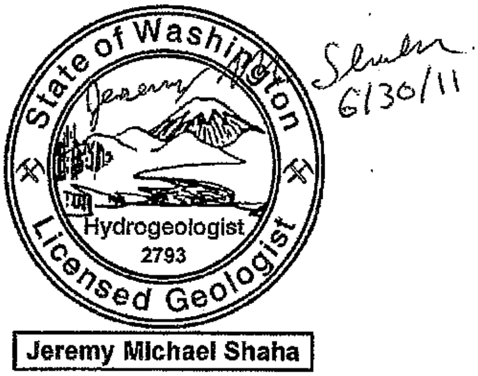
MEMORANDUM

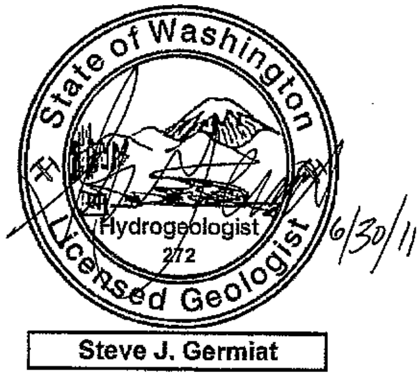
Project No.: 070024-013

June 29, 2011

To: John Foltz and Dave McClure, Klickitat County Natural Resources Department

cc: WRIA 30 Water Resource Planning and Advisory Committee





From: **Jeremy M. Shaha, LHG**
Project Hydrogeologist

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Senior Associate Hydrogeologist

Re: **2011 Swale Creek Subbasin Water Level Monitoring Summary, WRIA 30**

Project Objectives

In 2007, the Water Resource Planning and Advisory Committee (PAC) for Water Resource Inventory Area (WRIA) 30 received funding from the Washington State Department of Ecology (Ecology) to conduct a more detailed assessment of hydrologic and water use conditions in both the Swale Creek and Little Klickitat subbasins of WRIA 30 (Figure 1). The assessment provided additional information to help address data gaps regarding water availability on a subbasin scale, and thus support Ecology's processing of pending applications for new water rights in the subbasin (Aspect, 2007).

As part of the 2007 water availability study, water level monitoring networks were established for the two subbasins. Since June 2007, water level measurements have continued to be collected on a semi-annual basis in the well networks to begin assessment of long-term trends in groundwater levels, which helps determine sustainability of existing groundwater withdrawals and thus water availability. The semi-annual measurements have generally been collected corresponding to pre-irrigation (spring) and post-irrigation (autumn) conditions.

Subsequently, Ecology has provided additional funding (Grant No. G1000101) to provide annual water level monitoring data analysis and reporting. This memorandum provides a summary of the Swale Creek subbasin water level measurements to date (since June 2007).

Water Level Monitoring Network

The Swale Creek subbasin water level monitoring network was initially setup during the 2007 assessment of hydrologic and water use conditions (Aspect, 2007). The initial monitoring network consisted of a total of 25 wells (June 2007). In addition, several of the City of Goldendale's water level monitoring network wells (T03/R16-7X1, T03/R16-17N1, and T03/R16-18NW1) were added to the existing monitoring network in November 2007 and surveyed in December 2010. Since June 2007, there are several well owners that we have consistently been unable to get permission for continued water level measurements, including: T03/R14-11D1, T03/R14-23E1, and T03/R15-34M1. Therefore, these wells are no longer included in the water level monitoring network.

In February 2009, a dedicated monitoring well (SWC-MW-1) was installed in the alluvium aquifer in the vicinity of Warwick. A pressure transducer was installed in this monitoring well in order to provide nearly continuous water level data. An additional pressure transducer was also installed in the nearby well T03/R15-20H1 in May 2009 for comparison. A summary of the installation activities for these wells is provided in Aspect Consulting (2009).

As of May 2011 (most recent round of water level measurements), the Swale Creek subbasin water level monitoring network consists of a total of 26 wells (including SWC-MW-1). Table 1 presents well completion information for the wells included in the monitoring network, and Table 2 provides a summary of the water level measurements to date. Figure 2 depicts the locations of the wells included in the current monitoring network.

Water Level Measurements

Depth-to-water measurements were conducted in all monitoring network wells using either an electric water level indicator (tape) or a sonic water level indicator (sounder)[1]. 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. The Quality Assurance Project Plan (QAPP) (Aspect, 2010a) for this project provides a quality control (QC) evaluation between the tape and sonic sounder based on measurements collected since 2007. The evaluation documents reliability of the sonic sounder for measuring depths-to-water less than about 250 feet (Aspect, 2010a).

All depth-to-water measurements were made in accordance with the project-specific QAPP (Aspect, 2010a), and 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 during subsequent measurement rounds. Other pertinent information regarding the well or the measuring of water levels in it were also recorded in the field notes.

[1] Global Water WL600 or equivalent instrument.

If a downhole 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 either the respective well logs or previous monitoring event was carried in the field. Measurements that varied greatly from past measurements in a given well (accounting for differences between spring and fall) were repeated for confirmation.

Description of Well Monitoring Network Aquifers

A generalized geologic history of the Swale Creek subbasin is provided in the WRIA 30 Level 1 watershed assessment (WPN and Aspect, 2004). Water-bearing hydrostratigraphic units within the study area include (from youngest to oldest):

- Alluvium;
- Wanapum basalt (Priest Rapids, Roza, and Frenchman Springs members); and
- Grande Ronde basalt.

The Wanapum and Grande Ronde basalts are formations within the Columbia River Basalt Group (CRBG). Groundwater in the CRBG primarily occurs in the top of the individual flows ("flow top"), which became vesicular (porous) as gas bubbles escaped the flows during cooling, and/or at the 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. For wells completed in the interflow zones between the various basalt units, water levels are considered to be representative of the underlying basalt aquifer. A permeable flow top is normally present for each flow, while permeable flow bottoms range from relatively thick units to completely absent. The lateral continuity of water-bearing interflow zones is highly variable. Within Swale Creek subbasin, a majority of the wells completed in the CRBG are completed in the interflow zones of the Wanapum basalt aquifer (Priest Rapids, Roza, and Frenchman Springs members). Therefore, the water level monitoring network currently does not include any wells completed solely in the Grande Ronde basalt aquifer.

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 and can be either relatively permeable or impermeable; depending on composition, thickness, and lateral extent. Both the lateral continuity and thickness of the water-bearing interflow zones are highly variable.

Alluvium Aquifer

The alluvium aquifer generally consists of clay, silt and shale with some gravel (T03/R15-14D1) and sandstone (T03/15-23H1). As previously discussed, because the shallowest water-bearing interflow zone of the Wanapum basalt often immediately underlies the alluvium and is in direct hydraulic continuity, it is considered part of the alluvium aquifer (Aspect, 2007). Of the 26 wells included in the Swale Creek subbasin water level monitoring network, there are currently 8 wells completed in the alluvium aquifer. Figure 2 provides the location of these wells.

Wanapum Basalt Aquifer

Of the 26 wells included in the Swale Creek subbasin water level monitoring network, there are currently 18 wells completed in the Wanapum basalt aquifer. Figure 2 provides the location of these wells.

Summary of Groundwater Level Measurements

Table 2 provides a summary of the groundwater level measurements from the Swale Creek subbasin water level monitoring network to date. Evaluation of long-term trends in groundwater levels provides insight regarding aquifer response to precipitation patterns and sustainability of the existing level of groundwater withdrawal.

Long-Term Groundwater Level Trends

Long-term groundwater level trends can be evaluated for the 26 wells included in the Swale Creek subbasin water level monitoring network. Groundwater level measurements for 22 of these wells have been made on a semi-annual basis (pre-irrigation and post-irrigation) since June 2007. In addition, semi-annual water level measurements for the City of Goldendale's water level monitoring network wells (T03/R16-7X1, T03/R16-17N1, and T03/R16-18NW1) have been made since November 2007, and nearly continuous measurements have been made in SWC-MW-1 (T03/R14-24R1) since May 2009. Figure 3 provides the continuous water level measurements for both wells T03/R14-24R1 and T03/R15-20H1. Figure 4 provides long-term groundwater level hydrographs for the remainder of the wells included in the monitoring network, all of which are completed in either the alluvium or Wanapum basalt aquifer.

Alluvium Aquifer

Based on the continuous water level measurements provided in Figure 3, there is a very distinct seasonal fluctuation of groundwater levels in the alluvium aquifer (about 4 feet). The lowest groundwater levels generally occur from September to December, following a period of little rain in Swale Valley, and the highest groundwater levels generally occur from January to June, during a period of abundant winter rains. Based on this data, the alluvium aquifer appears to respond with very little lag time to precipitation events (Aspect, 2010b). Figure 4 also shows that many of the alluvium aquifer wells have exhibited similar seasonal fluctuations that have ranged between 4 to 7 feet (T03/R14-25C1, T03/R15-14D1, and T03/R15-20H1).

Based on the alluvium well groundwater hydrographs presented on Figure 4 (dashed hydrographs), none of the alluvium aquifer wells have shown substantive decline in groundwater levels since monitoring began in June 2007. However, well T04/R17-32P1 has shown about a 15-foot decline in groundwater levels since it was first monitored in 1973 (Brown, 1979); although recently this well has shown about a 15-foot rise in groundwater levels (since June 2007). It is important to note that this well is completed in (open to) both the alluvium aquifer and the Wanapum basalt aquifer. Conversely, two other wells completed solely in the alluvium aquifer with longer monitoring records (T03/R14-25C1 and T03/R15-20H1) have shown very stable long-term water level trends (Figure 4). Therefore, if a long-term decline in groundwater levels in the alluvium aquifer is occurring, it appears to be relatively localized and could be related to other factors, such as the well completion.

Wanapum Basalt Aquifer

As with many of the alluvium aquifer wells discussed above, a majority of the wells completed in the Wanapum basalt aquifer show seasonal variations in groundwater levels ranging between 5 and 15 feet. For these wells, the lowest groundwater levels were consistently observed during post-irrigation measurements (November) and the highest groundwater levels were consistently observed during pre-irrigation measurements (April - June). The seasonal high groundwater levels follow the wet season, when the greatest amount of recharge to the aquifer occurs. Meanwhile, the seasonal low groundwater levels follow the dry/irrigation season, when there is little recharge to the aquifer and increased withdrawals. However, it is important to note that not all of the Wanapum basalt aquifer wells show seasonal variations in groundwater levels.

As with the alluvium aquifer wells, a majority of the wells completed in the Wanapum basalt aquifer do not show a consistent declining trend in groundwater levels over the period of monitoring. The exceptions are wells T03/R14-14Q1, T03/R14-29A1, T03/R16-7X1, T03/R16-18NW1, and T04/R17-30A1. With the exception of well T04/R17-30A1, groundwater levels in these wells have declined from between 5 to 20 feet over the period of monitoring. Although groundwater levels in well T04/R17-30A1 have recently declined about 5 feet (since June 2007), Figure 4 indicates that groundwater levels in this well may have declined more than 200 feet since 1973. However, the amount of this decline is uncertain since it is possible that the 1973 measurements reported in Brown (1979) are from a different well. Therefore, it is important that water level measurements continue to be collected from this well.

Overall, the locations of the wells with significant declines in groundwater levels are scattered across Swale Creek subbasin. Therefore, the declines in the groundwater levels do not appear to be related to a subbasin-wide trend. Instead, the decline in groundwater levels in these wells is likely due to the wells being completed in an interflow zone of the Wanapum basalt which has a relatively limited extent or thickness, and therefore has a limited source of groundwater.

The decline in groundwater levels in the above wells may also be partially attributed to the below-average precipitation observed in the area since the late 1990s, and, longer-term, since 1984. Figure 5 presents both the annual precipitation and the mean annual precipitation (upper portion of figure) and the cumulative departure from the mean annual precipitation (lower portion of figure) in Goldendale (NOAA Station #453222) and at Satus Pass for the period of record (1931 - 2010)[2]. Note that individual months with more than 5 days of missing data were not used for monthly or annual precipitation statistics, so those years are not displayed on Figure 5. With the exception of

[2] The cumulative departure plot is an effective way to illustrate longer-term trends in precipitation which influence groundwater levels regionally (e.g., extended wet or drought periods). The absolute values on the plot's y axis have little meaning since they depend on the year started. However, the scale of the y axis and shape of the curve are not dependent on year started.

1995-1998 and 2010 (based on Goldendale data[3]) and 2006 (based on Satus Pass data), annual precipitation has been at or below the mean annual precipitation since 1984.

One of the basalt wells discussed above which has had a significant decline in groundwater levels is well T03/R14-29A1. This well is located to the west of Warwick fault (just outside Swale Valley), where the primary source of recharge is likely from the Columbia Hills. Due to the limited recharge area, this well is likely to be relatively sensitive to recent precipitation trends. Therefore, we infer that below-average precipitation explains at least a portion of the more than 15-foot decline in groundwater levels observed in this well since 2001. Further evidence for this area’s dependence on precipitation trends is the almost 5-foot increase in groundwater levels observed at the well during the spring of 2007, following an above-average precipitation year in 2006. Although the remaining wells with longer-term decreasing groundwater level trends do not have nearly as obvious of a correlation to precipitation, if the wells are completed in interflow zones of limited extent and thickness, groundwater levels in these wells may be more sensitive to precipitation trends compared to other wells in Swale Valley.

Recommendations

It is recommended that the water level monitoring network continue to be monitored on at least a semi-annual basis (pre-irrigation and post-irrigation measurements). Particular effort should be made to continue to collect water levels in the wells showing declining water level trends (T03/R14-14Q1, T03/R14-29A1, T03/R16-7X1, T03/R16-18NW1, and T04/R17-30A1). Care should be taken to note any fluctuating water levels observed in these wells during subsequent water level measurements. In addition, if possible, subsequent water level measurements for the Swale Creek subbasin water level monitoring network should be collected over a 1-week period of time.

References

Aspect, 2007, Hydrologic Information Report Supporting Water Availability Assessment – Swale Creek and Little Klickitat Subbasins, WRIA 30, June 29, 2007.

Aspect, 2009, Installation of Monitoring Well in Swale Valley, Swale Creek Subbasin, WRIA 30, Prepared for Klickitat County Department of Natural Resources, June 9, 2009.

Aspect, 2010a, Quality Assurance Project Plan for Water Level Monitoring – WRIA 30, April 9, 2010.

Aspect, 2010b, Addendum to the 2007 Hydrologic Information Report Supporting Water Availability Assessment for Swale Creek Subbasin, WRIA 30, June 30, 2010.

Brown, J.C., 1979, Geology and Water Resources of Klickitat County, Water Supply Bulletin No, 50, p. 1 - 413.

[3] The 1995 and 1998 data points for Goldendale are not plotted on Figure 5 because of gaps in the daily record; however, even with the missing the data, the annual precipitation is at or above average.

Watershed Professionals Network (WPN) and Aspect, 2004, WRIA 30 Level 1 Watershed Assessment, March 15, 2004.

Limitations

Work for this project was performed and this memorandum 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 Klickitat County for specific application to the referenced property. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

Attachments

Table 1 – Swale Creek Subbasin Water Level Monitoring Network
Table 2 – Monitoring Network Water Level Data
Figure 1 – Swale Creek Subbasin
Figure 2 – Swale Creek Subbasin Water Level Monitoring Network
Figure 3 – Continuous Alluvium Aquifer Hydrographs
Figure 4 – Groundwater Hydrographs
Figure 5 – Long-Term Precipitation Trends

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Table 1 - Swale Creek Subbasin Water Level Monitoring Network

Swale Creek Subbasin Annual Monitoring Report
WRIA 30, Washington

Ecology Well Log Data						Well Survey Data				
Ecology Well Log ID	TRS Label	Completion Date	Dia (in)	Depth (ft)	Aquifer	Northing[1] (SPS 83; ft)	Easting[1] (SPS 83; ft)	Wellhead Elevation[2] (ft MSL)	Casing Stick-up (ft)	Comments
149031	T03/R14-11D1	11/14/98	6	440	Wanapum	158400.6	1504803.3	2053.19	0.87	
142145	T03/R14-11N1	10/16/97	6	205	Wanapum	153730.0	1505374.3	2012.67	0.59	
136750	T03/R14-14Q1	10/18/79	6	200	Wanapum	149063.4	1509276.0	1719.73	0.54	
354742	T03/R14-18N1	5/20/97	6	695	Wanapum	149041.9	1484973.1	2153.66	1.43	
145052	T03/R14-23D1	4/17/98	6	103	Wanapum	147652.3	1505602.8	1697.48	0.47	
257441	T03/R14-23E1	7/13/00	6	262	Wanapum	145770.2	1505131.1	1662.06	2.21	
-	T03/R14-25C1	10/29/75	6	80	Alluvium and Wanapum	141882.6	1512560.9	1580.77	-	No ecology well log; obstructed at 22.8 ft btoc
257442	T03/R14-29A1	8/7/00	6	353	Wanapum	141946.6	1494168.8	1678.32	2.11	
138310	T03/R15-10P1	6/16/94	6	143	Wanapum	153172.6	1532826.4	1610.64	1.76	
314650	T03/R15-12H1	11/14/01	16	679	Wanapum	155984.6	1546301.3	1621.43	1.5	
314651	T03/R15-13B1	10/31/01	16	905	Wanapum	152313.6	1545722.6	1595.88	1.625	
144994	T03/R15-14D1	8/7/79	6	82	Alluvium and Wanapum	152412.8	1536954.3	1605.55	-	
140705	T03/R15-20H1	10/28/75	6	54	Alluvium	145871.4	1525996.3	1574.76	1.34	Outfitted with pressure transducer 2/5/09.
137418	T03/R15-23H1	8/2/93	6	140	Alluvium and Wanapum	145638.2	1541689.0	1634.66	1.5	
138800	T03/R15-34M1	8/21/79	6	480	Wanapum	132776.8	1531588.3	1940.19	0.7	
411866	T03/R16-2A1	5/18/05	6	123	Wanapum	163199.1	1572954.6	1855.25	-	
139455	T03/R16-4F1	2/8/81	10	512	Wanapum	161914.2	1559334.0	1740.30	1.3	
296331	T03/R16-7X1	4/24/69	12	302	Alluvium and Wanapum	153527.0	1548993.0	-	-	GPS Location
139604	T03/R16-17N1	9/27/79	8	320	Wanapum	147942.7	1521939.1	1592.88	-	
137572	T03/R16-18NW1	6/15/72	16	983	Wanapum	152042.8	1547607.8	1600.03	-	
302764	T04/R14-31L1	10/12/00	6	506	Wanapum	167675.2	1486274.0	1785.85	2.94	
138094	T04/R14-35N1	7/28/94	6	300	Wanapum	164498.8	1505579.5	1914.49	1.83	
303003	T04/R16-31M1	8/26/00	6	103	Wanapum	163668.5	1548245.4	1662.21	1.17	
136513	T04/R16-32J1	5/25/82	6	67	Alluvium and Wanapum	165643.7	1557437.9	1733.87	0.81	
296593	T04/R16-34H1	10/12/71	6	500	Wanapum	167237.9	1567894.2	1804.24	0.49	
146522	T04/R17-29D1	4/4/91	6	108	Wanapum	171742.5	1584907.1	1999.13	0.58	
146520	T04/R17-30A1	9/28/73	6	430	Wanapum	173572.1	1583929.0	1997.56	-	Sonic sounder provides invalid measurement.
139632	T04/R17-32P1	4/29/70	8	228	Alluvium and Wanapum	165764.2	1585021.8	1914.53	-	
580758	T3/R14-24R1	2/5/09	2	50	Alluvium	143223.0	1515314.2	1569.50	-0.3	Outfitted with pressure transducer 5/21/09.

Notes:

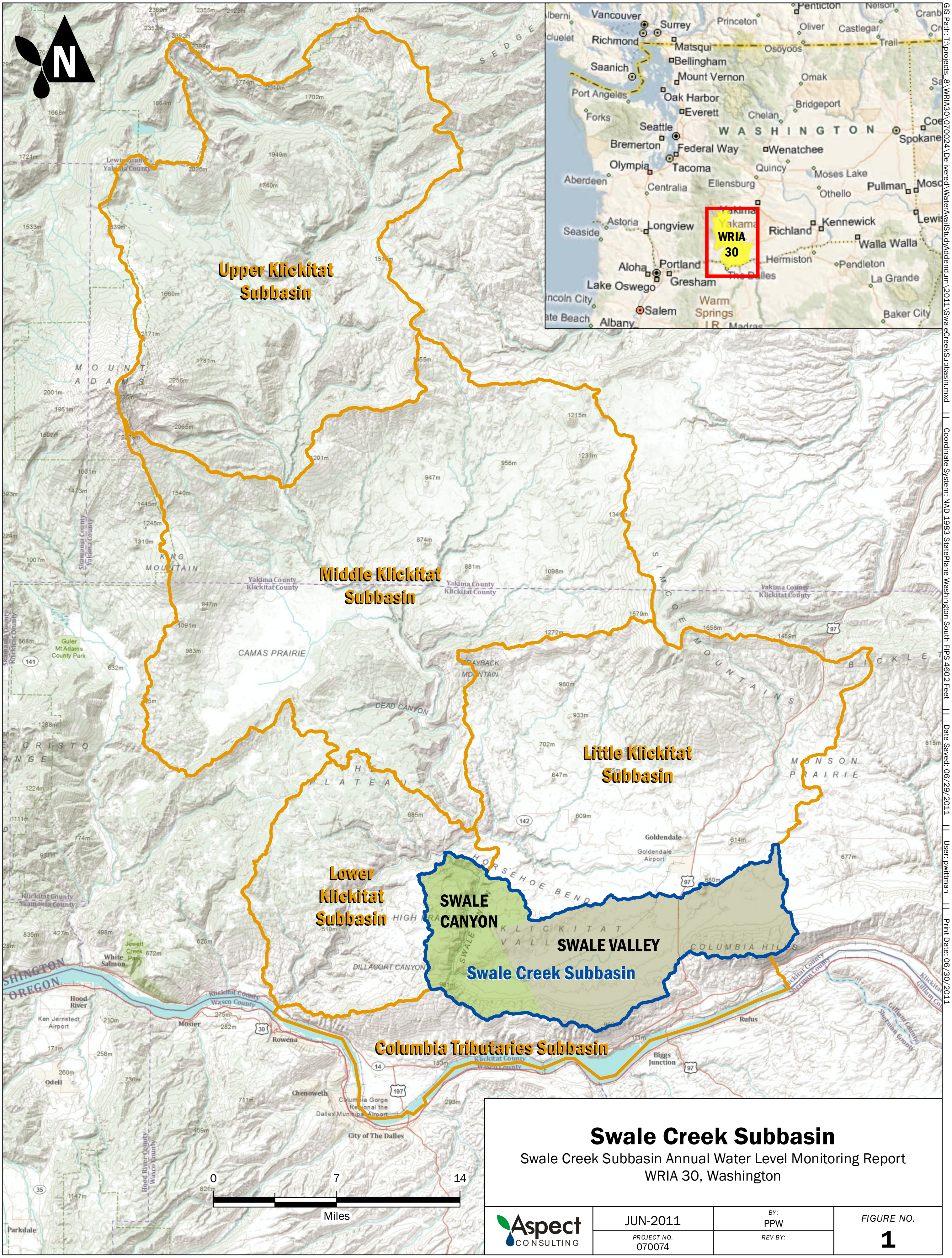
[1] Northing and Easting coordinates are in Washington South State Plane coordinate system (NAD 1983 datum)

[2] All elevations are in NAVD 1988 datum

[3] Indicates wells included in the City of Goldendale's groundwater level monitoring program

Table 2 - Monitoring Network Water Level Data
Swale Creek Subbasin Annual Monitoring Report
WRIA 30, Washington

Ecology Well Log Data		June 2007 Measurements			November 2007 Measurements			April 2008 Measurements			December 2008 Measurements			April 2009 Measurements			December 2009 Measurements			May 2010 Measurements			November/December 2010 Measurements			May 2011 Measurements		
Ecology Well Log ID	TRS Label	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments	Depth to Water (ft bTOC)	GW Elevation (ft)	Comments
149031	T03/R14-11D1	206.9	1846.3	Rising water level	200.3	1852.9		200.4	1852.8		-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission
142145	T03/R14-11N1	69.9	1942.8		70.1	1942.6		69.8	1942.8	Rising water level	71.0	1941.7	Rising water level	68.4	1944.3		69.2	1943.5		68.6	1944.1		69.49	1943.2		68.50	1944.2	
136750	T03/R14-14Q1	7.3	1712.5		-	-		6.6	1713.1		7.8	1711.9		12.3	1707.5		16.1	1703.6		14.8	1704.9		-	-	No permission	-	-	No permission
354742	T03/R14-18N1	516.7	1637.0		518.3	1635.4		517.9	1635.7		519.5	1634.2		518.3	1635.3		-	-	No permission	518.6	1635.1		-	-	No permission	518.7	1635.0	
145052	T03/R14-23D1	34.6	1662.9		41.8	1655.7		28.6	1668.9		43.4	1654.1		31.8	1665.7		41.2	1656.3		29.8	1667.7		39.1	1658.4		27.7	1669.8	
257441	T03/R14-23E1	76.8	1585.3		-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission			No permission
-	T03/R14-25C1	-	-	Obstructed at 22.8 ft	-	-	Obstructed at 21.3 ft	22.3	1558.5	Obstructed at 22.8 ft	-	-	Obstructed at 23.36 ft	21.8	1559.0		-	-	Obstructed at 25 ft	-	-	Obstructed	22.86	1557.9		20.90	1559.9	
257442	T03/R14-29A1	63.2	1615.2	Rising water level	55.7	1622.6		55.9	1622.5		59.7	1618.6		61.4	1616.9		62.7	1615.6		66.2	1612.1		68.45	1609.9	Rising water level	70.70	1607.6	
138310	T03/R15-10P1	36.9	1573.7		37.4	1573.2		30.5	1580.1		36.3	1574.3		30.8	1579.8		40.7	1569.9		36.8	1573.8		37.5	1573.1		30.0	1580.6	
314650	T03/R15-12H1	61.0	1560.5		67.0	1554.4		44.3	1577.1	Not recently pumped	65.9	1555.6	Fluctuating water level	55.5	1565.9		58.5	1562.9		106.0	1515.4		81.30	1540.1	Falling water level	42.50	1578.9	
314651	T03/R15-13B1	31.4	1564.5		36.2	1559.7		19.6	1576.3	Not recently pumped	38.5	1557.4	Fluctuating water level	27.3	1568.6		31.0	1564.9		66.5	1529.4		42.30	1553.6		18.30	1577.6	
144994	T03/R15-14D1	33.7	1571.9		36.0	1569.5		29.4	1576.1		35.6	1569.9		30.2	1575.3		38.5	1567.0		33.2	1572.3		35.8	1569.7		28.7	1576.9	
140705	T03/R15-20H1	5.5	1569.3		6.2	1568.6		3.2	1571.5		5.8	1568.9		3.0	1571.8		5.3	1569.5		4.6	1570.2		5.6	1569.1		2.8	1571.9	
137418	T03/R15-23H1	56.6	1578.1		-	-	No permission	-	-	No permission	60.2	1574.5		56.8	1577.9		60.7	1574.0		57.8	1576.9		60.9	1573.8		56.7	1578.0	
138800	T03/R15-34M1	387.4	1552.8		398.2	1542.0	Pumping water level	396.0	1544.2		-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission	-	-	No permission
411866	T03/R16-2A1	57.8	1797.4		58.2	1797.0		59.5	1795.8		63.4	1791.9		60.4	1794.8		64.2	1791.0		59.8	1795.4		63.1	1792.1		-	-	No permission
139455	T03/R16-4F1	80.4	1659.9		82.5	1657.8		79.5	1660.8		81.6	1658.7		79.4	1660.9		81.5	1658.8		79.6	1660.7		81.0	1659.3		78.6	1661.7	
296331	T03/R16-7X1	-	-	-	22.2	-		15.2	-		21.4	-		17.3	-		23.0	-		26.6	-		19.6	-		14.5	-	
139604	T03/R16-17N1	-	-	-	26.8	1566.1		22.3	1570.6		26.4	1566.5		23.9	1569.0		26.5	26.5		-	-	No permission	25.8	1567.1		22.0	1570.9	
137572	T03/R16-18NW1	-	-	-	32.5	1567.6		20.7	1579.3		32.5	1567.5		30.1	1569.9		41.2	41.2		-	-	Irrigating with pump	32.2	1567.9		19.7	1580.4	
302764	T04/R14-31L1	267.1	1518.7		265.4	1520.5		264.9	1521.0		265.2	1520.7		265.9	1520.0		264.8	1521.1		-	-	No permission	-	-	No permission	-	-	No permission
138094	T04/R14-35N1	135.2	1779.3		135.4	1779.1		134.9	1779.6		134.3	1780.2		133.6	1780.9		133.6	1780.9		133.0	1781.5		132.8	1781.7		133.2	1781.3	
303003	T04/R16-31M1	22.3	1639.9		25.1	1637.1		21.4	1640.8		23.3	1638.9		21.5	1640.7		23.8	1638.4		-	-	No permission	-	-	No permission	-	-	No permission
136513	T04/R16-32J1	62.0	1671.9		63.4	1670.5		60.0	1673.8		61.8	1672.1		59.6	1674.3		61.6	1672.3		60.1	1673.8		61.6	1672.2		59.8	1674.1	
296593	T04/R16-34H1	52.7	1751.5		56.3	1748.0		52.3	1752.0		55.8	1748.4		52.2	1752.0		55.3	1748.9		-	-	No permission	55.7	1748.5		52.2	1752.0	
146522	T04/R17-29D1	63.5	1935.6		65.4	1933.7		64.2	1934.9		65.0	1934.1		63.4	1935.7		64.0	1935.1		62.5	1936.6		63.5	1935.6		61.6	1937.6	
146520	T04/R17-30A1	277.4	1720.2	Rising water level	278.4	1719.2		287.6	1710.0	Rising water level	293.8	1703.8		280.0	1717.6		297.5	1700.1		-	-		324.0	1673.6	Rising water level	303.2	1694.4	Rising water level
139632	T04/R17-32P1	59.4	1855.2		-	-	No permission	-	-	No permission	66.3	1848.2		52.0	1862.5		55.5	1859.0		49.9	1864.6		51.4	1863.1		-	-	No permission
580758	T3/R14-24R1	-	-		-	-		-	-		-	-											5.9			2.4		



Swale Creek Subbasin

Swale Creek Subbasin Annual Water Level Monitoring Report
WRIA 30, Washington

Aspect CONSULTING	JUN-2011	BY: PPW	FIGURE NO.
	PROJECT NO. 070074	REV BY: - - -	1

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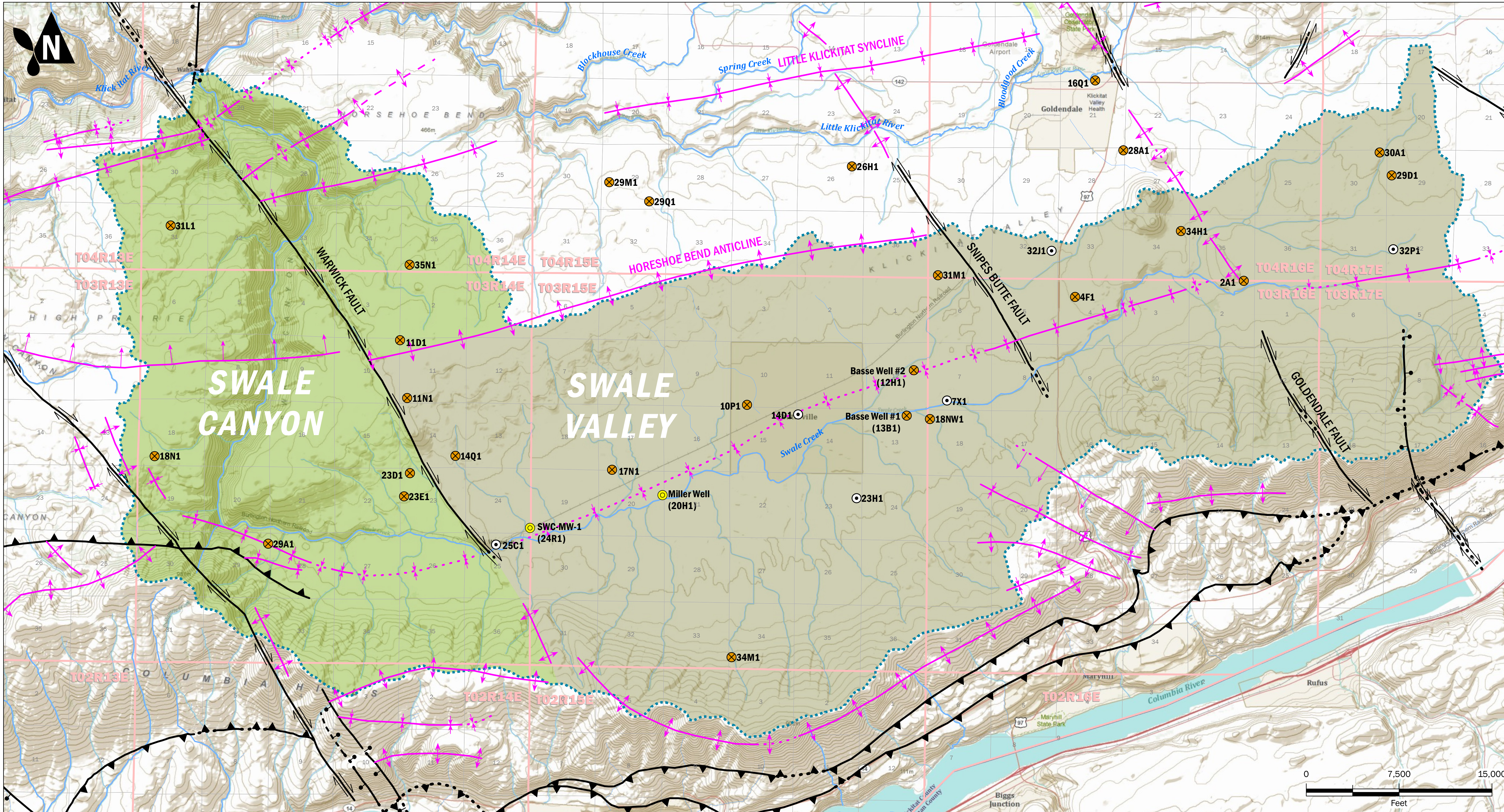

Swale Creek Subbasin

Swale Canyon

Swale Valley

Township/Range

Sections

Well Locations in the Groundwater Level Monitoring Network (by completion aquifer):

Alluvium

Wanapum

Alluvium & Wanapum

Faults (WA DNR 1:100K)

Normal fault, location accurate. Bar and ball on downthrown block

Normal fault, location concealed. Bar and ball on downthrown block

Thrust fault, location accurate. Sawteeth on upper plate

Thrust fault, location inferred. Sawteeth on upper plate

Thrust fault, location concealed. Sawteeth on upper plate

Right-lateral strike-slip fault, location accurate.Arrows show relative motion

Right-lateral strike-slip fault, location approximate. Arrows show relative motion

Right-lateral strike-slip fault, location concealed. Arrows show relative motion

Left-lateral strike-slip fault, location accurate. Arrows show relative motion

Fault, unknown offset, location accurate

Fault, unknown offset, location concealed

Folds (WA DNR 1:100K)

Anticline, location accurate

Anticline, location approximate

Anticline, location inferred

Anticline, location concealed

Syncline, location accurate

Syncline, location concealed

Monocline, anticlinal bend, location accurate

Monocline, synclinal bend, location accurate

Swale Creek Subbasin Water Level Monitoring Network

Swale Creek Subbasin Annual Water Level Monitoring Report
WRIA 30, Washington

Aspect CONSULTING

JUN-2011	BY: JMS / PPW	FIGURE NO. 2
PROJECT NO. 070024	REV BY: - - -	

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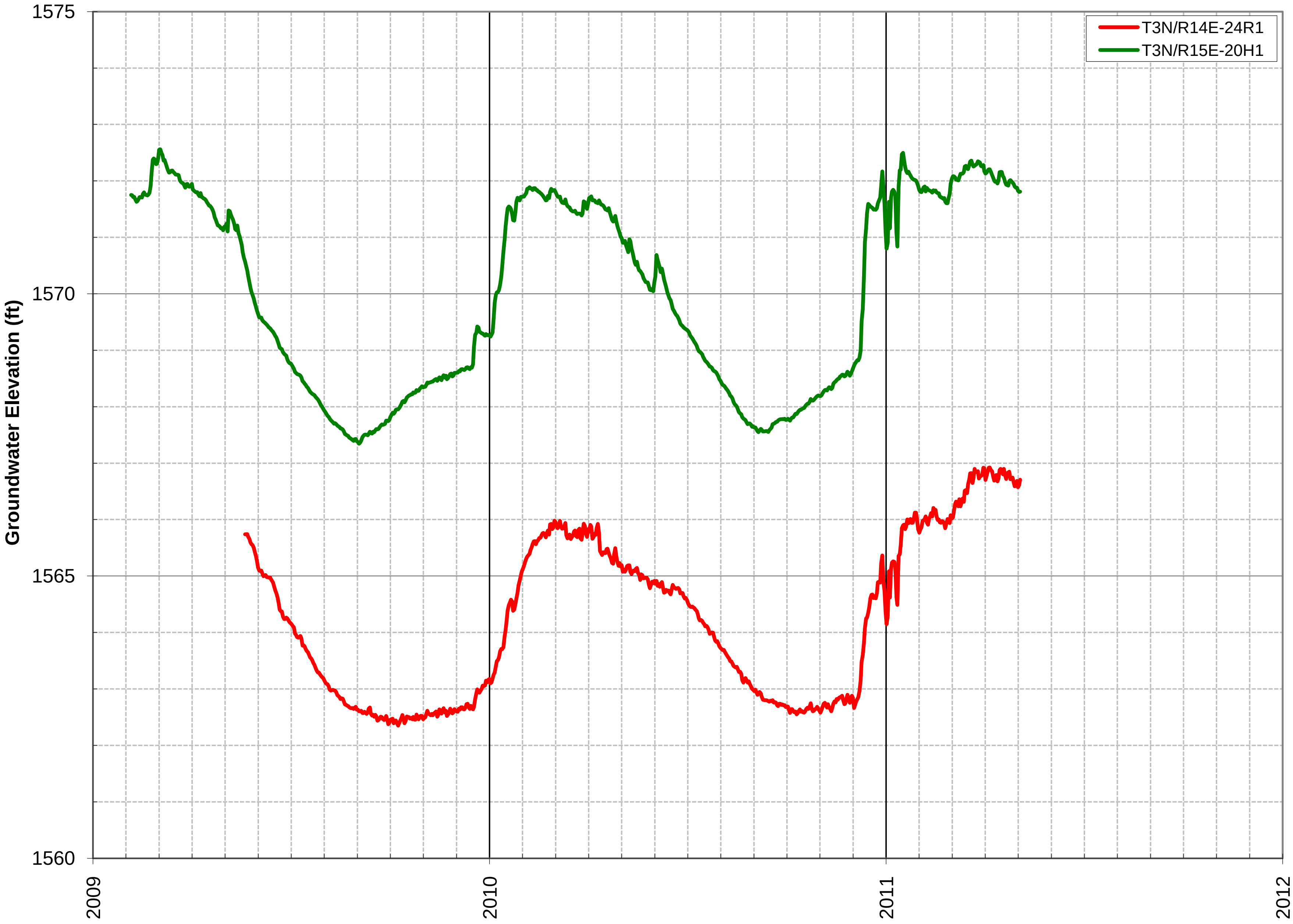

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Figure 3 - Continuous Alluvium Aquifer Hyrdographs
Swale Creek Subbasin Annual Monitoring Report
WRIA 30, Washington

Notes:
Dashed hydrographs are indicative of wells completed in the alluvium aquifer.
Dotted hydrographs are presented as depth-to-water (secondary axis).
Non-static groundwater level measurements from Table 2 were not included in the hydrographs.

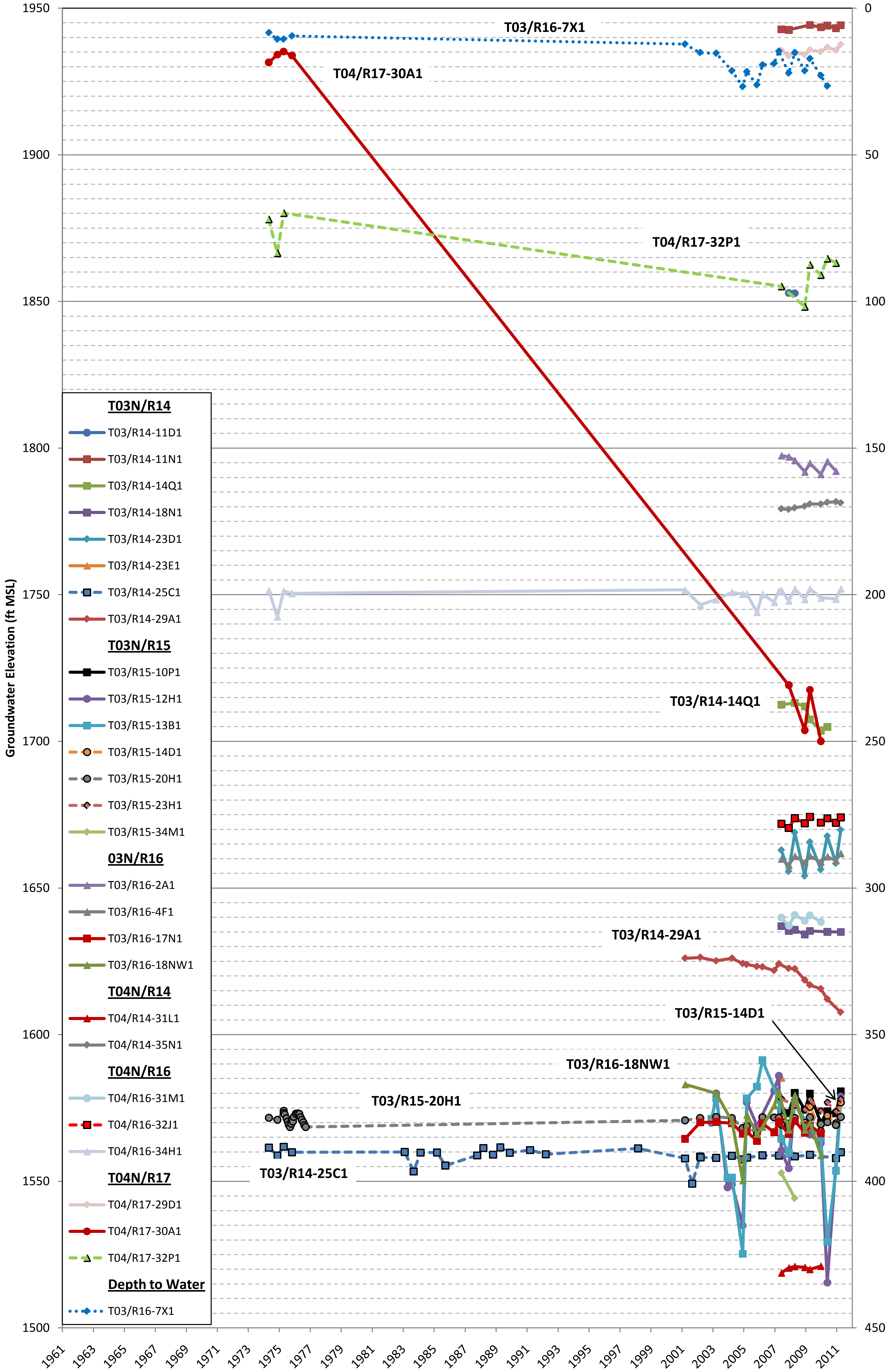

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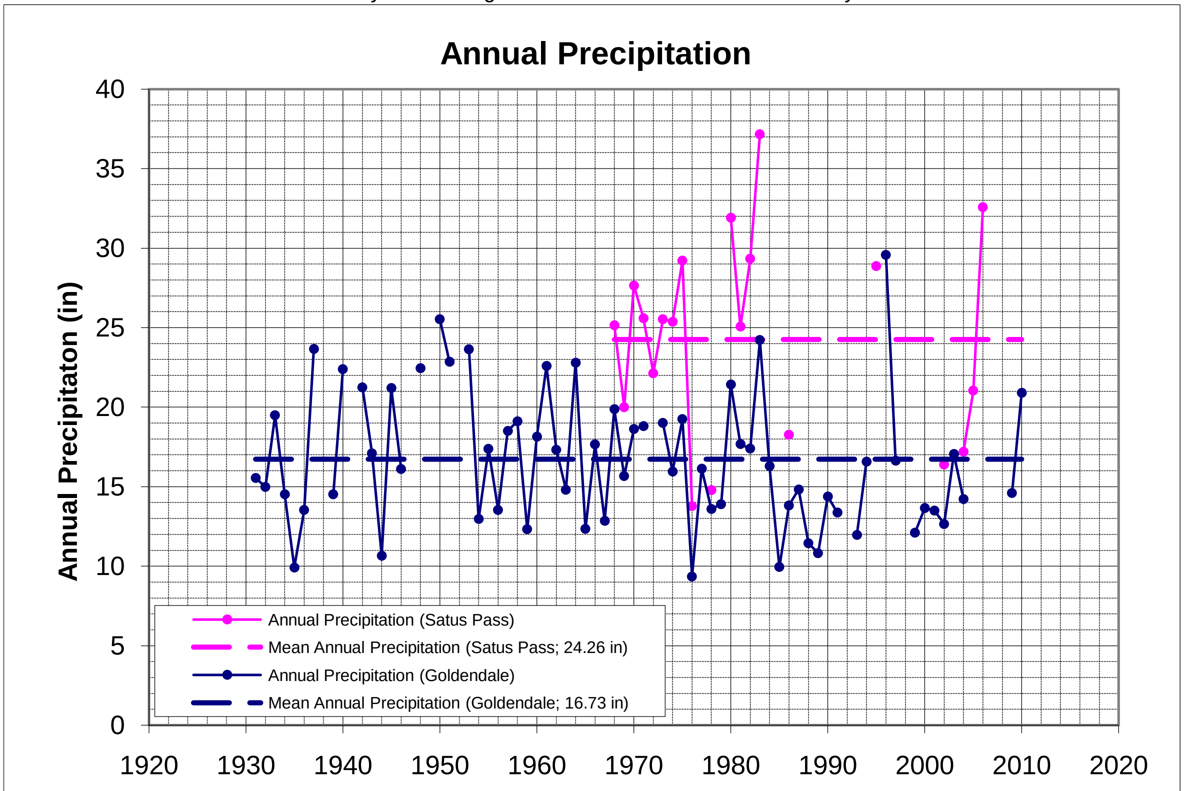
Figure 4 - Groundwater Hydrographs
Swale Creek Subbasin Annual Monitoring Report
WRIA 30, Washington

Notes:

Goldendale annual precipitation data from Goldendale (NOAA #453222) and Goldendale 2E (NOAA #453226).

Satus Pass annual precipitation data from Satus Pass 2 SSW (NOAA #457342)

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



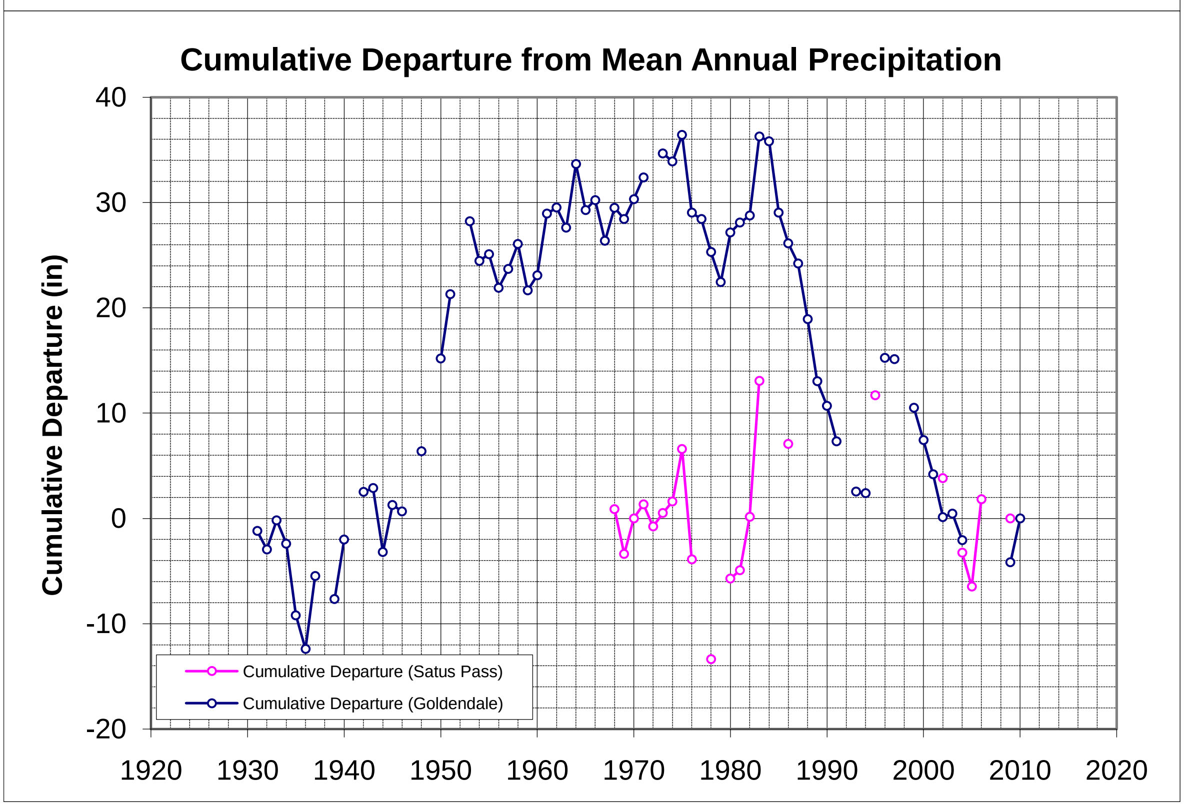


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Figure 5 - Long-Term Precipitation Trends
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WRIA 30, Washington