grande Ronde basalt. As discussed above, water levels from the interflow zones between the various members of the Wanapum basalt are considered to be representative of the underlying basalt aquifer.

Figures 3.3 and 3.4 present the groundwater elevation contour maps for the Wanapum basalt aquifers, compiled using water level data from both well logs and the water level monitoring network (April 2010 measurements). Since the well log water levels were collected over decades of time, and multiple seasons of the year (irrigation and non-irrigation), they reflect annual and seasonal changes in groundwater levels, in addition to errors associated with the well locations and DEM elevations. Therefore, the April 2010 water level monitoring network measurements from surveyed well locations (Table 2.1), were used to verify and supplement the historical data by gathering a basin-wide “snapshot” of groundwater levels over a relatively short (5-day) period of time. The data collected for this study are reliable data upon which interpretations of groundwater conditions are primarily based.

Groundwater levels in the youngest, shallowest member of the Wanapum Basalt (Priest Rapids) appear to be 50 to several hundred feet higher than in the deeper Roza and Frenchman Springs members. Therefore, despite the limited number of wells completed within the Priest Rapids member, groundwater levels from the Roza and Frenchman Springs members were used to create one groundwater elevation contour map (Figure 3.3), while groundwater levels from the Priest Rapids member were used to create another groundwater elevation contour map (Figure 3.4).

The resulting groundwater elevation contour maps represent an aggregate interpretation of the basalt aquifer groundwater data. Due to the disparity in accuracy between the well log water levels and the surveyed water levels, and the fact that the water levels are from wells spanning one or more vertically distinct water bearing zones within the basalt, the interpreted groundwater elevation contours may be inconsistent with water level measurements in individual wells, but are considered representative of the Wanapum basalt aquifer groundwater flow system on a basin scale. Establishment of the water level monitoring network also allows for future monitoring to document seasonal or longer-term changes in the flow system.

Based on the groundwater elevation contour maps (Figure 3.3 and Figure 3.4), groundwater flow in the Wanapum basalt aquifers on the Dallesport Peninsula is generally to the southwest, towards the Columbia River. However, due to the presence of numerous folds and faults within the study area, which can act as barriers to groundwater flow (Section 3.2), there are several areas where groundwater flow within fault-bounded ("compartmentalized") sections of the basalt is likely occurring. The following sections provide a brief description of groundwater flow in the various regions of the study area.

Murdock Area

In the northwestern region of the Dallesport Peninsula (Murdock area) there is a southwest-northeast trending thrust fault which likely acts as a barrier to groundwater flow, due to the significant displacement across the fault (several hundred feet). Groundwater flow in the Wanapum basalt aquifers to the northwest of the fault is to the southwest, towards the Columbia River, while groundwater flow to the southeast of the fault is slightly more to the south-southwest towards the unnamed syncline north of the Wetle Butte anticline (Figure 3.3). In this region, groundwater levels in the Priest Rapids member appear to be several hundred feet higher than in the Roza and Frenchman Springs members of the Wanapum basalt.

Fivemile Creek Area

In the northeastern region of the Dallesport Peninsula (Fivemile Creek area), groundwater flow in the Wanapum basalt aquifers appears to be to the south-southwest, based on the limited groundwater level data available (Figures 3.3 and 3.4). In this region, groundwater levels in the Priest Rapids member appear to be several hundred feet higher than in the Roza and Frenchman Springs members of the Wanapum basalt.

Due to the limited extent of the groundwater level data, it cannot be confirmed that the local northwest-southeast trending normal fault acts as a barrier to groundwater flow. However, the cross section (Figure 3.2) indicates that there is approximately 180 feet of offset across the fault, so it is likely that this fault acts as a barrier to groundwater flow.

Central Region of Dallesport Peninsula

In the central region of the Dallesport Peninsula, south of the southwest-northeast trending thrust fault (flow barrier), groundwater flow in the Wanapum basalt aquifers is to the south-southwest, towards the northwest-southeast trending normal fault associated with the Quarry fault (Figure 3.3).

The northwest-southeast trending normal fault associated with the Quarry fault cuts across the center of the Dallesport Peninsula and has an offset of between 40 and 100 feet (see Figure 3.2), likely causing it to act as a barrier to groundwater flow. Newcomb (1969) first hypothesized this based on a comparison of water levels between T02/R13-27B1 and T02/R13-34L. However, later geologic mapping (Bela and Hull, 1982) indicated that the fault likely extends between T02/R13-22Q1 and T02/R13-22Q2. The extension of the fault between these wells, and its impact as a boundary to groundwater flow was later confirmed by continuous monitoring of water levels as described above (Aspect, 2008).

Dallesport Industrial Park

In the southeastern region of the Dallesport Peninsula (Dallesport Industrial Park), to the northeast of the Quarry fault and to the southwest of the normal fault associated with the Quarry fault, groundwater flow in the Wanapum basalt aquifers appears to be to the southeast, towards the Columbia River. However, this interpretation is based on limited groundwater level data available for that region (Figure 3.3). Although the Quarry fault does not appear to have as significant an offset as the faults to the north, the distinct change in the groundwater flow direction indicates that both the Quarry fault and the normal fault associated with the Quarry fault likely act as barriers to lateral groundwater flow.

This is further corroborated by a pumping test conducted at the Columbia Gorge Regional Airport Replacement well (T02/R13-34L4), which did not indicate any drawdown in wells T02/R13-25N1 and T02/R13-26J on the opposite side of the fault (Figure 3.3) during pumping at a rate of 1520 gpm for a 24-hour period of time (Aspect, 2008). Although wells T02/R13-25N1 and T02/R13-26J are more than 1.5 miles away from the Airport Replacement well, they were completed in a similar confined aquifer of the Wanapum basalt, so a change in the pressure head would be expected to be observed if the wells were in hydraulic continuity (i.e., if the Quarry fault was not acting as a flow barrier).

Dallesport

In the southwestern region of the Dallesport Peninsula (Dallesport), to the south of the Wetle Butte anticline and the normal fault associated with the Quarry fault and to the southwest of the Quarry fault itself, groundwater flow in the Wanapum basalt aquifers is generally to the south-southwest, towards the Columbia River (Figures 3.3 and 3.4). In this region, groundwater levels in the Priest Rapids member appear to be 50 to 150 feet higher than in the Roza and Frenchman Springs members of the Wanapum basalt.

Although there are several normal faults along the western edge of the Dallesport Peninsula, it is unlikely that these faults act as significant barriers to groundwater flow, since they are mapped to be of limited extent. The pumping test conducted at the Airport Replacement well (T02/R13-34L4) provides data that confirms this (Aspect, 2008). During the pumping test, drawdown was observed in well T02/R13-34E2, located on the opposite side of the extension of the fault if it existed between the wells (Figure 3.1).

3.4 Aquifer Hydraulic Parameters

A summary of both regional and local aquifer hydraulic parameters, including lateral hydraulic conductivity, transmissivity and storativity are provided in Table 3.1. Hydraulic conductivity is a quantitative measure of an aquifer’s ability to transmit water. Transmissivity is hydraulic conductivity multiplied by aquifer thickness and is a measure of how much water can move through the aquifer and thus the aquifer’s productivity. Storativity is the product of specific storage and aquifer thickness, where specific storage is defined as the volume of water (cubic feet) that a 1 cubic foot volume of aquifer releases from storage when the water level drops 1 foot.

Regional hydraulic parameters for the Columbia Plateau aquifer system were estimated by the USGS as part of its Regional Aquifer System Analysis program (Vaccaro, 1999). Estimates of lateral hydraulic conductivity were initially based on specific capacity data from select well logs. Values for a well’s specific capacity (pumping rate divided by drawdown) can be used to calculate aquifer transmissivity based on the empirical equation (Driscoll, 1986):

$$T = 2000\frac{Q}{s}$$

Where: T = Transmissivity (gpd/ft)

Q = Yield of well (gpm)

s = Drawdown in well (ft)

In addition, the USGS provided estimates of hydraulic conductivity, transmissivity, and storage coefficient values based on hydrogeologic modeling of the Columbia River basalt aquifer system throughout the Columbia Plateau (Vacarro 1999; Hansen et al., 1994; Whiteman et al., 1994).

More localized hydraulic parameters for the Wanapum basalt aquifers within the Dallesport Peninsula were estimated based on a pumping test of the Columbia Gorge Regional Airport Replacement well (Aspect, 2008), and specific capacity data from several wells included in the water level monitoring network. The hydraulic parameters for these data are summarized in Table 3.1.

The pumping test of the Airport Replacement well (T02/R13-34L4) indicated that the Frenchman Springs aquifer is locally productive, with a transmissivity of between 79,000 and 174,000 ft^2/day (580,000 to 1.3 million gpd/ft) and a storativity of approximately 1 x10^{-4} (Aspect, 2008). Specific capacity data from the nearby Dallesport Water District Well No. 2 (T02/R13-34E1 on Figures 2.1 and 3.1) confirms this, with a transmissivity of approximately 10,500 ft^2/day (78,400 gpd/ft). However, specific capacity data from the Port of Klickitat Well No. 1 (T02/R13-25N1), located to the northeast of the Quarry fault, indicates that the Frenchman Springs aquifer may be less productive in the fault-bound block to the northeast of the Quarry fault, with a transmissivity of only 740 ft^2/day (5,600 gpd/ft). In addition, wells not included in the monitoring well network, but completed in the Frenchman Springs aquifer in northwestern Dallesport Peninsula (T02/R13-16), in the vicinity of the southwest-northeast trending thrust fault, also appear to have significantly lower transmissivities, ranging between 30 and 1,680 ft^2/day (between 30 and 12,500 gpd/ft). Therefore, it is important to note that productivity of the Wanapum basalt aquifers, and in particular the Frenchman Springs aquifer, can be highly variable due to the presence of geologic structures (folds and faults), and the nature and extent of interflow zones.

A monitoring network well, located in the western Dallesport Peninsula (T02/R13-28F1) and completed in the Priest Rapids aquifer, indicates that the Priest Rapids aquifer may be less productive than the underlying Frenchman Springs aquifer, with an estimated transmissivity of 300 ft^2/day (2,300 gpd/ft). Other wells completed in the Priest Rapids aquifer which were not included in the water level monitoring network had estimated transmissivities between 30 and 1,100 ft^2/day (between 200 and 8,000 gpd/ft).

As previously discussed in Section 3.3 (Groundwater Occurrence), there are a limited number of wells completed in the unconsolidated aquifer, only one of which has specific capacity data (T02/R13-22J1). The specific capacity data for this well indicates a low transmissivity for the unconsolidated aquifer of about 110 ft^2/day (820 gpd/ft).

3.5 Long-Term Water Level Trends

The long-term water level data (groundwater elevation hydrographs) for the Dallesport study area are provided on Figure 3.5. The hydrographs confirm that the groundwater levels in the Priest Rapids member of the Wanapum basalt (wells T02/R13-12SE and T02/R13-16R1) are several hundred feet higher than the groundwater levels in the Roza and Frenchman Springs members of the Wanapum basalt in the Murdock and Fivemile Creek areas.

Due to the limited number of groundwater level measurements collected to date (2 pre-irrigation and 1 post-irrigation monitoring events), no interpretations of the long-term water level trends will be made as part of this water availability study. Based on continued funding, both pre-irrigation and post-irrigation water level measurements will continue to be collected, and subsequent interpretations of long-term water level trends will be included in the annual reports summarizing the water level monitoring activities.

3.5.1 Precipitation Trends

Based on the National Oceanic and Atmospheric Administration (NOAA) Weather Observation Station (Dallesport Station #451968), Dallesport has a mean annual precipitation of 13.7 inches over the station’s period of record (1948 - 2010). The upper half of Figure 3.6 presents both the annual precipitation and the mean annual precipitation in Dallesport for the period of record. It is important to note that individual months with more than 5 days of missing data were not used for monthly or annual precipitation statistics.

In addition, a cumulative departure from the mean annual precipitation is presented in the lower half of Figure 3.6. Based on Figure 3.6, it is observed that the annual precipitation has generally fluctuated within about 3 inches of the average since 1999. There were several consecutive years of slightly below average precipitation between 1999 and 2002, with slightly above average precipitation between 2003 and 2006, and slightly below average precipitation again between 2007 and 2009. These relatively small fluctuations around the average have not likely had significant impacts on the groundwater levels measured over the short period of monitoring during this assessment. We expect that water level changes due to fluctuating precipitation would become more apparent as a longer period of monitoring data is available.

3.6 Interaction of Groundwater and Surface Waters

3.6.1 Springs and Creeks

There are numerous springs across the Dallesport Peninsula, especially in the northwestern region of the peninsula (Sections 15, 16, and 21; Figure 3.1). There are also springs located in Sections 24, 27, and 33. Many of these springs are caused by groundwater percolating through the relatively permeable unconsolidated deposits (Qd/Qfg), or the Dalles Formation (Mc[d]), and being transported along the top of the

CRBG before discharging in intermittent or perennial springs at the downgradient extent of the unconsolidated deposits or the Dalles Formation (Piper, 1932).

In addition, there are numerous creeks, including Threemile and Fivemile creeks, which flow off the slopes of the Columbia Hills anticline and ultimately discharge into the Columbia River to the south. The source of water for these creeks is likely a combination of precipitation runoff and groundwater discharge from the various members of the Wanapum basalt (Newcomb, 1969).

3.6.2 Columbia River

Based on the geologic map (Figure 3.1) and subsurface cross section (Figure 3.2), the Priest Rapids member of the Wanapum basalt is exposed at the surface adjacent to the Columbia River in the southern region of the study area and is thus likely in direct hydraulic continuity with river, although we are aware of no pumping test or water level data available to date to support this.

The deeper aquifers of the Roza and Frenchman Springs members, which are also known as The Dalles Ground Water Reservoir in this area (Brown, 1979), occur at least 100 feet below the bottom of the adjacent Columbia River and do not appear to be in direct hydraulic continuity with it (Figure 3.2; also Newcomb, 1969). This is supported by the fact that groundwater levels in these aquifer zones did not respond to higher Columbia River levels associated with the construction of the Bonneville and The Dalles dams (Brown, 1979). In addition, the pumping test conducted at the Columbia Gorge Regional Airport Replacement well (T02/R13-34L4) did not show a recharge boundary associated with the river.

Within the Murdock and Dallesport Industrial Park areas, the Frenchman Springs member is exposed at the surface adjacent to the Columbia River and could be in direct hydraulic continuity with the river. However, the areas in which the Frenchman Springs is in hydraulic continuity with the Columbia River may be highly localized due to the presence of folds and faults which act as barriers to groundwater flow (Sections 3.2 and 3.3.2).

4 Water Balance

For this assessment, we prepared a basin-scale water balance representing current conditions for the Dallesport study area, using the same general methodologies applied in the prior water availability assessments for Swale and Little Klickitat subbasins of WRIA 30 (Aspect, 2007 and 2010b) and the WRIA 31 Level 1 Watershed Assessment (Aspect and WPN, 2004). Appendix B details the water balance methods and assumptions.

Based on the proportion of water rights for the study area, an estimated 2/3 of the total water use in the study area is supplied from groundwater versus 1/3 supplied from the Columbia River system. Streams provide a very small percentage of the total water use in the study area. We estimate that irrigation comprises the largest water use in the study area (63% of total use), with non-residential (commercial/industrial) and residential uses comprising 28% and 9% of total use, respectively.

In terms of the groundwater supply source for the entire study area, the water balance estimates that the annual consumptive groundwater use is approximately 33% of the annual groundwater recharge from precipitation plus return flow from Columbia River water use. This calculation "nets out" recharge of return flow from groundwater use, so the net water input and output for the groundwater system can be compared. However, the study area's basalt aquifers are compartmentalized, as described in Section 3, and the volume of groundwater production is not uniformly distributed across the study area. Documenting groundwater use versus recharge for localized areas would require considerable additional information and is beyond the scope of this basin-scale study. Instead, a water level monitoring network is now established for the study area, and continued monitoring of water levels, particularly in areas of greater groundwater production, will provide the best indication (empirical) regarding sustainability of current pumping, and capacity to accommodate additional future withdrawals (i.e. groundwater availability for appropriation).

5 Conclusions and Recommendations

The primary conclusions and recommendations from this assessment are as follows:

- The primary sources of water supply for the study area include groundwater withdrawal from the Wanapum basalt aquifer system, and surface water diversions from the Columbia River system. Based on water rights information, we estimate that groundwater and Columbia River sources supply roughly 2/3 and 1/3 of the total water use, respectively, in the study area.

- The Wanapum basalt formation is divided into three members, which, from youngest (shallowest) to oldest (deepest) are: Priest Rapids, Roza, and Frenchman Springs. Aquifer zones occur in vertically distinct interflow zones within each member. Groundwater levels in the shallower aquifer zones can be up to several hundred feet higher than those in the deeper zones. The deeper aquifer zones appear to be the primary groundwater supply source for the study area as a whole, with use of the shallower zones occurring primarily in the southwestern and northeastern regions of the study area. Along the southern study area boundary, shallow aquifer zones within the uppermost Priest Rapids member are likely in direct hydraulic continuity with the adjacent Columbia River, but, because of their great depth, the deeper aquifer zones are not.

- Groundwater in the basalt aquifers generally flows to the south-southwest, towards the Columbia River. However, the numerous geologic structures (folds and faults) mapped in the study area generally represent barriers to lateral groundwater flow, which has been confirmed with pumping tests conducted in some localities. As a result of the geologic structures, the basalt aquifer and groundwater flow system is “compartmentalized”. This can affect the productivity of the aquifer system locally, since flow barriers limit lateral flow of groundwater to replenish drawdown created by pumping.

- To date, only three rounds of groundwater level measurements spanning one year have been collected from the water level monitoring network (2 pre-irrigation and 1 post-irrigation monitoring events). Therefore, no interpretations of long-term groundwater level trends can yet be made as part of this study.

- On the scale of the entire study area, the annual quantity of consumptive groundwater use is approximately 1/3 of the annual groundwater recharge including return flow from Columbia River water use. This suggests that additional groundwater is available for appropriation and use within the study area. However, potential for impairment to senior water users and surface water bodies would need to be determined individually for each pending water right application.

- A groundwater level monitoring network has been established that provides the opportunity, with continued landowner permission, to track future seasonal and/or long-term changes in the groundwater flow system of the Dallesport study area. We recommend continuation of the water level monitoring program. Evaluation of long-term groundwater level trends will provide key empirical information regarding sustainability of groundwater production in the study area, and thus availability of additional groundwater for supply purposes. It is critical to track long-term trends in water levels, particularly given the apparent compartmentalized nature of the basalt aquifer.

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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 WRIA 30 Water Resource Planning & Advisory Committee for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made

Table 2.1 - Groundwater Level Monitoring Network

Dallesport Water Availability Study
WRIA 30, Washington

Ecology Well Log Data							Well Survey Data				
Ecology ID	TRS Label	Well Log Date	Dia. (in)	Depth (ft)	Static Water Level (ft bgs)	Unit of Completion	Survey Northing[1] (SPS 83; ft)	Survey Easting[1] (SPS 83; ft)	Surveyed Top of Casing Elevation[2] (ft MSL)	Casing Stick-up (ft)	Comments
138775	T02/R13-12Q2	8/9/97	6	725	125	Frenchman Springs	123725.50	1481398.52	1024.73	0.75	Airline measurement. Pump set at 588 ft bTOC.
465563	T02/R13-12SE	8/23/06	6	345	40	Priest Rapids	123266.30	1481017.88	971.36	-	Not accessible with electric tape. Sounder provides accurate measurement.
145444	T02/R13-12Q6	8/4/93	6	405	270	Frenchman Springs	121882.67	1481564.33	929.34	1.7	Sounder does not provide accurate measurement.
142046	T02/R13-13R1	6/15/91	6	410	275	Frenchman Springs	122286.01	1481798.15	948.18	1.8	Sounder does not provide accurate measurement.
138643	T02/R13-13B1	10/12/94	6	340	185	Frenchman Springs	121214.65	1480935.42	830.04	0.59	Not included in monitoring network.
417069	T02/R13-16K1	8/5/93	6	420	225	Frenchman Springs	118147.47	1464644.59	372.74	1.21	Well No. 2. Not accessible with electric tape. Sounder provides accurate measurement.
-	T02/R13-16K2	1/2/1953	6	128	-	Frenchman Springs	118025.02	1464322.29	342.69	0.84	Well No. 1. Airline measurement. Pump set at ? ft bTOC.
137029	T02/R13-16L1	10/10/94	6	285	195	Frenchman Springs	119007.57	1462972.71	275.76	1.32	Sounder does not provide accurate measurement.
317851	T02/R13-16Q1	8/12/01	6	400	205	Frenchman Springs	116612.61	1464841.48	334.48	-	Airline measurement (AGM-064). Pump set at 378 ft bTOC.
317853	T02/R13-16Q2	8/19/01	6	425	243	Frenchman Springs	116903.67	1464691.57	336.41	0.65	
142075	T02/R13-16R1	4/1/60	8	107	10	Priest Rapids	116660.78	1464679.93	349.96	0.92	Located below windmill.
317854	T02/R13-21C1	7/26/01	6	385	150	Frenchman Springs	115644.53	1465013.80	302.29	1.69	
403826	T02/R13-21J1	1/26/05	6	129	75	Roza	115853.35	1465564.49	327.29	1.87	Well Tag AKL-706. Sounder provides accurate measurement.
403822	T02/R13-21J2	2/1/05	6	405	240	Frenchman Springs	115889.50	1465594.21	325.57	0.98	Well Tag AKL-708. Sounder provides accurate measurement.
142285	T02/R13-22Q1	7/26/90	10	460	210	Frenchman Springs	112544.90	1470711.16	296.35	0.10	No pump; remove entire lid for access.
543344	T02/R13-22Q2	2/18/08	10	516	202	Frenchman Springs	111968.49	1468963.01	268.29	2.07	Deepened. Remove vent; collect measurement from access port.
142308	T02/R13-25N1	7/7/70	6	210	70	Frenchman Springs	105892.58	1478141.71	203.05	-	Airline measurement. Direct reading from pressure gage. Airline is 160 ft in length.
138377	T02/R13-26J	12/4/82	12	292	55	Frenchman Springs	107499.12	1477145.24	213.80	-	Sounder provides accurate measurement. Need pipe wrench to remove vent.
341488	T02/R13-27A5	5/16/02	8	495	195	Frenchman Springs	110604.04	1470928.63	263.41	-	Airline measurement. Pump set at 315 ft bTOC.
140656	T02/R13-28F1	10/18/72	-	170	-	Priest Rapids	109297.01	1464673.50	210.64	0.83	Sounder does not provide accurate measurement.
143530	T02/R13-28J3	3/7/80	6	210	125	Priest Rapids	107813.42	1466449.09	211.72	0.54	Access with electric tape; must remove entire vent and manipulate end to get below 0.5 ft bTOC.
556409	T02/R13-28R7	9/29/08	6	240	140	Roza	108582.73	1466393.08	222.12	2.11	Not accessible with electric tape. Sounder provides accurate measurement.
138380	T02/R13-34E1	6/19/79	10	334	150	Frenchman Springs	104245.12	1467092.93	224.48	1.69	DWD Well No. 2. Not accessible with electric tape. Sounder provides accurate measurement.
429754	T02/R13-34E2	1/11/06	6	390	180	Frenchman Springs	104277.98	1467708.03	225.14	2.34	DWD Well No. 3. Sounder does not provide accurate measurement.
521081	T02/R13-34L4	12/18/07	12	558	189	Frenchman Springs	103274.59	1469738.43	242.24	2.35	Sounder does not provide accurate measurement. Need pipe wrench to access well.

Notes:

[1] Northing and Easting coordinates are in Washington South State Plane coordinate system (NAD 1983 datum).

[2] All elevations are in NAVD 1988 datum.

Table 2.2 - Monitoring Network Groundwater Level Data

Dallesport Water Availability Study
WRIA 30, Washington

Ecology Well Log Data		April 2010			November/December 2010			April 2011		
Ecology ID	TRS Label	Depth to Water^3 (ft bTOC)	GW Elevation^2 (ft MSL)	Comments	Depth to Water^3 (ft bTOC)	GW Elevation^2 (ft MSL)	Comments	Depth to Water^3 (ft bTOC)	GW Elevation^2 (ft MSL)	Comments
138775	T02/R13-12Q2	507.15	517.58		-	-	Airline did not provide accurate measurement (>65 psi).	-	-	Airline did not provide accurate measurement (>86 psi).
465563	T02/R13-12SE	51.2	920.16		53.9	917.46		54.0	917.36	
145444	T02/R13-12Q6	330.32	599.02		325.83	603.51		219.00	710.34	
142046	T02/R13-13R1	346.92	601.26		342.40	605.78		335.60	612.58	
138643	T02/R13-13B1	-	-	Not included in monitoring network.	-	-	Not included in monitoring network.	-	-	Not included in monitoring network.
417069	T02/R13-16K1	220.9	151.84		-	-	Sounder did not provide an accurate measurement.	220.9	151.84	Same as April 2010; inaccurate measurement?
-	T02/R13-16K2	-	-	Need airline setting.	-	-	Need airline setting.	-	-	Need airline setting.
137029	T02/R13-16L1	189.56	86.2		194.25	81.51		188.01	87.75	
317851	T02/R13-16Q1	204.75	129.73		213.99	120.49	Airline is leaking, questionable measurement (71 psi).	209.37	125.11	Airline is leaking, questionable measurement (73 psi).
317853	T02/R13-16Q2	244.89	91.52		250.10	86.31		244.20	92.21	
142075	T02/R13-16R1	60.84	289.12		63.96	286		61.4	288.56	
317854	T02/R13-21C1	64.76	237.53	Rising water level.	66.13	236.16		-	-	No longer wants to be included in monitoring network.
403826	T02/R13-21J1	82.11	245.18		74.03	253.26	Owner recharges with water from deep well in winter.	66.39	260.9	Owner recharges with water from deep well in winter. Fluctuating water level.
403822	T02/R13-21J2	233.80	91.77		239.09	86.48	Rising water level.	233.75	91.82	Fluctuating water level.
142285	T02/R13-22Q1	223.61	72.74		229.77	66.58		-	-	No measurement, well in use.
543344	T02/R13-22Q2	198.97	69.32		205.16	63.13		-	-	No measurement, well in use.
142308	T02/R13-25N1	-	-		152	51.05		152	51.05	Same as November/December 2010 measurement; inaccurate measurement?
138377	T02/R13-26J	51.02	162.78		53.2	160.60		48.4	165.40	
341488	T02/R13-27A5	185.64	77.77		178.71	84.7		164.85	98.56	Measurement on May 5th.
140656	T02/R13-28F1	92.35	118.29		93.76	116.88		55.0	155.64	Questionable sonic measurement.
143530	T02/R13-28J3	143.41	68.31		153.80	57.92		139.4	72.32	
556409	T02/R13-28R7	147.2	74.92		157.4	64.72	Falling water level.	161.6	60.52	Fluctuating water level.
138380	T02/R13-34E1	162.6	61.88		164.4	60.08		159.8	64.68	
429754	T02/R13-34E2	166.20	58.94		167.50	57.64		162.16	62.98	
521081	T02/R13-34L4	180.42	61.82		181.86	60.38		175.59	66.65	Measurement on May 5th.

Notes:

[1] Northing and Easting coordinates are in Washington South State Plane coordinate system (NAD 1983 datum).

[2] All elevations are in NAVD 1988 datum.

[3] Sonic measurements recorded to nearest 0.1 ft, electric tape measurements recorded to nearest 0.01 ft. Red values indicate fluctuating water level.

Table 3.1 - Hydraulic Parameter Estimates for Unconsolidated and Basalt Aquifers

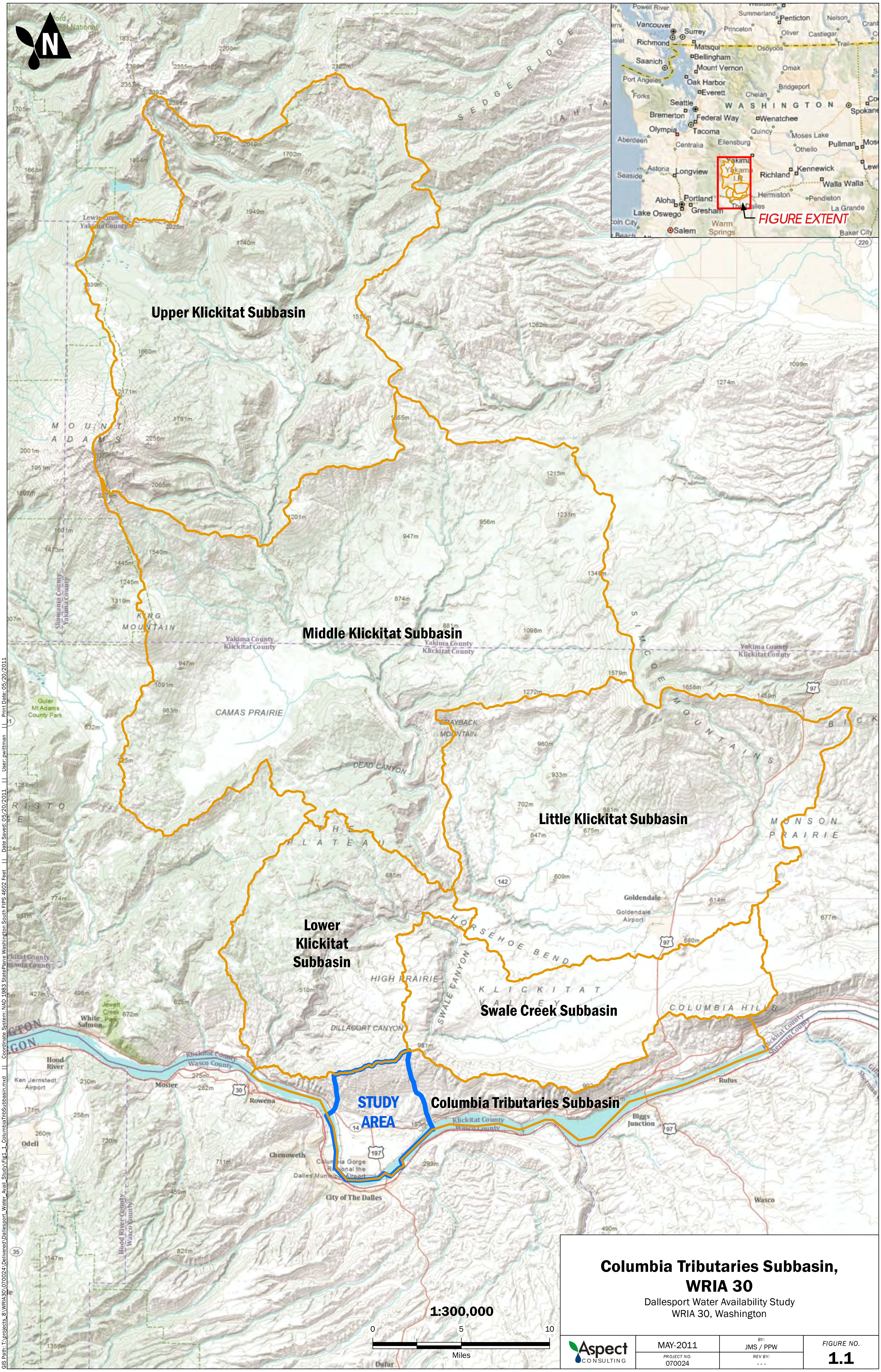
Dallesport Water Availability Study
WRIA 30, Washington

Unconsolidated Aquifer

Hydraulic Conductivity (ft/day)			Transmissivity (ft^2/day)			Storativity (Dimensionless)			Location	Aquifer	Data Type	Source
Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean				
-	-	-	-	-	107	-	-	-	T02/R13-22J1 Well Log	Eolian Alluvial	Specific Capacity	Department of Ecology Well Log Database

Wanapum Basalt

Hydraulic Conductivity (ft/day)			Transmissivity (ft^2/day)			Storativity (Dimensionless)			Location	Aquifer	Data Type	Source
Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean				
0.09	8	3	4	9331	1339	2.E-06	1.E-04	3.E-05	Columbia Plateau Aquifer System	-	Model	Vacarro, 1999; Whiteman et. al, 1994
0.01	5244	66	-	-	-	-	-	-	Columbia Plateau Aquifer System	-	Specific Capacity	Vacarro, 1999
0.43	1	-	-	-	-	-	-	-	Dallesport Peninsula	-	Model	Hansen, Vacarro and Bauer, 1994
-	-	-	79060	174200	-	-	-	1.E-04	T02/R13-34L4	Frenchman Springs	Pumping Test	Aspect Consulting, 2008
-	-	-	-	-	10497	-	-	-	T02/R13-34E1	Frenchman Springs	Specific Capacity (Well Log)	Department of Ecology Well Log Database
-	-	-	-	-	744	-	-	-	T02/R13-25N1	Frenchman Springs	Specific Capacity (Well Log)	Department of Ecology Well Log Database
			27	1675	-	-	-	-	T02/R13-16	Frenchman Springs	Specific Capacity (Multiple Well Logs)	Department of Ecology Well Log Database
-	-	-	-	-	305	-	-	-	T02/R13-28F1	Priest Rapids	Specific Capacity (Well Log)	Department of Ecology Well Log Database
-	-	-	27	1072	-	-	-	-	T02/R13-21 T02/R13-22 T02/R13-28 T02/R13-33	Priest Rapids	Specific Capacity (Multiple Well Logs)	Department of Ecology Well Log Database

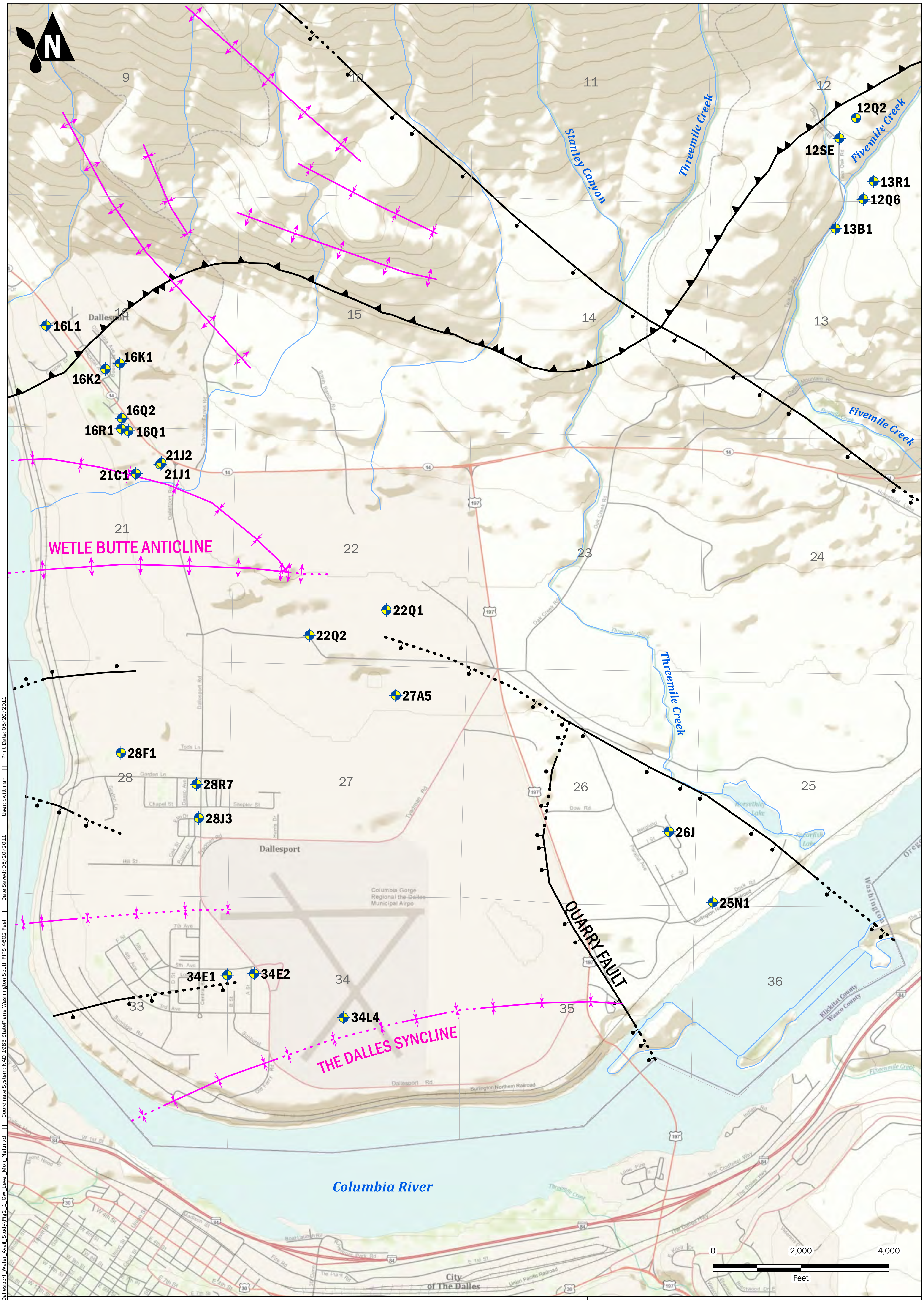


Columbia Tributaries Subbasin, WRIA 30

Dallesport Water Availability Study
WRIA 30, Washington

Aspect CONSULTING	MAY-2011	BY: JMS / PPW	FIGURE NO.
	PROJECT NO. 070024	REV BY: - - -	1.1

GIS Path: T:\projects_8\WRIA30\070024\Delivered\Dallesport_Water_Avail_Study\Fig1_1_ColumbiaTribSubbasin.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 05/20/2011 || User: pwittman || Print Date: 05/20/2011



26H1 ⊕ Surveyed Monitoring Network Well Location

8 Sections

Folds (Washington DNR 1:100K mapping)

Anticline (location accurate)

Anticline (location concealed)

Syncline (location accurate)

Syncline (location concealed)

Faults (Washington DNR 1:100K mapping)

Thrust fault (location accurate).
Sawteeth on upper plate.

Normal fault (location concealed).
Bar and ball on downthrown block.

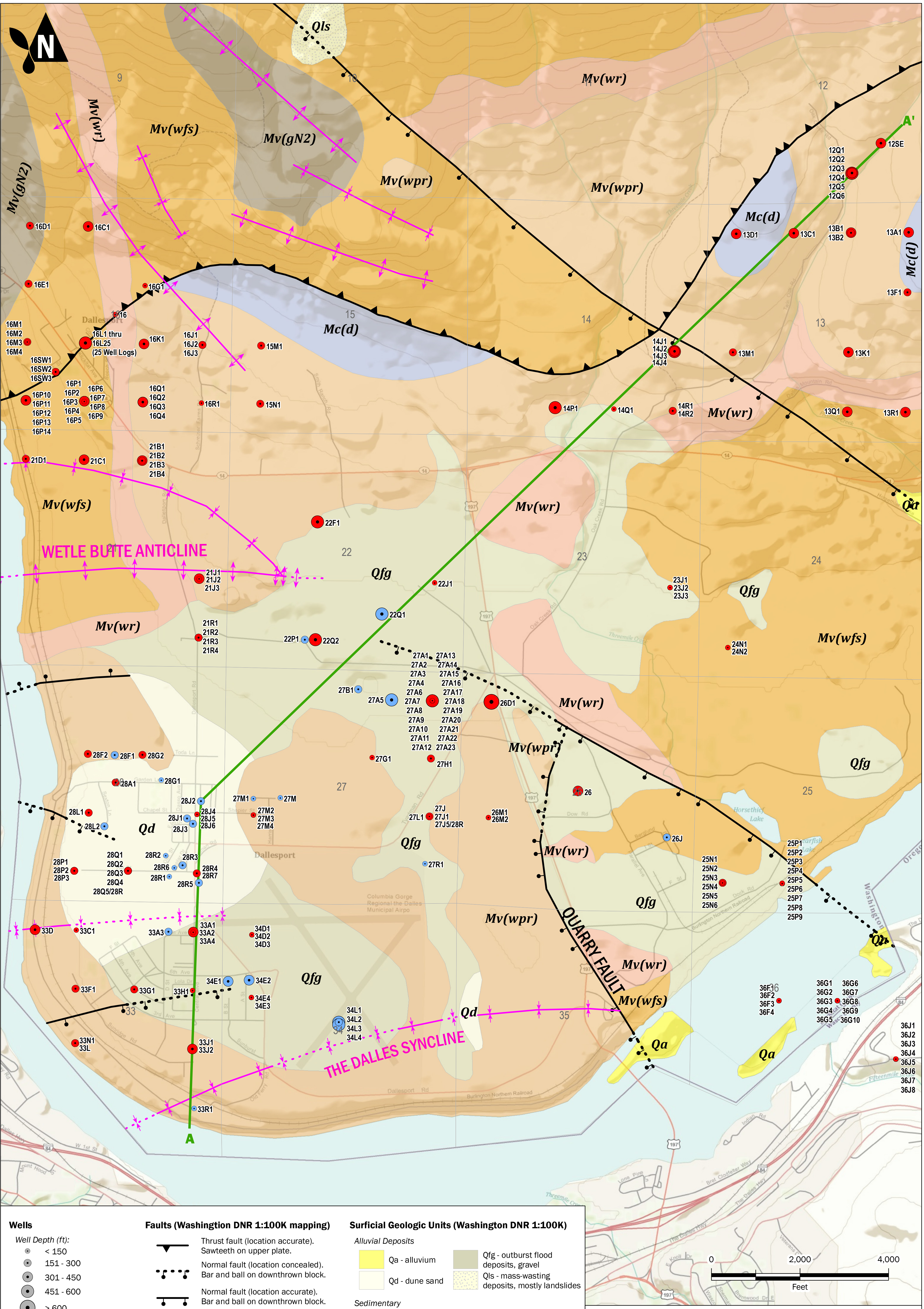
Normal fault (location accurate).
Bar and ball on downthrown block.

Groundwater Level Monitoring Network - Wanapum Basalt

Dallesport Water Availability Study
WRIA 30, Washington

Aspect CONSULTING	MAY-2011	BY: JMS/PPW	FIGURE NO.
	PROJECT NO. 070024	REV BY: - - -	2.1

GIS Path: T:\projects_8\WRIA30\070024\Delivered\Dallesport_Water_Avail_Study\Fig2_1_GW_Level_Mon_Net.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 05/20/2011 || User: pwittman || Print Date: 05/20/2011



Wells

Well Depth (ft):

- < 150
- 151 - 300
- 301 - 450
- 451 - 600
- > 600

Location Source (not surveyed):

- Aspect (Approximate)
- Dept. of Ecology
- Cross Section A-A'
- 8 Sections

Faults (Washingtion DNR 1:100K mapping)

- Thrust fault (location accurate). Sawteeth on upper plate.
- Normal fault (location concealed). Bar and ball on downthrown block.
- Normal fault (location accurate). Bar and ball on downthrown block.

Folds (Washingtion DNR 1:100K mapping)

- Anticline (location accurate)
- Anticline (location concealed)
- Syncline (location accurate)
- Syncline (location concealed)

Surficial Geologic Units (Washington DNR 1:100K)

Alluvial Deposits

- Qa - alluvium
- Qd - dune sand
- Qfg - outburst flood deposits, gravel
- Qls - mass-wasting deposits, mostly landslides

Sedimentary

- Mc(d) - continental sedimentary deposits or rocks, Dalles Formation

Bedrock

- Mv(wpr) - Wanapum Basalt, Priest Rapids Member
- Mv(wr) - Wanapum Basalt, Roza Member
- Mv(wfs) - Wanapum Basalt, Frenchman Springs Member
- Mv(gN2) - Grande Ronde Basalt, upper flows of normal magnetic polarization

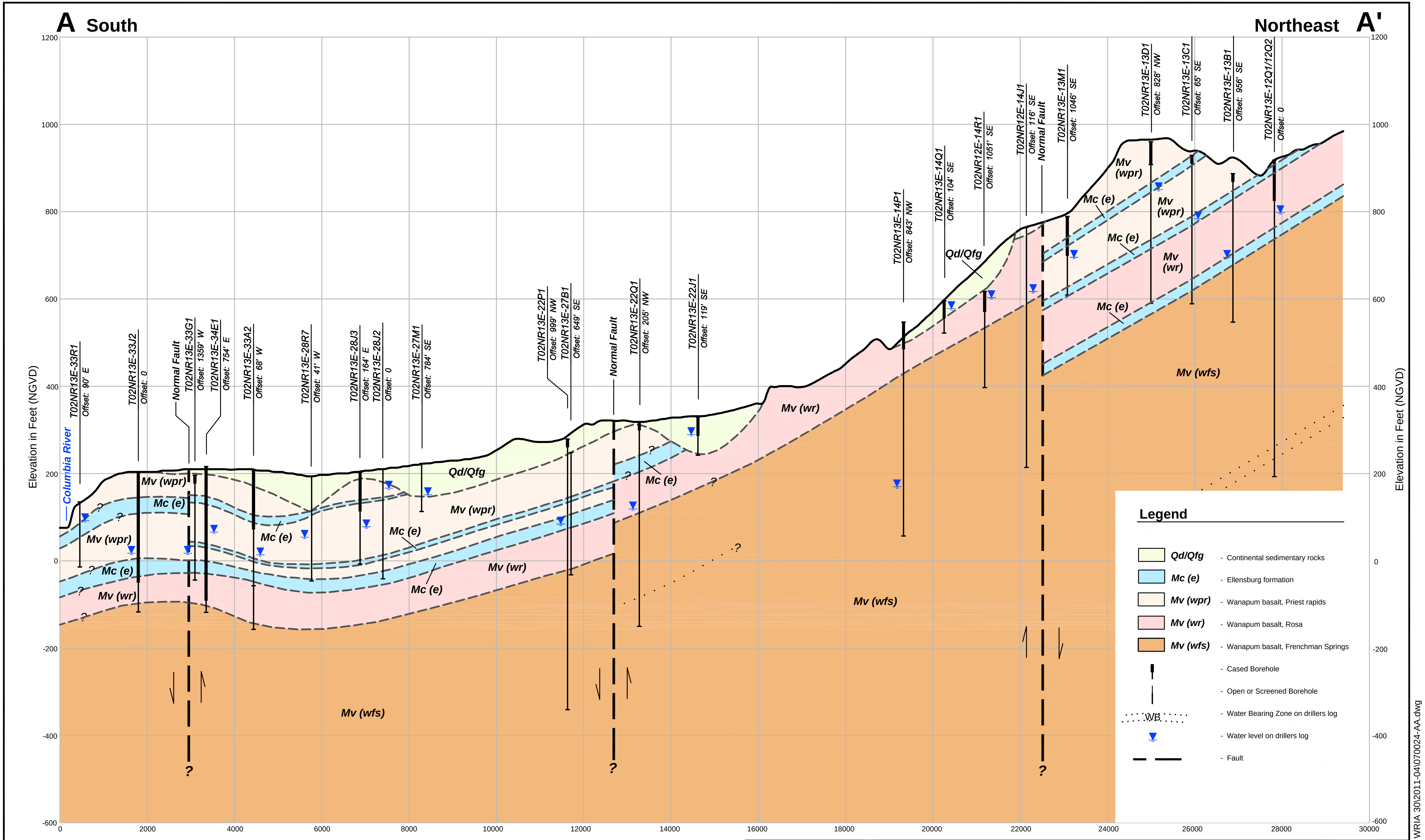
Well Location and Geologic Map

Dallesport Water Availability Study
WRIA 30, Washington

Aspect CONSULTING

MAY-2011	BY: JMS/PPW	FIGURE NO.
PROJECT NO. 070024	REV BY: - - -	3.1

GIS Path: T:\projects_8\WRIA30\070024\Delivered\Dallesport_Water_Avail_Study\Fig3_1_WellLocsAndGeology.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 05/12/2011 || User: pwittman || Print Date: 06/14/2011



Vertical Exaggeration = 10X
Scale: 1" = 2000' Horiz.
1" = 200' Vert.

0 2000 4000
Feet

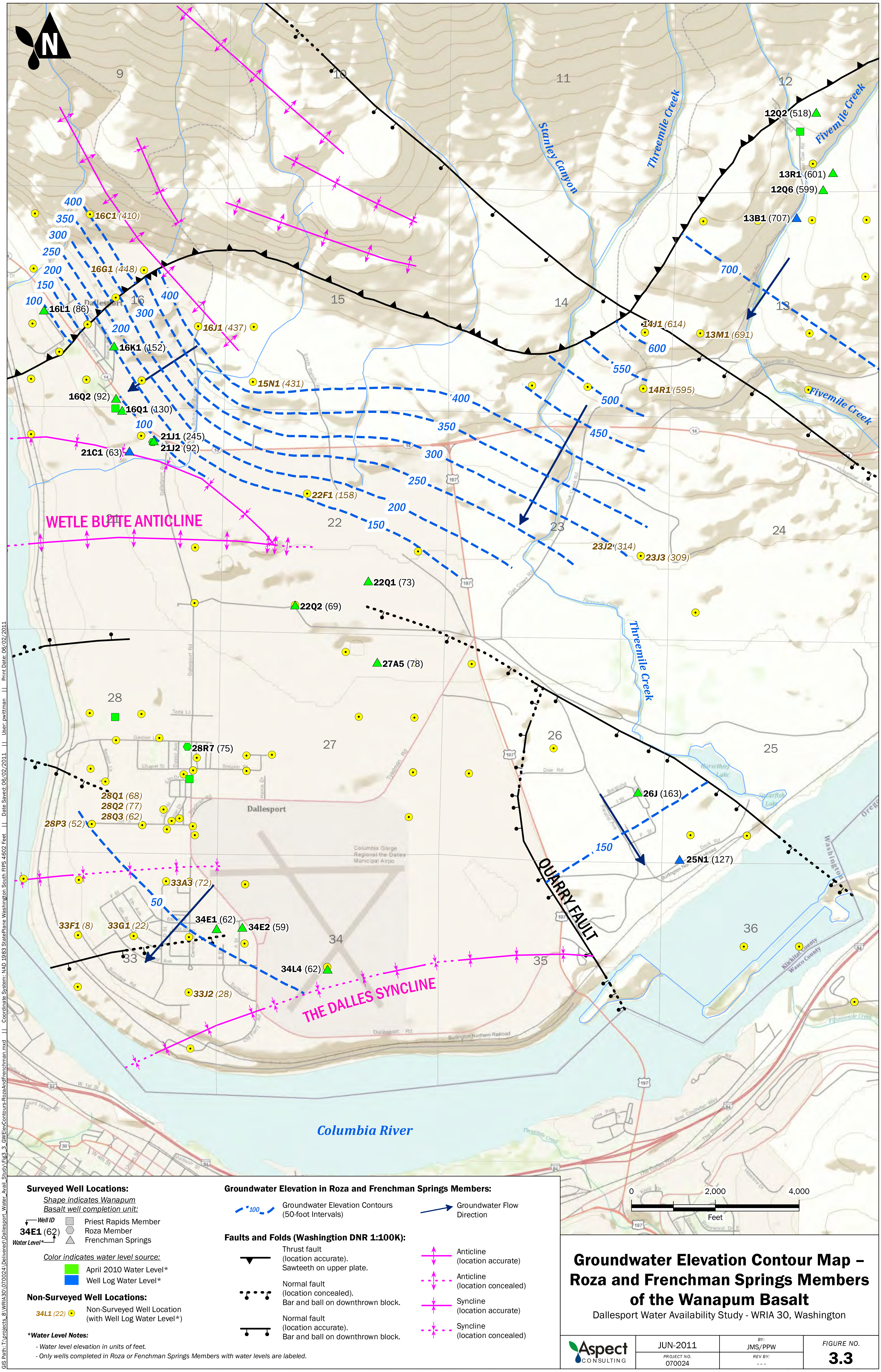
Aspect CONSULTING

Cross Section A-A'

Dallesport Water Availability Study
WIPA 30, Washington

DATE:	April 2011
DESIGNED BY:	JMS
DRAWN BY:	PMB
REVISED BY:	JMS (May 2011)
PROJECT NO.	070024
FIGURE NO.	3.2

Q:\WRIA\070024 WRIA 30\2011-04\070024-AA.dwg

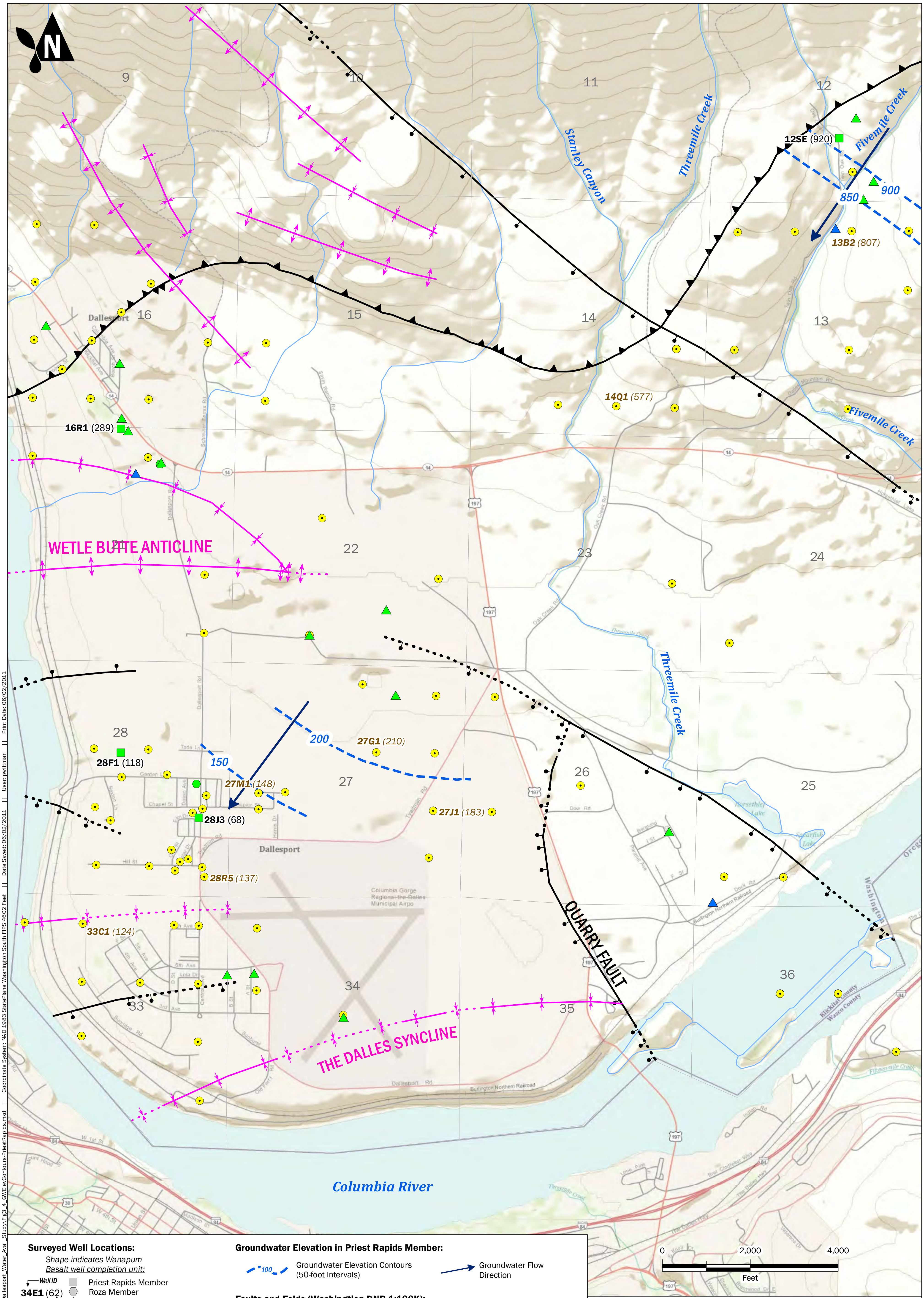


GIS Path: T:\projects_8\WRIA30\070024\Delivered\Dallesport_Water_Avail_Study\Fig3_3_GWElevContours-RozaAndFrenchman.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 06/02/2011 || User: pwittman || Print Date: 06/02/2011

Groundwater Elevation Contour Map – Roza and Frenchman Springs Members of the Wanapum Basalt

Dallesport Water Availability Study - WRIA 30, Washington

Aspect CONSULTING	JUN-2011	BY: JMS/PPW	FIGURE NO. 3.3
	PROJECT NO. 070024	REV BY: - - -	



Surveyed Well Locations:

Shape indicates Wanapum Basalt well completion unit:

Well ID — 34E1 (62) — Water Level*

- ■ Priest Rapids Member
- ⬡ Roza Member
- △ Frenchman Springs

Color indicates water level source:

- 🟩 April 2010 Water Level*
- 🟦 Well Log Water Level*

Non-Surveyed Well Locations:

34L1 (22) ⊙ Non-Surveyed Well Location (with Well Log Water Level*)

Water Level Notes:

- *Water level elevation in units of feet.*
- *Only wells completed in Priest Rapids Member with water levels are labeled.*

Groundwater Elevation in Priest Rapids Member:

- 100 Groundwater Elevation Contours (50-foot Intervals)
- Groundwater Flow Direction

Faults and Folds (Washingtion DNR 1:100K):

- Thrust fault (location accurate). Sawteeth on upper plate.
- Normal fault (location concealed). Bar and ball on downthrown block.
- Normal fault (location accurate). Bar and ball on downthrown block.
- Anticline (location accurate)
- Anticline (location concealed)
- Syncline (location accurate)
- Syncline (location concealed)

Groundwater Elevation Contour Map – Priest Rapids Member of the Wanapum Basalt

Dallesport Water Availability Study - WRIA 30, Washington

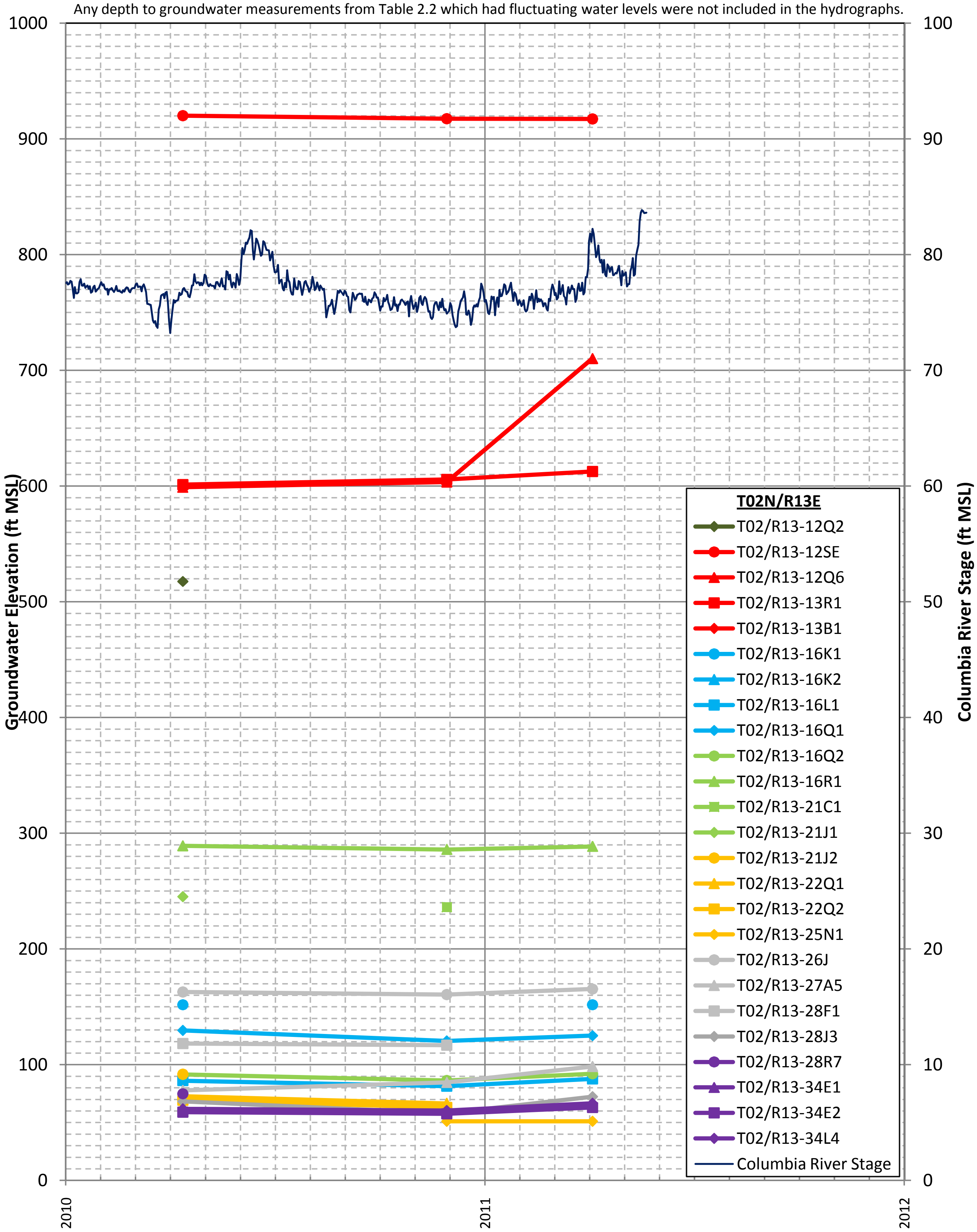
Aspect CONSULTING	JUN-2011	BY: JMS/PPW	FIGURE NO.
	PROJECT NO. 070024	REV BY: - - -	3.4

GIS Path: T:\projects_8\WRIA30\070024\Delivered\Dallesport_Water_Avail_Study\Fig3_4_GWElevContours-PriestRapids.mxd || Coordinate System: NAD 1983 StatePlane Washington South FIPS 4602 Feet || Date Saved: 06/02/2011 || User: pwittman || Print Date: 06/02/2011

Notes:

Columbia River stage is from USGS Station # 1410570; located 2.6 miles downstream from The Dalles Dam.

Any depth to groundwater measurements from Table 2.2 which had fluctuating water levels were not included in the hydrographs.



Aspect Consulting
6/17/2011
S:\WRIA 30\Phase 4\LowerKlick Dallesport Avail Study -012\Dallesport Water Availability Study\Report\Well Summary Table - Dallesport Area.xls

Figure 3.5 - Water Level Hydrographs

Dallesport Water Availability Study
WRIA 30, Washington

Notes:

Dallesport annual precipitation data from DALLESPORT FCWOS AP (NOAA #451968).

Individual months with more than 5 days of missing data were not used for either monthly or annual statistics.

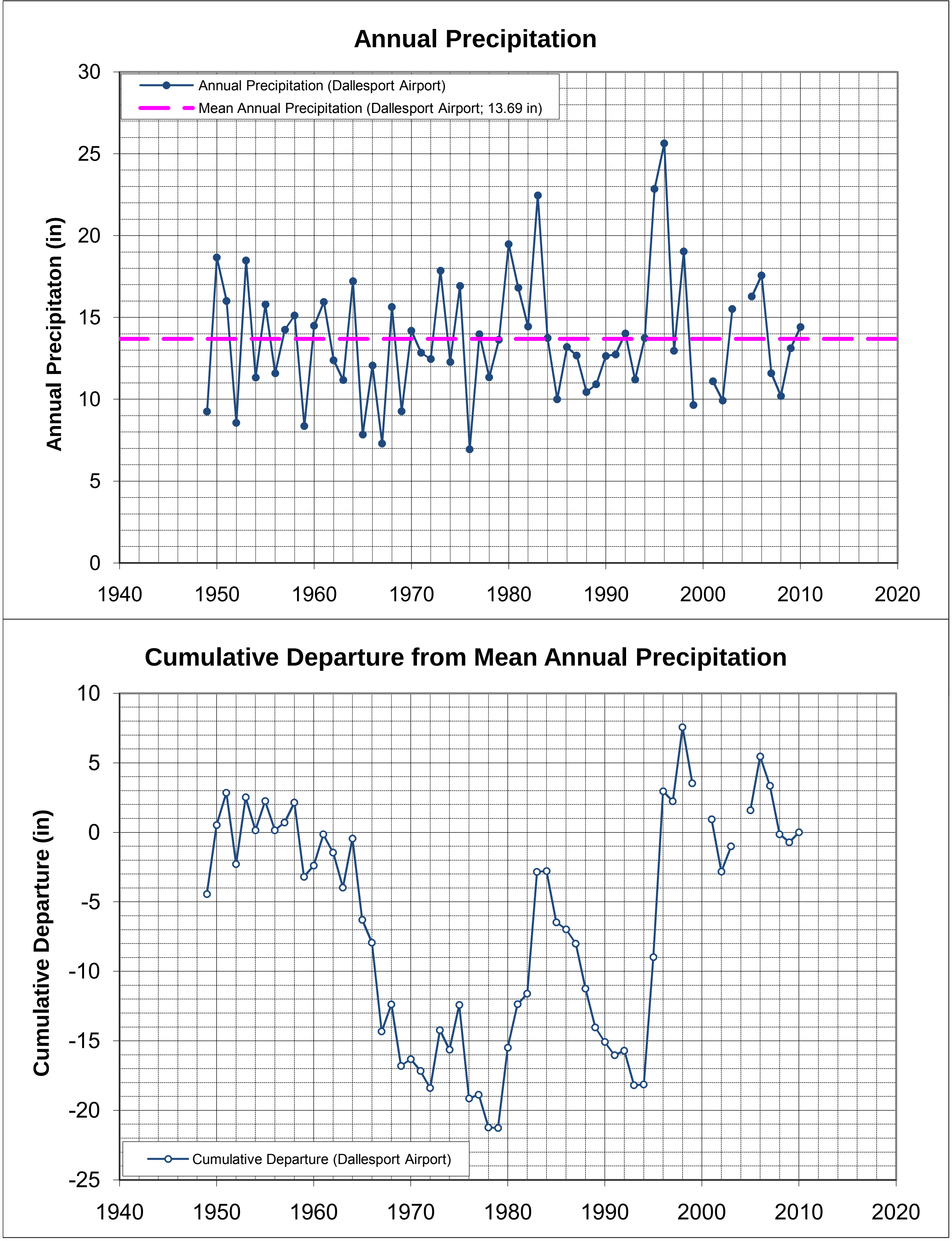


Figure 3.6

Long-Term Precipitation Analysis

Dallesport Water Availability Study
WRIA 30, Washington

Aspect Consulting
6/17/2011
S:\WRIA 30\Phase 4\LowerKlick Dallesport Avail Study -012\Dallesport Water Availability Study\Report\Figure 3.6 - Precipitation Analysis.xls

APPENDIX A

Well Completion Summary Table for the Dallesport Peninsula

Appendix A - Well Completion Summary for the Dallesport Peninsula

Dallesport Water Availability Study
WRIA 30, Washington

Well ID	Original Well Owner	Map Location	Well Depth (ft)	Year Drilled	Static Water Level (ft bgs)	Well Diameter (in)	Open/Screen Interval		Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Comments
							Upper (ft bgs)	Lower (ft bgs)				
465563	DENNIS E BEEKS	12SE	345	8/23/2006	40	6	19	345	50	-	-	
138773	DENNIS BEEKS	12Q1	385	7/24/1985	325	6	20	385	40	-	-	
138775	DENNIS BEEKS	12Q2	725	8/9/1997	125	6	85	725	50	-	-	
141059	JACK SCHREINER	12Q3	590	11/11/1992	40	6	19	590	3	-	-	
141060	JACK SCHREINER	12Q4	460	11/16/1992	50	6	44	460	60	-	-	
141821	JOHN HUTESON JR.	12Q5	390	10/17/1980	225	6	39	390	10	-	-	
145444	STAN MILLER	12Q6	405	8/4/1993	270	6	79	405	60	-	-	
138798	DENNIS HOEYE	13A1	310	6/12/1994	165	6	79	310	60	-	-	
138643	DAVID HYDE	13B1	340	10/12/1994	185	6	19	340	75	-	-	
143205	MELVIN THORNBUG	13B2	200	4/3/1978	85	6	35	200	60	-	-	
341485	MIKE JABLONSKI	13F1	266	6/20/2002	135	6	226	266	75	-	-	
145062	RONALD JOHNSON	13C1	340	5/16/1984	152	6	20	340	110	-	-	
137804	CHARLES STERRIT	13D1	370	4/8/1978	125	6	52	370	25	-	-	
143532	MURDOCK WATER ASSOC. 904	13K1	420	8/5/1993	225	6	-	-	80	-	-	
142046	JULIUS COURTNEY	13R1	410	6/15/1991	275	6	65	410	70	-	-	
141061	JACK SCHREINER	13Q1	390	11/24/1992	0	10	39	390	550	-	-	
145274	SCHREINER FARMS	13M1	180	3/9/1994	100	6	79	180	50	-	-	
140001	FRENCHE VEZINA	14J1	550	3/16/1982	150	6	375	550	150	-	-	
142012	JOSEPH BLANCK	14J2	340	4/14/1978	125	8	20	340	-	-	-	
191941	RICHARD MURRAY	14J3	130	5/17/1999	81	6	57	130	15	-	-	
191942	RICHARD MURRAY	14J4	330	5/21/1999	31	6	59	330	18	-	-	
302716	DAN STINGL	14R1	220	4/10/2001	15	6	220	80	-	-	-	
417939	JOHN BOGGESS	14R2	250	7/25/2005	115	6	-	-	35	-	-	
475774	JOSEPH SCHREINER	14Q1	74	12/12/2006	20	6	35	60	100	-	-	
143035	MARTHA NIBLACK	14P1	490	2/12/1981	370	6	60	490	30	-	-	
417934	GARY AND LYNDA LAVINE	15M1	280	8/4/2005	175	8	39	280	75	-	-	
141350	JERRY FRAZIER	15N1	290	9/25/1979	48	6	40	290	125	-	-	
143790	ORISON MURDOCK	16	128		80	8	49	128	25	-	-	
140252	GEORGE MC KINNON	16G1	142	1/27/1971	100	6	22.5	142	15	-	-	
257404	ERIC SCHMID	16C1	405	6/28/2000	230	6	148	405	60	-	-	
296476	IVOR JONES	16D1	205		130	6	20	205	8	-	-	
534981	ROBERT HOGFOSS	16E1	180	5/30/2008	70	6	59	180	20	-	-	
142439	LARRY FRAZIER INC.	16J1	100	5/29/1978	55	6	20	100	30	-	-	
145275	SCHREINER FARMS	16J2	295	5/15/1989	100	6	220	295	300	-	-	
296487	JACK SCHREINER	16J3	285		97	8	216	285	1000	-	-	
417069	MURDOCK WATER ASSOC. 904	16K1	420	8/5/1993	225	6	-	-	80	-	-	
142075	KARL MOORE	16R1	107	4/1/1960	10	8	14	107	75	-	-	
317851	KARL MOORE	16Q1	400	8/12/2001	205	6	-	-	100	-	-	
317853	KARL MOORE	16Q2	425	8/19/2001	243	6	-	-	80	-	-	
352374	KARL MOORE	16Q3	385	10/12/2002	85	6	140	160	75	-	-	
377239	IVOR JONES	16Q4	306	10/14/1995	216	6	246	306	25	-	-	
140251	GEORGE MC KIMMOM	16SW1	175	10/24/1972	119	6	-	-	60	-	-	
140255	GEORGE MCKINNON	16SW2	270	7/28/1989	145	6	-	-	65	-	-	
140856	HOWARD SHAW	16SW3	280	8/15/1989	196	6	20	280	50	-	-	
137029	Bert Arndt	16L1	285	10/10/1994	195	6	245	285	30	-	-	
137660	CECIL ADOM	16L2	286	7/28/1977	-	6	-	-	40	-	-	
137669	CECIL ODOM	16L3	220	1/15/1980	120	6	120	220	65	-	-	
139363	EARL COOPER	16L4	280	3/27/1982	90	6	-	-	70	-	-	
139365	EARL COOPER ADD.	16L5	175	4/6/1979	99	6	30	175	20	-	-	
139366	EARL COOPER ADD.	16L6	325	4/5/1979	175	6	38.5	325	75	-	-	
139367	EARL COOPER ADD.	16L7	344	4/3/1979	175	6	29	344	90	-	-	
139368	EARL COOPER ADDDITION	16L8	150	3/30/1979	99	6	62	150	60	-	-	
140253	GEORGE MC KINNON	16L9	175	10/24/1972	119	6	175	175	60	-	-	
140933	IVER JONES	16L10	315	6/2/1973	157	6	0	315	25	-	-	
142476	LARRY ODOM	16L11	330		-	6	-	-	-	-	-	
142800	LOUIS MELIUS	16L12	320	6/26/1996	240	6	39	320	45	-	-	
143531	MURDOCK TRACT WATER FUND	16L13	250		156	6	190	199	40	76	0.5	
143986	PEARL & JAMES FEHR	16L14	115	4/19/1983	70	6	50	115	125	-	-	
144776	ROBERT KNOWLES	16L15	125		100	6	18	125	20	6	3.3	
144777	ROBERT KNOWLES	16L16	250	6/30/1972	183	6	26	250	17	-	-	
145047	RONADL JOHNSON	16L17	395	7/15/1996	235	6	335	395	85	-	-	
191888	LARRY G CLARK	16L18	471	7/26/1999	260	6	-	-	120	-	-	

Appendix A - Well Completion Summary for the Dallesport Peninsula

Dallesport Water Availability Study
WRIA 30, Washington

Well ID	Original Well Owner	Map Location	Well Depth (ft)	Year Drilled	Static Water Level (ft bgs)	Well Diameter (in)	Open/Screen Interval		Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Comments
							Upper (ft bgs)	Lower (ft bgs)				
257405	NORMAN BENNETT	16L19	410	8/23/2000	225	6	350	390	30	-	-	
296177	CECIL ODOM	16L20	190		48	6	53	191	8	128	0.06	
335149	CECILL ODOM	16L21	395	4/9/2002	225	6	-	-	85	-	-	
341486	DARYL BEEKS	16L22	198	8/29/2002	71	6	24	198	11	-	-	
375716	LARRY CLARK	16L23	445	2/19/2004	290	6	99	445	50	-	-	
377238	CECIL ODOM	16L24	280	5/3/1995	175	6	-	-	60	-	-	
382350	STEVE COOK	16L25	503	5/26/2004	303	5.25	423	503	12.5	2	6.25	
139324	E. B. COOPER	16M1	109		65	6	30	109	40	35	1.14	
140101	GARY MORRIS	16M2	300	7/6/1992	175	6	19	300	60	-	-	
142200	KEN ZEILINSKI	16M3	88	4/7/1982	40	6	59	88	50	40	1.25	
144075	PHILLIP HEARRON	16M4	109	4/9/1982	32	6	59	109	15	70	0.21	
139132	DONALD CHAFFEE	16P1	200	4/20/1995	115	6	79	200	35	-	-	
139865	FRANK HEALEY	16P2	-	1/28/1971	-	-	19.5	130	12	-	-	
140934	IVOR JONES	16P3	205	1/11/1971	130	6	20	205	8	55	0.15	
143438	MINORS ADDITION WATER SUPPLY	16P4	260	6/10/1985	135	6	119	260	105	-	-	
145252	SAMUEL DEAN	16P5	20	9/15/1955	14	42	0	20	18	-	-	
317852	DACIA JOHNSON	16P6	408	8/2/2001	230	6	159	408	100	-	-	
341487	MINORS ADDITION	16P7	430	5/24/2002	250	6	-	-	75	-	-	
363885	DAVID OJALA	16P8	383	6/17/2003	225	6	-	-	60	-	-	
534968	AL LA FAZIO	16P9	82	8/28/2006	25	6	42	82	20	-	-	
139364	EARL COOPER	16P10	280	7/19/1978	105	6	88.5	280	100	-	-	
296386	FRANK HEALEY	16P11	130		-	6	20	130	12	-	-	
382338	GERALD SWEET	16P12	330	6/2/2004	225	6	290	330	30	-	-	
465564	NOAH J BOOHER	16P13	330	12/5/2006	200	6	260	320	50	-	-	
465565	BRAD GEARHART	16P14	330	10/19/2006	160	6	270	330	100	-	-	
138493	King, Darrel	21B1	170	7/29/1982	65	6	35	170	12	90	0.1	open hole
142438	Larry Frazier Inc.	21B2	150	2/13/1980	85	6	30	150	25	-	-	open hole
146082	Triple M Trust	21B3	350	8/16/1994	135	6	280	340	40	-	-	perforated
359317	Murray, Richard	21B4	270	5/18/1995	107	6	210	270	25	-	-	perforated
317854	Mcleod, John	21C1	385	7/26/2001	150	6	345	385	25	-	-	perforated
144558	Murray Richard	21D1	230	3/11/1991	76	6	37	230	20	-	-	open hole
403826	Moore, Charles	21J1	129	1/26/2005	75	6	79	129	30	-	-	no screen; perf 79-129 ft; 30 gpm/1 hr
403822	Moore, Charles	21J2	405	2/1/2005	240	6	219	405	100	-	-	no screen, no perforation; 100 gpm/ 1 hr
627931	Charles L Moore	21J3	125	11/27/2009	85	6	85	125	40	-	-	
139054	Graves, Don	21R1	160	9/3/1982	125	6	-	-	40	-	-	open bottom
139146	Groves, Donald	21R2	140		111	8	-	-	100	6	16.7	open bottom
405756	Graves, Douglas	21R3	180	3/18/2005	125	6	-	-	45	-	-	open bottom
413144	Graves, Donald	21R4	180	7/1/2005	125	6	-	-	200	-	-	open bottom
139979	Smith, Fred	22F1	500		200	12	90	500	700	7	100	no screen, no perf; 700 gpm w/ 7ft drawdown after 60 hrs
143367	Roggencamp, Mike	22J1	87	5/11/1991	25	6	47	87	20	50	0.4	no screen; perf 47-87 ft; 20 gpm w/ 50ft drawdown after 2 hrs
146335	Gregory, W.H.	22P1	285	5/18/1973	77	10	20	285	800	-	-	no screen, no perf
142285	Kiewit-Pacific Company	22Q1	460	7/26/1990	210	10	20	460	700	-	-	no screen, no perf; 700 gpm/1 hr
543344	Myron Smith/Hood River Sand & Gravel	22Q2	516	2/18/2008	202	10	343	618	600	-	-	deepening of Kiewit-Pacific Company well
254773	Ross Island Sand & Gravel	23J1	42	11/18/1999	-	2	22	42	-	-	-	monitoring well
254774	Ross Island Sand & Gravel	23J2	40	11/19/1999	17	2	20	40	-	-	-	monitoring well
254775	Ross Island Sand & Gravel	23J3	35	11/22/1999	22	2	20	35	-	-	-	monitoring well
-	Gilmore, Roy	26D1	720	1/0/1900	205	6	-	-	25	-	-	no screen, no perf; 25 gpm/1 hr
257407	DALE DENNIS	24N1	28	7/13/2000	-	2	65	75	15	-	-	monitoring well
257408	DALE DENNIS	24N2	21	7/13/2000	-	2	18	28	-	-	-	monitoring well
257409	SCHREINER FARM	25P1	50	7/14/2000	-	2	40	50	-	-	-	monitoring well
257410	SCHREINER FARM	25P2	16	7/14/2000	-	2	6	16	-	-	-	monitoring well
257411	SCHREINER FARM	25P3	30	7/17/2000	-	2	20	30	-	-	-	monitoring well
257412	SCHREINER FARM	25P4	48	7/17/2000	-	2	38	48	-	-	-	monitoring well
413145	RECYCLED ALUMINUM METALS	25P5	80	6/27/2005	47.5	2	70	80	-	-	-	monitoring well
413146	RECYCLED ALUMINUM METALS	25P6	81	6/27/2005	46	2	71	81	-	-	-	monitoring well
413147	RECYCLED ALUMINUM METALS	25P7	80	6/27/2005	45	2	69.5	79.5	-	-	-	monitoring well
413148	RECYCLED ALUMINUM METALS	25P8	69	6/27/2005	46.5	2	58.5	68.5	-	-	-	monitoring well
413149	RECYCLED ALUMINUM METALS	25P9	71	6/27/2005	-	2	61	71	-	-	-	monitoring well
556430	DEPT OF ECOLOGY	25P10	81	8/15/2008	-	2	71	81	-	-	-	monitoring well
142308	KLICKITAT COUNTY PORT DIS. #1	25N1	210	7/7/1970	70	6	210	210	250	90	2.8	
302091	US ARMY CORPS OF ENGINEERS	25N2	20	9/5/2000	8.5	4	5	20	-	-	-	monitoring well
302092	US ARMY CORPS OF ENGINEERS	25N3	20	9/5/2000	8.5	4	5	20	-	-	-	monitoring well

Appendix A - Well Completion Summary for the Dallesport Peninsula

Dallesport Water Availability Study
WRIA 30, Washington

Well ID	Original Well Owner	Map Location	Well Depth (ft)	Year Drilled	Static Water Level (ft bgs)	Well Diameter (in)	Open/Screen Interval		Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Comments
							Upper (ft bgs)	Lower (ft bgs)				
302093	US ARMY CORPS OF ENGINEERS	25N4	20	9/5/2000	8.5	4	5	20	-	-	-	monitoring well
302094	US ARMY CORPS OF ENGINEERS	25N5	20	9/5/2000	8.5	4	5	20	-	-	-	monitoring well
590547	DICK WISE	26	388	4/5/1968	150	8	-	-	-	-	-	
140342	ROY GILMORE	26D1	720	8/5/1998	205	6	-	-	25	-	-	
138377	Dallesport Industrial Park	26J	292	12/4/1982	55	12	98	292	1450	-	-	no screen, no perf; blow test 1450 gpm
144448	Recycled Aluminum Metals Co	26M1	36	5/9/1991	Dry	4.5	31	36	-	-	-	perforated; dry well
144449	Recycled Aluminum Metals Co	26M2	40	5/9/1991	Dry	4.5	35	40	-	-	-	perforated; dry well
141242	Jarl Construction	27A1	215	5/6/1975	48	10	19	215	20	0	>20	no screen; no perf; 20 gpm w/ 0 ft drawdown after 1 hr.
141243	Jarl Construction	27A2	595	8/27/1975	183	12	185	595	20	0	>20	no screen, no perf; 20 gpm w/ 0 ft drawdown after 1 hr.
146238	Jarl, Vernie	27A3	150	4/15/1980	55	6	30	150	55	-	-	no screen; no perf; blow test 55 gpm
296607	Mid-Columbia Asphalt	27A4	520	1/0/1900	208	6	179	520	300	-	-	no screen, no perf; 300 gpm/ 1 hr
341488	Eiesland, Robert	27A5	495	5/16/2002	195	8	-	-	1000	-	-	no screen; no perf; 1000 gpm/ 1 hr
474060	Mid Columbia Asphalt	27A6	8	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474062	Mid Columbia Asphalt/ Farallon Construction	27A7	15	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474064	Mid Columbia Asphalt/ Farallon Construction	27A8	13	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474066	Mid Columbia Asphalt/ Farallon Construction	27A9	11	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474068	Mid Columbia Asphalt/ Farallon Construction	27A10	3	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474070	Mid Columbia Asphalt/ Farallon Construction	27A11	8	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474077	Mid Columbia Asphalt	27A12	8	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474079	Mid Columbia Asphalt	27A13	15	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474081	Mid Columbia Asphalt	27A14	13	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474083	Mid Columbia Asphalt	27A15	11	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474085	Mid Columbia Asphalt	27A16	3	2/12/2007	Dry	4.25	-	-	-	-	-	boring
474087	Mid Columbia Asphalt	27A17	8	2/12/2007	Dry	4.25	-	-	-	-	-	boring
556422	Granite Grado Ventures	27A18	8	1/8/2008	Dry	-	-	-	-	-	-	boring
556423	Granite Grado Ventures	27A19	11	1/8/2008	Dry	-	-	-	-	-	-	boring
556424	Granite Grado Ventures	27A20	18	1/8/2008	Dry	-	-	-	-	-	-	boring
556425	Granite Grado Ventures	27A21	8	1/8/2008	Dry	-	-	-	-	-	-	boring
556426	Granite Grado Ventures	27A22	11	1/8/2008	Dry	-	-	-	-	-	-	boring
556427	Granite Grado Ventures	27A23	18	1/8/2008	Dry	-	-	-	-	-	-	boring
296561	Tidyman, Lawrence	27B1	280		86	10	20	280	1000	-	-	1000 gpm
137954	Circle T Enterprises	27G1	120	4/3/1998	30	6	19	120	60	-	-	no screen, no perf; 60 gpm/ 1 hr
144446	Rabanco Regional Landfill	27H1	185	10/5/1990	70	6	100	140	15	-	-	no screen; perf 100-140 ft; 15 gpm/ 1hr
144274	Carstens, Ralph	27J	85	3/16/1993	10	6	20	85	60	-	-	no screen, no perf; 60 gpm/ 1 hr
144933	Cool, Roger	27J1	125	3/20/1980	30	6	20	125	65	-	-	no screen, no perf; blow test 65 gpm
465567	Trujillo, William	27L1	150	12/1/2006	70	6	19	150	70	-	-	open hole
145929	Harth, Tom	27M	140	3/16/1993	25	6	26	140	60	-	-	no screen, no perf; 60 gpm/ 1 hr
142551	Showalter, LeRoy	27M1	110	7/27/1982	75	6	80	110	35	-	-	no screen, no perf; blow test 35 gpm
145124	Gilmore, Roy	27M2	125	3/31/1988	49	6	65	125	70	-	-	no screen, no perf; blow test 70 gpm
359648	Ellett, Donald	27M3	105	4/9/2003	25	6	19	105	10	-	-	open hole
359650	Ellett, Donald	27M4	150	4/10/2003	45	6	19	150	45	-	-	open hole
-	Unknown	27R1	-		-	-	-	-	-	-	-	no available well log
137656	Sterritt, Catherine	27J5/28R	185	11/29/1993	40	6	19	185	45	-	-	no screen, no perf; 45 gpm/ 1hr
296088	Ogawa, Akira	28A1	169		66	8	60	148	80	20	4.0	perforated & open hole; 80 gpm w/ 20 ft drawdown
140656	Toda, Harry	28F1	170	10/18/1972	-	-	-	-	-	-	-	no well log
-	Toda, Harry	28F2	170		79	8	140	170	25	22	1.1	no screen; perf 140-170 ft; 25 gpm w/ 22 ft. drawdown after 1.5 hrs
139900	Toda, Frank	28G1	100	2/2/1953	65	8	98	100	160	-	-	yield 160 gpm
141581	Wise, Jim	28G2	155	4/12/1979	27	6	19	155	150	-	-	no screen, no perf; blow test 150 gpm
296723	Sisson, Owen	28J1	189		-	8	44	189	50	-	-	yield 50 gpm
140619	Shepler, Harold	28J2	251	12/12/1975	45	8	59	251	40	-	-	no screen, no perf; 20 gpm w/ 60 ft drawdown after 1 hr
143530	Mt. View Water Association	28J3	210	3/7/1980	125	6	95	208	70	-	-	no screen, no perf; blow test 70 gpm
140618	Shepler, Harold	28J4	120	3/10/1983	37	6	20	120	40	-	-	no screen, no perf; blow test 40 gpm
142451	Holliday, Larry	28J5	140	3/14/1983	68	6	100	140	35	-	-	no screen, no perf; blow test 35 gpm
138378	Dallesport Mobile Home	28J6	-	10/11/1988	50	8	-	-	60	-	-	reconditioned well
140864	Bullock, Hugh	28L1	220	2/27/1979	101	6	18.5	220	120	-	-	no screen, no perf; blow test 120 gpm
136635	Sexton, Allen	28L2	225	4/18/1989	150	6	29	225	50	-	-	no screen, no perf; blow test 50 gpm/ 1 hr
143092	Harrison, Marvin	28P1	200	9/23/1980	95	6	20	200	100	-	-	no screen, no perf; blow test 100 gpm
143498	Leno, Franke	28P2	205	11/20/1981	115	6	30	200	100	-	-	no screen, no perf; blow test 100 gpm
302710	Saburo, Akita	28P3	220	3/12/2001	125	6	160	220	75	-	-	no screen; perf 160-220 ft; blow test 75 gpm/ 1 hr.
137479	Williams, Bud	28Q1	205	12/1/1971	119	6	19	205	50	-	-	no screen, no perf; 50 gpm air lift
138375	Dallesport Domestic Water	28Q2	182	1/24/1980	110	6	-	-	75	-	-	no screen, no perf; blow test 75 gpm
136785	Dahl, Arthur	28Q3	210	3/7/1980	125	6	95	208	70	-	-	no screen, no perf; blow test 70 gpm

Appendix A - Well Completion Summary for the Dallesport Peninsula

Dallesport Water Availability Study
WRIA 30, Washington

Well ID	Original Well Owner	Map Location	Well Depth (ft)	Year Drilled	Static Water Level (ft bgs)	Well Diameter (in)	Open/Screen Interval Upper (ft bgs)	Open/Screen Interval Lower (ft bgs)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Comments
-	Dallesport Domestic Water	28Q4	182		110		-	-	75	-	-	no screen, no perf; blow test 75 gpm / 1 hr
138376	Dallesport Domestic Water	28Q5/28R	290	8/1/1988	147	6	-	-	33	0	>33	no screen, no perf; no drawdown
-	Unknown	28R1	-		-	-	-	-	-	-	-	no available well log
296179	Odom, Cecil	28R2	90		3	6	40	90	10	67	0.1	yields 10 gpm w/ 67 ft drawdown after 30 min
296968	Williams, Tom	28R3	187		120	8	8	187	-	-	-	no screen, no perf; thickness of aquifer unknown
141854	Lundry, John	28R4	86	8/15/1989	23	6	19	86	75	-	-	no screen, no perf; blow test 75 gpm / 1 hr
-	Ogawa, Akira	28R5	169		60	6	60	169	80	20	4.0	perf 60-90 ft; open 115-169 ft; 80 gpm with 20 ft drawdown
-	Unknown	28R6	-		-	-	-	-	-	-	-	no available well log
556409	Joanne E Payne	28R7	240	9/29/2008	140	6	200	240	40	-	-	perf 200-240
143338	Helyer, Mike	33A1	265	12/15/1975	162	6	19	265	40	80	0.5	no screen, no perf; 40 gpm w/ 80 ft drawdown after 1 hr
138374	Dallesport Community Park	33A2	365	7/29/1981	185	8	280	365	600	-	-	no screen, no perf; blow test 600+ gpm
145813	Marjory, T. & Foley, R.	33A3	250	8/18/1983	135	8	170	250	360	-	-	no screen, no perf; blow test 360 gpm
138373	Dallesport Community Park	33A4	-	5/10/1986	-	-	-	-	-	-	-	reconditioned well
296266	Dallesport Development Community	33C1	110		40	6	18	110	1	20	0.1	open hole
144133	Prospect Water Association	33D	313	9/26/1988	165	6	189	312	60	0	>60	no screen, no perf; blow test 60 gpm/ 1 hr; 0 ft drawdown
140590	Hays, Harold	33F1	245	9/14/1989	153	6	180	240	45	-	-	no screen; perf 180-280 ft; blow test 45 gpm / 2hrs
142708	Williams, Lindsey	33G1	240	7/1/1987	175	6	19	240	32	-	-	no screen, no perf; blow test 32 gpm
141797	Haggard, John	33H1	120	5/22/1978	10	6	21.5	120	10	-	-	no screen, no perf; blow test 10 gpm
140272	Sheradella, George	33J1	230	8/2/1977	57	6	19	230	21	165	0.1	no screen, no perf; 21 gpm w/ drawdown 165 ft after 1 hr
142849	Lyle School District No. 406	33J2	320	4/15/1981	175	6	250	320	350	-	-	no screen, no perf; blow test 350 gpm
139141	Dietz, Donald	33L	163	5/23/1984	98	6	65	163	40	-	-	no screen, no perf; blow test 40 gpm
296230	Whitt, Cliff	33N1	298		168	6	247	298	60	1	60.0	open hole
-	Spokane, Portland & Seattle Railway	33R1	149		47	6	8	149	45	0	>45	45 gpm after 2 hr, negligible drawdown; no well log
560109	Klickitat Cnty PUD #1	34D1	40	10/1/2008	-	8	-	-	-	-	-	boring
560115	Klickitat Cnty PUD #2	34D2	35	10/1/2008	-	8	-	-	-	-	-	boring
560116	Klickitat Cnty PUD #3	34D3	40	10/1/2008	-	8	-	-	-	-	-	boring
560117	Klickitat Cnty PUD #4	34D4	35	10/1/2008	-	8	-	-	-	-	-	boring
138380	Dallesport Water Association	34E1	334	6/19/1979	150	10	296	334	235	6	39.2	Well No. 2 no screen; perf 296-334 ft; 235 gpm w/ 6 ft drawdown after 1 hr
429754	Dallesport Water Association	34E2	390	1/11/2006	180	6	307	309	250	-	-	Well No. 3 open hole
452274	Dallesport Water Association	34E3	-	4/21/2006	-	-	-	-	-	-	-	Well No. 1 well decommissioning
138379	Dallesport Water Association	34E4	-	7/27/1979	-	-	-	-	-	-	-	Well No. 2 well reconditioning
-	Unknown	34E1	-		-	-	-	-	-	-	-	no available well log
296265	The Dalles, OR	34L1	541		208	6	42	541	85	0	>85	original Airport Well - 85 gpm w/ 0 ft drawdown
521049	City of the Dalles & Klickitat Co	34L2	235	2/27/2008	151	8	-	-	-	-	-	Original Airport Well well decommissioning
534955	City of the Dalles & Klickitat Co	34L3	235	4/15/2008	151	8	-	-	-	-	-	Original Airport Well well decommissioning
521081	City of the Dalles & Klickitat Co	34L4	558	12/18/2007	189	12	342.5	539	1520	5	304	Replacement Airport Well screen 342.5-372.5 & 514-539
210652	US ARMY CORPS OF ENGINEERS	36G1	36	8/29/1999	-	-	-	-	-	-	-	decomissioned boring
210653	US ARMY CORPS OF ENGINEERS	36G2	30	8/30/1999	-	-	-	-	-	-	-	decomissioned boring
210654	US ARMY CORPS OF ENGINEERS	36G3	30	8/30/1999	-	-	-	-	-	-	-	decomissioned boring
210655	US ARMY CORPS OF ENGINEERS	36G4	30	8/31/1999	-	-	-	-	-	-	-	decomissioned boring
210656	US ARMY CORPS OF ENGINEERS	36G5	19	9/1/1999	-	-	-	-	-	-	-	decomissioned boring
210657	US ARMY CORPS OF ENGINEERS	36G6	103	9/3/1999	-	-	-	-	-	-	-	decomissioned boring
210658	US ARMY CORPS OF ENGINEERS	36G7	51	9/4/1999	-	-	-	-	-	-	-	decomissioned boring
210659	US ARMY CORPS OF ENGINEERS	36G8	50	9/7/1999	-	-	-	-	-	-	-	decomissioned boring
210660	US ARMY CORPS OF ENGINEERS	36G9	49	9/9/1999	-	-	-	-	-	-	-	decomissioned boring
566907	US ARMY CORPS OF ENGINEERS	36G10	87	9/2/1999	-	-	-	-	-	-	-	decomissioned boring
145792	US ARMY CORPS OF ENGINEERS	36F1	5	8/12/1993	-	-	-	-	-	-	-	decomissioned boring
579223	US ARMY CORPS OF ENGINEERS	36F2	5	8/12/1993	-	-	-	-	-	-	-	decomissioned boring
579224	US ARMY CORPS OF ENGINEERS	36F3	5	8/12/1993	-	-	-	-	-	-	-	decomissioned boring
579225	US ARMY CORPS OF ENGINEERS	36F4	5	8/12/1993	-	-	-	-	-	-	-	decomissioned boring
210661	US ARMY CORPS OF ENGINEERS	36J1	40	9/14/1999	-	-	-	-	-	-	-	decomissioned boring
210662	US ARMY CORPS OF ENGINEERS	36J2	44	9/10/1999	33	4	36	44	-	-	-	monitoring well
210663	US ARMY CORPS OF ENGINEERS	36J3	40	9/11/1999	24	4	18	26	-	-	-	monitoring well
210664	US ARMY CORPS OF ENGINEERS	36J4	40	9/12/1999	33	4	35	40	-	-	-	monitoring well
210665	US ARMY CORPS OF ENGINEERS	36J5	40	9/13/1999	22	4	20	25	-	-	-	monitoring well
257413	GEOTECHNICAL EXPLORATION	36J6	80	6/5/2000	30	10	40	50	-	-	-	monitoring well
257414	GEOTECHNICAL EXPLORATION	36J7	80	6/8/2000	30	6	54	71	-	-	-	monitoring well
257415	GEOTECHNICAL EXPLORATION	36J8	80	6/8/2000	30	1	50	70	-	-	-	monitoring well
257416	GEOTECHNICAL EXPLORATION	36J9	80	6/8/2000	30	1	50	70	-	-	-	monitoring well

APPENDIX B

Basin-Scale Water Balance for Dallesport Study Area

Basin-Scale Water Balance for Dallesport Study Area

The conventional basin-scale water balance approach partitions precipitation into evapotranspiration (ET: water evaporated from soil, rock, or open water, plus water consumed [transpired] by growing plants), runoff becoming streamflow, and groundwater recharge – all on an annual basis. To complete a full assessment, estimated water use by human activities – partitioned into estimated consumptive water use and return flow (water used but not consumed) – is added to the annual water balance. The water balance analysis for this study area is similar to that applied in the Water Availability Report for Swale Creek and Little Klickitat subbasins (Aspect, 2007). The following subsections present the water use estimates, and then the full water balance, for the Dallesport study area.

Water Use Estimates

Estimated water use is an important element of the basin-scale water balance, supporting the assessment of water availability. Water use is estimated for the major categories of use including irrigation, residential, and non-residential (e.g., commercial/ industrial). The water use estimates represent current average annual conditions based on available information and numerous assumptions. Actual use varies for any given time period due to factors such as temperature, precipitation, or land use including cropping practices. A summary of the methods and results of estimating each of these water use categories are presented below.

Irrigation Use

Annual irrigation water use (acre-feet/year) is estimated by multiplying the irrigated area (acres) in the study area by a representative annual irrigation requirement, or water duty (feet/year). As of May 2010, information from the Farm Services Agency (FSA) indicated that irrigated acreage for the Dallesport study area included 13.8 acres of vineyard crop. However, after reviewing aerial maps, it was apparent that not all irrigated acreage is accounted for in FSA's records, presumably because the acreage is not under FSA's programs. Therefore, we used Geographical Information System (GIS) data with the aerial photos and direct land observations to estimate the irrigated acreage for this analysis. Based on photo review, the total irrigated areas estimated for the Dallesport study area is 545 acres. Based on photo review supplemented with a field reconnaissance to evaluate crop types, this includes approximately 90 acres of alfalfa (center pivot), 380 acres of orchards, and 75 acres of vineyards.

The water duty varies for each crop type. Based on analysis performed for the WRIA 31 Level 1 Watershed Assessment (Aspect and WPN, 2004), the assumed annual water duties are: alfalfa = 3.4 feet (40.8 inch), orchards = 4.9 feet (58.8 inch) which includes cooling and freeze protection, and vineyards = 1.5 feet (18.0 inch). Using these water duties and estimated irrigated acres, the estimated total irrigation water use for the study area is 2,281 acre-feet per year, with orchards comprising the primary usage, as shown in Table B-1 below. However, the water duties for crops do not take into account how much of the total water applied to the crops is actually consumed versus returned to the watershed via runoff or infiltration (return flow). The estimated consumptive and non-consumptive uses of the irrigation water are outlined below.

Consumptive and Non-Consumptive Irrigation Use

Water delivered for irrigation is either consumed by evapotranspiration, or it is not consumed and augments streamflow or recharges groundwater in the study area, referred to as return flow. Of the estimated 2,281 acre-feet/year of water used for irrigation, the consumptive use versus return flow components of this use are also estimated for use in the water balance.

The irrigation method in the area is primarily driven by crop type, and the irrigation method largely dictates the consumptive versus nonconsumptive fraction of irrigation use. For the purposes of this assessment, we assumed that alfalfa is irrigated using either a center pivot or a wheel line based on aerial photos and field observations, orchards are irrigated using solid set overtree sprinklers, and vineyards are irrigated using micro-irrigation drip lines. The estimated percent of total irrigation use that is consumed for each irrigation method was obtained from Ecology's (2005) Guidance 1210 for calculating annual consumptive quantity for irrigation use. The assumed consumptive use percentage for each crop type/irrigation method is presented in footnote c to Table B-1.

Using this methodology, the total consumptive and nonconsumptive irrigation water uses are estimated at 1,969 and 313 acre-feet/year, or 86% and 14%, respectively, for the study area (Table B-1).

The difference between the amount of water delivered and the amount of water consumed is returned to the watershed (return flow) as either groundwater recharge or streamflow. Given the relatively flat terrain and lack of surface drainages in the primary irrigation areas, we assume the irrigation return flow is partitioned 90% to 10% between groundwater recharge and streamflow, respectively.

Table B-1 – Estimate of Consumptive and Nonconsumptive Estimated Annual Irrigation Water Use

Crop	Total Irrigated Acres[a]	Water Duty in Feet/Year[b]	Annual Total Irrigation Use in Acre-Ft/Year	Annual Consumptive Quantity in Acre-Ft/Year[c]	Annual Return Flow Quantity in Acre-Ft/Year[c]
Alfalfa (center pivot)	62	3.4	211	202	11
Alfalfa (wheel line)	28	3.4	95	80	14
Orchards	380	4.9	1862	1583	279
Vineyards	75	1.5	113	104	8
Total	**545**	**--**	**2,281**	**1,969**	**312**
		Percent of total irrigation use:		86%	14%

Notes:

[a] Estimated from aerial photos and field reconnaissance observations of general crop types.

[b] Developed as part of the WRIA 31 Level 1 Watershed Assessment (Aspect and WPN, 2004). Assumes alfalfa water duty 40.8 inch/year, orchard water duty of 58.8 inch/year, and vineyard water duty of 18.0 inch/year.

[c] Assumes 95% consumptive use and 5% non-consumptive return flow for alfalfa using center pivot; 85% consumptive use and 15% non-consumptive use for wheel line irrigated alfalfa and solid set over tree orchard irrigation; and 93% consumptive and 7% non-consumptive use for micro-irrigation trickle drip for vineyards (based on Ecology Guidance 1210) .

Residential and Non-Residential Use

Public Water System Use

Using data from the state Department of Health (DOH) public water system (PWS) database, an estimated 246 acre-feet of PWS-supplied residential water use occurs within the study area, based on multiplying each PWS' number of residents served by an assumed 230 gallons per capita day[1] (gpcd), and converting to an annual volume in acre-feet/year. Table B-2 presents the DOH database information for numbers of connections and resident population served, and the resulting calculated residential water use for each PWS.

The total PWS-supplied non-residential water uses in the study area include commercial and industrial development and gravel mines. The Dallesport Airport Park (served by the Dallesport Water District) and the Port of Klickitat's Dallesport Industrial Park (Industrial Park served by Klickitat PUD) are the two main areas of industrial/commercial activity within the study area.

Based on actual water use data provided by the Dallesport Water District, the Dallesport Airport Park currently uses approximately 3 acre-feet per year, assuming the majority of commercial and industrial users are present at the business park. Based on water production data provided by the Klickitat PUD, the Industrial Park currently uses approximately 40 acre-feet/year for non-residential uses.

The only other PWS in the study area with a significant number (15) of non-residential connections is Columbia Hills State Park. Water use information could not be obtained for the park, so an estimate of 34 gpd per non-residential connection (averaged for a year-round water use) was applied based on information from Maryhill State Park, located on the Columbia River just upstream of the study area, obtained as part of the WRIA 30 Level 1 Watershed Assessment (WPN and Aspect, 2004). The estimated non-residential water use for Columbia Hills State Park is 0.6 acre-feet/year, rounded to 1 acre-foot/year for this analysis.

Based on the available information, the estimated non-residential annual water use supplied by PWS in the study area is 44 acre-feet/year (Table B-2).

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[1] Per capita water demand estimated in Dallesport Water District's 2009 Water System Plan, where 1 ERU = 419.8 gallons/day = 1.8 people (based on the Plan's population count)

Table B-2 - Estimated Annual Public Water System (PWS) Use

							Estimated Annual Water Use in Acre-Feet/Year		
PWS ID	**PWS Name**	**Group**	**Residents Served**	**No. Total Connects**	**No. Resid. Connects**	**No. Non-Resid. Connects**	**Residential**	**Non-Residential**	**Total**
17715	Dallesport Water District	A	398	227	223	4	103	3	106
238	Dallesport Industrial Park	A	0	57	0	57	0	40	40
8136	Dallesport Mobile Home Park	A	135	49	49	0	35	0	35
1842	Prospect Water Assn Inc	A	92	39	39	0	24	0	24
682	Murdock Water*	A	62	33	33	0	16	0	16
AC160	PJ Apartments	A	44	24	24	0	11	0	11
20527	Mountain View Association*	A	60	21	21	0	15	0	15
SP325	Columbia Hills State Park	A	3	16	1	15	1	1	2
15077	Dallesport Domestic Water Sharers	A	32	14	14	0	8	0	8
15804	Northdalles Fruit & Garden Tracts	B	14	9	9	0	4	0	4
19536	Riverview - Schmidt	B	24	9	9	0	6	0	6
20327	Minor Addition Water Supply	B	15	8	7	1	4	0	4
AB835	Third & Central Water System	B	13	6	6	0	3	0	3
AC021	Columbia Vineyards	B	18	6	6	0	5	0	5
4518	Ellis Water System	B	16	4	4	0	4	0	4
2679	Newcastle Water System	B	12	4	3	1	3	0	3
32821	Odom S Well	B	9	4	4	0	2	0	2
22401	Smith Ranch	B	5	3	2	1	1	0	1
2768	Sexton, Gisela Water System	B	2	2	2	0	1	0	1
Water Demand Totals			**954**	**535**	**456**	**79**	**246**	**44**	**290**

*: Murdock Water and Mountain View Water Associations now owned by Dallesport Water District.

Self-Supplied (Non-PWS) Water Use

Water uses not supplied by PWS are considered “self-supplied”. The self-supplied residential population (domestic wells) was estimated by first determining the total population in 2010 (1,291 people) for the study area using 2010 US Census data for census blocks within the study area as determined with GIS analysis. The study area population served by PWS (as determined by DOH database; Table B-2) was then subtracted from the total population to arrive at the self-supplied population. Approximately 954 people in the study area are served by a PWS, leaving 337 people as self-supplied water users (Table B-3). Annual water use estimates for the self-supplied population were calculated assuming the same average residential consumption of 230 gpcd as assumed for PWS-supplied residents, and converting that volume of water into acre-feet/year, for a total of 87 acre-feet/year (Table B-3).

The gravel mines located within the Dallesport study area have their own wells and water rights, and are thus considered self-supplied non-residential (industrial) uses. Water use information was not obtained for these facilities. Using Ecology water rights records, there are two water rights for gravel mines within the study area, totaling 977 acre-feet/year. We assumed these water rights are being fully used.

One additional category of minor non-residential water use not included in this water balance is stock watering from wells, which is exempt from water right permitting. Stock watering is considered to be a small component of total water use in the study area, especially relative to irrigation and industrial uses.

Table B-3 - Estimated Self-Supplied Annual Residential Water Use

Total Population in 2010[a]	Population Served by Public Water Systems[b]	Self-Supplied Population	Self-Supplied Residential Water Use in Acre-Feet/Year
1,291	954	337	87

Notes:

[a] Based on 2010 US Census data for census blocks within the study area.

[b] Based on Washington State Department of Health database of public water systems.

Consumptive and Nonconsumptive Residential and Non-Residential Uses

The Dallesport Wastewater Treatment Plant (WWTP) treats wastewater from the Dallesport and the Industrial Park areas (PWS-supplied), discharging its effluent (non-consumed water) to a subsurface perforated pipe within 90 feet of the Columbia River. Given proximity to the river, we consider this return flow to be discharging to the Columbia River (export from study area) for the purpose of this water balance, rather than recharging the basalt aquifer system.

Approximately 107 acre-ft/yr of wastewater is discharged from the WWTP, based on 2009-2010 facility records provided by Klickitat PUD. This volume of return flow is assumed to be split between PWS-supplied industrial and residential users since both are served by the WWTP. The PWS-supplied industrial users in the study area are assumed to be served by the WWTP. The remaining volume of WWTP discharge is assumed to be return flow from PWS-supplied residential uses.

Using domestic water use numbers for Washington State (Solley et al, 1998), it is assumed that 12 percent of the residential uses (PWS-supplied and self-supplied) in the study area are consumptive. We assume the PWS-supplied and self-supplied residents not served by the WWTP treat their effluent via septic tanks and drain fields, thus representing groundwater recharge return flow in the water balance.

PWS-supplied non-residential uses include industrial and commercial uses. Solley et al, (1998) provides estimated consumptive use percentages of 13 and 20 percent for industrial and commercial water uses, respectively, in Washington State. The average of these two values, 16 percent, is applied for PWS-supplied non-residential uses in the study area.

For the gravel mines, we assumed 34% of the total water used is consumed. This estimate is based on an evaporation analysis conducted for a gravel mine in western Washington State (6% evaporation), with an upward adjustment in percent evaporation to account for the warmer, drier climate of the study area. The climate adjustment is made using the ratios of pan evaporation to precipitation between the western Washington mine area and Dallesport. The ratio of pan evaporation to precipitation for the Dallesport area is 5.6 times higher than that for the western Washington mine site, so the 6% evaporation for the western Washington mine site is multiplied by 5.6 to arrive at an estimated 34% evaporation (consumptive use) for the Dallesport gravel mines (self-supplied non-residential water use). Given the relatively flat terrain and lack of surface drainages in the mine areas, we assume that return flow from gravel mine water use is partitioned 90% to 10% between groundwater recharge and streamflow, respectively.

Summary of Water Uses

Applying the methodology and assumptions described above, the resultant estimated annual consumptive and non-consumptive (return flow) volumes for each use category are presented in Table B-4. The estimated total annual water use (roughly 3,600 acre-feet/year) is approximately 58% of the appropriated annual water rights for the study area (roughly 6,200 acre-feet/year), based on Ecology's Water Rights Tracking System.

Table B-4 – Estimated Annual Water Use in Dallesport Study area

	Water Use in Acre-Feet/Year by Category					
	Irrigation	**PWS-Supplied Residential**	**Self-Supplied Residential**	**PWS-Supplied Non-Residential**	**Self-Supplied Non-Residential**	**Total Use in Acre-Feet/Year**
Total Use	2,281	246	87	44	977	**3,635**
Consumptive Use	1,970	30	10	7	332	2,349
Total Return Flow	311	216	77	37	645	1,286
Return Flow to Groundwater	*280*	*146*	*77*	*0*	*581*	*1,084*
Return Flow to Surface Water	*31*	*70*	*0*	*37*	*64*	*202*

Notes:

PWS: Public water system.

Consumptive uses are assumed to be 12% of total residential use, 16% of PWS-supplied non-residential uses, and 34% of self-supplied non-residential uses (refer to text). Irrigation consumptive use assumptions provided in Table B-1.

Water Balance Calculations

Water Balance Methods

For the water balance, precipitation translates into groundwater recharge, runoff becoming streamflow, evapotranspiration, consumptive water use and return flow on an annual basis, which is expressed by:

Precipitation + Import = Recharge + Streamflow + Evapotranspiration + Consumptive Water Use - Return Flow (non-consumptive use) + Export

Each component of the water balance is described below. The water balance values are presented in Table B-5, with the annual volume values rounded to the nearest 10 acre-feet/year. Return flow quantities are assigned a negative sign in Table B-5 to reflect that they are returned to the watershed as groundwater recharge or streamflow (not consumed).

Mean annual precipitation in the Dallesport study area is estimated at 15 inches per year, which is the value estimated for the Columbia River Tributaries subbasin[2] of WRIA 30 in the WRIA 30 Level 1 Watershed Assessment (WPN and Aspect, 2004). The precipitation data for the Level 1 assessment were obtained from the Parameter-Elevation Regressions on Independent Slopes Model (PRISM; Daly and others, 1994). Applying the 15 inches per year across the study area's approximately 17,400 acres provides an average annual precipitation volume of approximately 22,030 acre-feet/year (Table B-5).

Based on the USGS recharge estimates (Bauer and Vaccaro, 1990) for the Columbia Tributaries subbasin described in the WRIA 30 Level 1 Assessment, the natural condition mean annual groundwater recharge in the study area is estimated at approximately 3 inches, which equates to an annual recharge volume of 4,350 acre-feet/year (Table B-5). An estimated additional 1,080 acre-feet/year of groundwater recharge is generated by return flow (Table B-4); this is part of the return flow component in Table B-5.

The annual runoff in the study area was estimated from a continuous flow stormwater runoff model, WWHM4 (Clear Creek Solutions, 2010). The model uses land cover (vegetated, hard surface, etc.), the land slope gradient, the permeability of the soils, and historical precipitation data to estimate the amount of stormwater runoff. This model is used in Western Washington because of its ability to account for soil moisture and recharge before converting the flow into runoff. For this analysis, this feature was a way to reduce runoff overestimation. Based on the model results, approximately 1.3% of the average annual precipitation that falls in the Dallesport study area becomes runoff. The annual volume of runoff is estimated to be 300 acre-feet/year. In addition to stormwater runoff, an estimated 200 acre-feet/year of runoff occurs from return flows, as shown in Table B-4; this is part of the return flow component in Table B-5.

There are no reliable basin-scale ET estimates that can be used in the water balance equations. However, since it was the only undetermined value in the water balance, we solved the water balance equation (net balance equal to zero) to estimate ET. The resultant ET estimate is 17,450 acre-feet/year. This value represents ET for the study area's non-irrigated vegetation/soil cover, not the irrigated acreage which is accounted for in the irrigation water use values. Therefore, irrigated acres were subtracted from the total study area before converting ET value into inches/year. The resultant estimated ET value for the study area is 12 inches/year (Table A-6).

Water Balance Results

Table B-5 provides the estimated average annual water quantities (acre-feet/year) associated with each water balance term for the Dallesport study area.

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[2] Study area is within the Columbia Tributaries subbasin (refer to Figure 1.1 in main body of report).

Table B-5 – Annual Water Balance Summary for Dallesport Study area

				Outputs						
	Inputs			Natural Conditions				Water Use		
Area	Precipitation		Import from Columbia River	ET (non-irrigation)		Recharge	Runoff	Consumptive Use	Return Flow	Export to Columbia River
in acres[1]	in inches [2]	in ac-ft [3]	in ac-ft [4]	in inches [5]	in ac-ft [3]	in ac-ft [6]	in ac-ft [7]	in ac-ft	in ac-ft	in ac-ft
17,390	15	22,030	1,240	12	17,450	4,350	300	2,350	-1,290	110

Notes:

1) Source: Actual WRIA 30 study area delineation includes portions of the Columbia River. These areas of open water have been removed from the water balance acreage total.

2) Source: Study area average based on PRISM data

3) Source: Calculated from corresponding value in inches.

4) Source: Columbia River water imported based on proportion of Columbia River vs. groundwater water rights (Ecology's Water Rights Tracking System) and total estimated use.

5) Source: Calculated in water balance from other parameter estimates.

6) Source: USGS deep percolation model (Bauer and Vaccaro 1990), as reported in WRIA 30 Level 1 Assessment, 3.0 inches per year

7) Source: Based on percentage of precipitation that is converted to runoff (1.3%), estimated using stormwater modeling software WWHM4.

8) All acre-foot quantities rounded to nearest 10.

Water availability can be assessed on the basin scale by comparing the total consumptive surface water use relative to total streamflow, and total consumptive groundwater use relative to groundwater recharge. Outside of the Columbia River system (including backwater lakes like Spearfish Lake), there is very little surface water use in this study area, due to the lack of streams with reliable flow year-round. Based on information in Ecology's Water Rights Tracking system, roughly 1/3 of the study area's water rights are appropriated from the Columbia River system[3]. For the purposes of this assessment, we assume that the proportion of the study area's total actual water use supplied by Columbia River surface water is equal to the proportion of the area's total annual water right volume from the Columbia River system. In the water balance, water diverted from the Columbia River (estimated 1,240 acre-feet/year; Table B-5) is treated as an import into the study area.

Similarly, discharge from the Dallesport WWTP (estimated 110 acre-feet/year) is treated as an export from the study area, since it is discharged indirectly to the Columbia River.

Based on the water balance analysis, roughly 65% of the water put to beneficial use within the study area is consumed, with 35% becoming nonconsumptive return flow. Of the annual return flow quantity, most is groundwater recharge (30% of total use). Based on this, we estimate that recharge within the study area is increased by approximately 370 acre-feet/year (9% of natural recharge condition) as a result of return flow from use of imported Columbia River water.

Consistent with the approach for estimating water use supplied by the Columbia River, we assume that the proportion of the study area's total actual water use supplied by groundwater supplies is

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[3] 2,150 of 6,263 acre-feet/year, or 34%, based on annual water right volumes appropriated under permits and certificates, as obtained from Ecology's Water Right Tracking System. The Columbia River diversion rights are for irrigation use.

equal to the proportion of the area's total annual water right volume from groundwater sources. Based on the water balance analysis, the total consumptive use of groundwater in the study area is then estimated as 33% of estimated annual groundwater recharge from precipitation infiltration ("natural conditions") plus return flow from Columbia River water use. This calculation "nets out" nonconsumptive groundwater use (return flow) that recharges the groundwater system.

Uncertainties in Basin-Scale Water Balance

The basin-scale water balance estimate does not accurately reflect hydrologic conditions at all locations within a study area, or during all years, or all seasons. They are meant to represent the generalized long-term average hydrologic conditions of the study area. Quantifying the level of uncertainty in the water balance in terms of +/- percent is difficult at best. However, sources of uncertainty in calculating the annual water balance can be discussed qualitatively in terms of the uncertainties associated with each water balance term.

As the primary input to the water balance, precipitation is the single greatest factor in determining the water balance. Fortunately, long-term precipitation monitoring and the advancement of precipitation models (e.g. PRISM) has produced a reliable record of precipitation that can be applied to the water balance. However, the precipitation value represents average conditions in the past, and may not necessarily predict average conditions in the future. Year-to-year rainfall fluctuation, seasonal droughts, and the potential for long-term climate change are several factors that add uncertainty to the water balance as a tool to predict water availability within the Dallesport study area.

Groundwater recharge as modeled by the USGS also introduces uncertainty into the water balance. It was a regional model which did not specifically model the Dallesport study area. Additionally, the recharge estimates were based on a different period of record (1956-1977) than the PRISM precipitation data used in the water balance (1961-1990).

The use of a continuous simulation stormwater model to estimate runoff can introduce some uncertainty into the water balance since the model uses precipitation and ET data that may not be applicable to every portion of the study area. The model uses an HSPF (Hydrological Simulation Program – Fortran) for modeling the stormwater runoff, which is considered to be one of the more robust modeling methods for estimating this term. An HSPF model takes into account soil moisture and storage, whereas most other stormwater runoff models do not. Since there are no gages to measure actual streamflow within the study area (excluding Columbia River), this model provides a reasonable estimate of runoff volumes for the purposes of this study.

Since ET was calculated from other terms in the water balance, no additional uncertainty is introduced into the water balance from estimating ET. However, uncertainties associated with the other terms are propagated into the resultant ET value for the study area.

Water use in the study area is dominated by irrigation, although gravel mining is also a major water use. Uncertainties in the total irrigated acreage, annual average water duty, and the total consumptive versus non-consumptive water use, and estimating mining water use from the water rights information, all add uncertainty to the total water use estimate. Specific to irrigation use, the information collected from aerial photography, land cover data (GIS), and direct observations provides confidence that the irrigated acreages are reasonable estimates of current conditions for the study area. Although the water duties are reasonable based on the crop assumptions, they may be conservatively high. Given the magnitude of irrigation water use, even small uncertainties in these values can influence the estimated water use, and thus overall water balance, calculations.

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