Annual Report Regarding OWRD Technical Assistance for the U.S. Bureau of Reclamation Pilot Water Bank in the Upper Klamath Basin

Federal Fiscal Years 2019-2020

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Introduction

The Oregon Water Resources Department (OWRD) has been contracted to provide technical assistance to the U.S. Bureau of Reclamation (USBR) during Federal Fiscal Years (FFY) 2015-2019 under agreement R15AP00061. Technical assistance includes collection and assessment of groundwater use and groundwater level data from wells in Lost River Subbasin in Oregon associated with, and proximal to, the USBR's Klamath Project Area ("Project Area") in the Upper Klamath River Basin. This report summarizes water-use data and groundwater level data for the March through October 2019 irrigation season (Water-Year 2019).

Background

Prior to 2015, the Klamath Water and Power Agency (KWAPA) managed water bank operations through the Water Use Mitigation Program (WUMP) under the guidance of the USBR. This program was used to augment diversion of surface water for the purpose of irrigation with groundwater pumping. The primary motivation was to enhance in-stream flows for fisheries during spring and summer. Groundwater users with valid rights, including primary, supplemental, and emergency drought permits, were offered financial incentives to pump groundwater in lieu of surface water, either for land application or pumping directly to USBR-operated canals, and to idle agricultural lands to conserve water. OWRD has provided technical assistance and field presence for the groundwater use and water level monitoring component of the WUMP since 2010. KWAPA was dissolved in 2016 and the water bank program is no longer in effect but OWRD continues to collect water use data under USBR contracts.

A Governor's drought declaration in 2010 allowed OWRD to issue emergency drought permits for Oregon irrigators. Subsequently, during the 2010 irrigation season the USBR, KWAPA, and area irrigators relied extensively on supplemental groundwater to augment limited surface water supplies, pumping approximately 141,000 acre-feet (AF) of groundwater in Oregon and California. Drought declarations and emergency drought water use permits were also issued in 2012, 2013, 2014, 2015 and 2018. In 2018 OWRD issued 37 emergency drought permits in the study area, authorizing an additional 9,752 acres of irrigation, with limited duty, and denied drought permits in areas that had seen extensive groundwater level declines (over 20 ft since the early 2000s). In 2018 OWRD recorded just under 30,000 AF of groundwater pumped (Thoma 2019).

A return to "normal" annual precipitation in 2016, 2017, and 2019 lead to significantly less groundwater withdrawals in the study area with metered withdrawals of less than 20,000 AF in each year. In 2019, metered withdrawals totaled less than 15,000 AF with approximately 80% of groundwater users reporting less groundwater pumping than the 2018 irrigation season and 20% reporting no groundwater pumping at all. As expected with lower groundwater withdrawals, groundwater levels across the study area rose higher in fall 2019 than they were in fall 2018 for the majority (90%) of wells measured in both years.

Purpose of This Report

This report presents 2019 groundwater use data from metered production wells within the Lost River Subbasin, which includes land within and adjacent to the Oregon portion of the Project Area, and groundwater level data from representative wells in Oregon. Overall, 261 wells were visited in the study area between October 2019 and January 2020 for the purpose of recording water use and collecting water level data (this time-frame is referred to in this report as the "2019 Synoptic survey"). Some wells were visited for water level measurements only (33 wells), and some wells intended for water use recording did not have operable flowmeters. A breakdown of well flowmeter status during the 2019 Synoptic survey is presented in Table 1 and the complete list of the type of data collected at each well is presented in the Appendix. The information collected was used to assess the impact of pumping on groundwater resources and to inform water management decisions. These data have been particularly important in recent years due to the dry conditions experienced during the last decade.

2019 Field Data Collection and Analysis

OWRD field staff mobilized to the Klamath Basin from the Salem, Bend, and Klamath Falls offices during the 2019 Synoptic. During the synoptic, OWRD staff visited 261 wells in and adjacent to the Project Area in Oregon to collect flowmeter and water level data. In total, 228 wells were visited to collect water use data and 33 wells were visited solely to collect water level data. The visited wells are a subset of all permitted water-supply wells in, and adjacent to, the Project Area for which current or historic permit conditions require water metering (e.g., flowmeter installation), or wells which have been voluntarily metered or used as water level observation wells in the past. Figure 1 shows the area of interest and shows the location of permitted and visited wells for water use data collection. Overall, there was a recorded 13,734 AF of water pumped from 163 metered wells in the study area in the 2019 irrigation season and the majority of wells recorded less pumping in 2019 than in 2018. The Appendix lists all wells visited to collect water use data during the 2019 Synoptic or visited to collect water level data at any time during 2019.

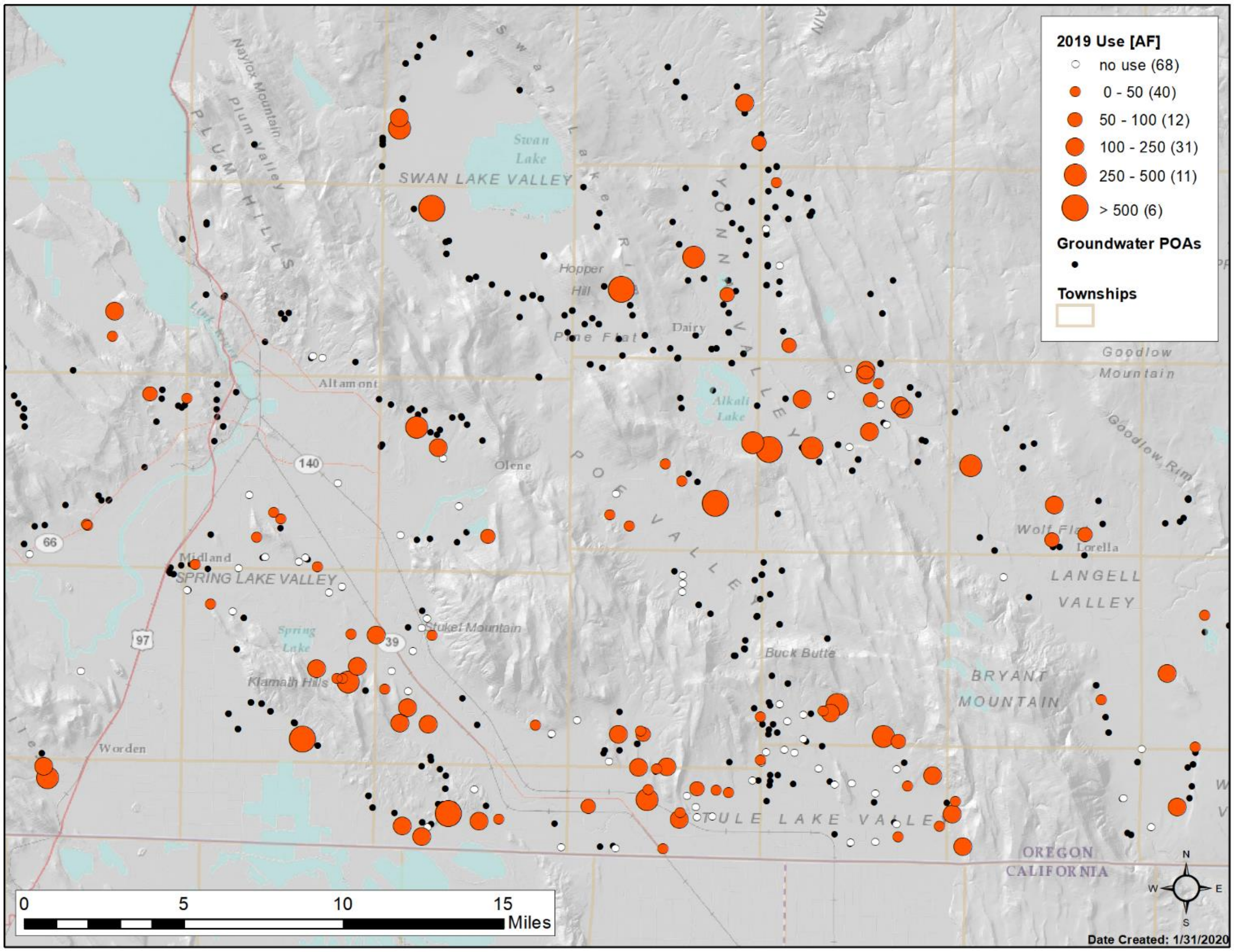

Figure 1: Existing permit wells and wells where water-use was calculated as part of the 2019 Synoptic survey within the Lost River Subbasin which includes the Bureau of Reclamation Klamath Project Area

Metered Groundwater Use

Flowmeter readings collected during the 2019 Synoptic were compared to readings from previous years to calculate metered groundwater use in the study area for the 2019 irrigation season. Of the 228 wells visited for water use during this synoptic, approximately 75% (172 wells) had working flowmeters installed and 155 had flowmeter values from the previous year. Successive years of flowmeter data allowed OWRD to calculate water use directly for a given well (Table 1). Indirect methods of estimating groundwater use based on power consumption are sometimes available but were not included as part of this analysis.

Table 1: Summary of 2019 metered groundwater use and flowmeter status in the study area

		# Records	% Wells Visited	Groundwater Use (AF)
Wells visited by OWRD in the study area for use		228		
Visited wells with operable flowmeters		172	75 %	
Visited Wells where use was calculated		166[a]	73 %	13,734
2019 Flowmeter Status [b]	No Flowmeter	41[c]	18 %	
	New Flowmeter	2	1 %	
	Flowmeter Broken	4	2 %	
	Flowmeter Fixed	0	0 %	
	No Access	11[d]	5 %	
	Shared Flowmeter	5	2 %	
Wells with flowmeter readings and water level measurements in 2019		31	14 %	

[a] Only wells with flowmeter readings in 2018 and 2019 could be used to calculate annual use

[b] Refer to Appendix A for details regarding flowmeter status definitions

[c] For some wells that historically have not had flowmeters, a “No Flowmeter” status was confirmed by calls to well-owners, in some cases where the owners reported no use these wells were included in calculation of reported use

[d] A higher percentage of wells were classified as “No Access” in 2019 due to bad weather and road conditions during the survey

Metered irrigation water use calculated in the study area totaled 13,734 AF in 2019 compared to 28,450 AF in 2018. There are nearly 600 authorized groundwater points of appropriation (POAs) in the study area and many are associated with older water rights that do not require flowmeters to be installed.

Therefore, groundwater use volume listed in Table 1 and described in the report represents only a portion of groundwater extracted in the area during 2019. However, the number of metered wells is similar from year to year and relative changes in volumetric groundwater extraction in the area can be estimated by comparing annual data. Additionally, primary groundwater rights, where groundwater is the sole source of irrigation, should have relatively consistent use and acreage from year to year so changes in annual use may reflect climate conditions (e.g., wetter spring, cooler summer). A direct comparison of the 155 wells that have both 2019 and 2018 water use data identifies 58% of wells reporting a use of at least 50 AF less water in 2019 compared to 2018. An additional 28% of wells reported a change in use of less than 10 AF (20% reporting less use and 8% reporting more use). Figure 2 shows the distribution of change in water use from 2018 to 2019 and Table 2 summarizes groundwater use from metered wells measured by OWRD during synoptic surveys conducted since 2010.

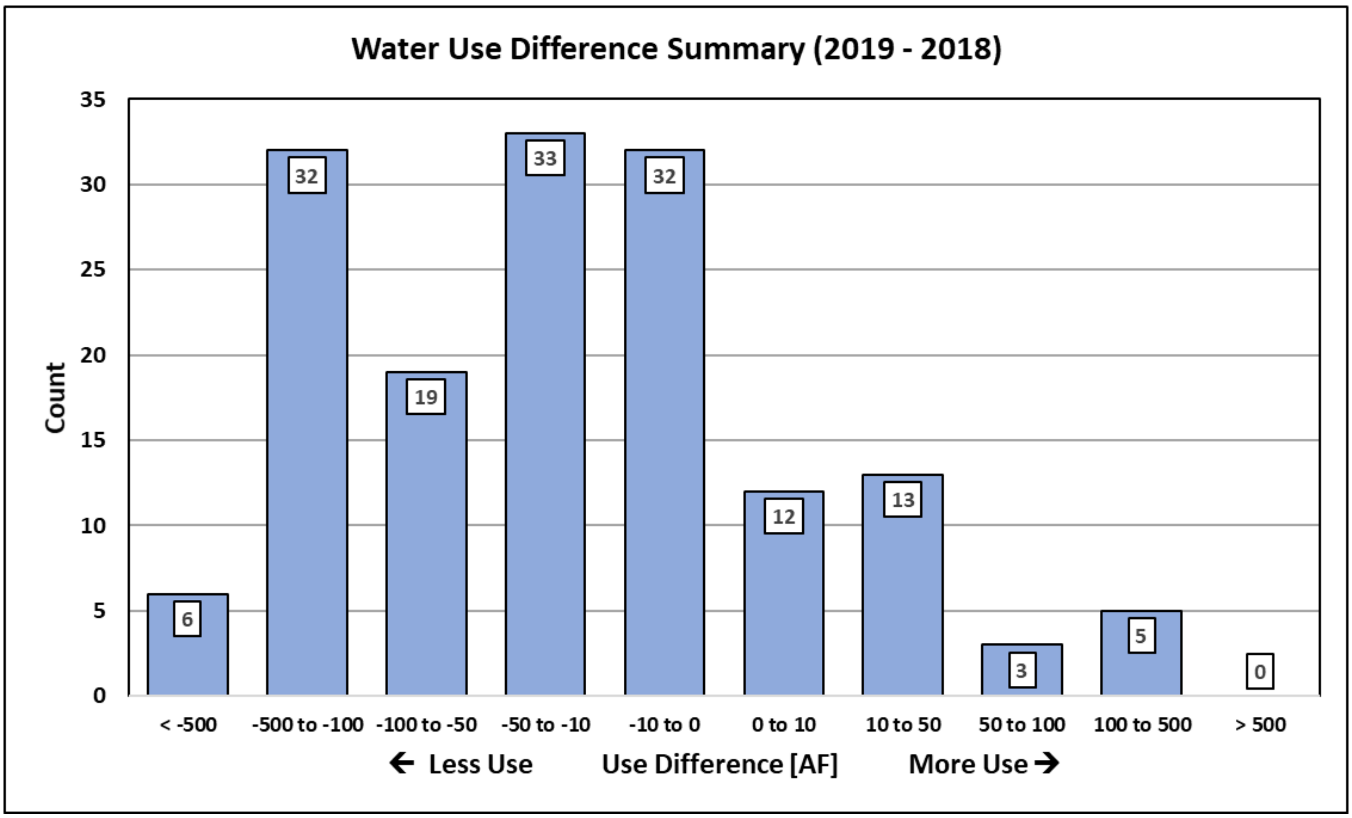

Figure 2: Distribution of reported change in water use from 2018 to 2019 irrigation seasons

Table 2: Metered groundwater use in the study area from 2010 to 2019

Year	Number of visited wells where use was calculated	Metered Groundwater Withdrawal in Oregon (acre-feet)	Drought Permit Aces Issued
2010	204	78,920	34,121
2011	209	18,377	-
2012	223	35,864	-
2013	233	58,048	4,493
2014	249	72,574	19,423
2015	238	61,645	21,082
2016	173	19,409	-
2017	190	17,358	-
2018	194	28,448	9,752
2019	**166**	**13,734**	-

Water Level Data

OWRD and USGS staff also collected water level data from 88 wells in the study area during 2019 (Figure 3). A comparison of fall water level data between 2019 and 2018 shows that approximately 90% of wells reported higher water levels (recovery) in 2019 and the remaining wells reported declines less than 2 ft (Figure 4). Groundwater level data are housed in the OWRD Groundwater Information System (GWIS) database and are available to the public at https://apps.wrd.state.or.us/apps/gw/gw_info/gw_info_report/Default.aspx. A subset of this groundwater data can be accessed through a USGS-hosted web interface at http://or.water.usgs.gov/projs_dir/klamath_cooperative_monitoring/index.html

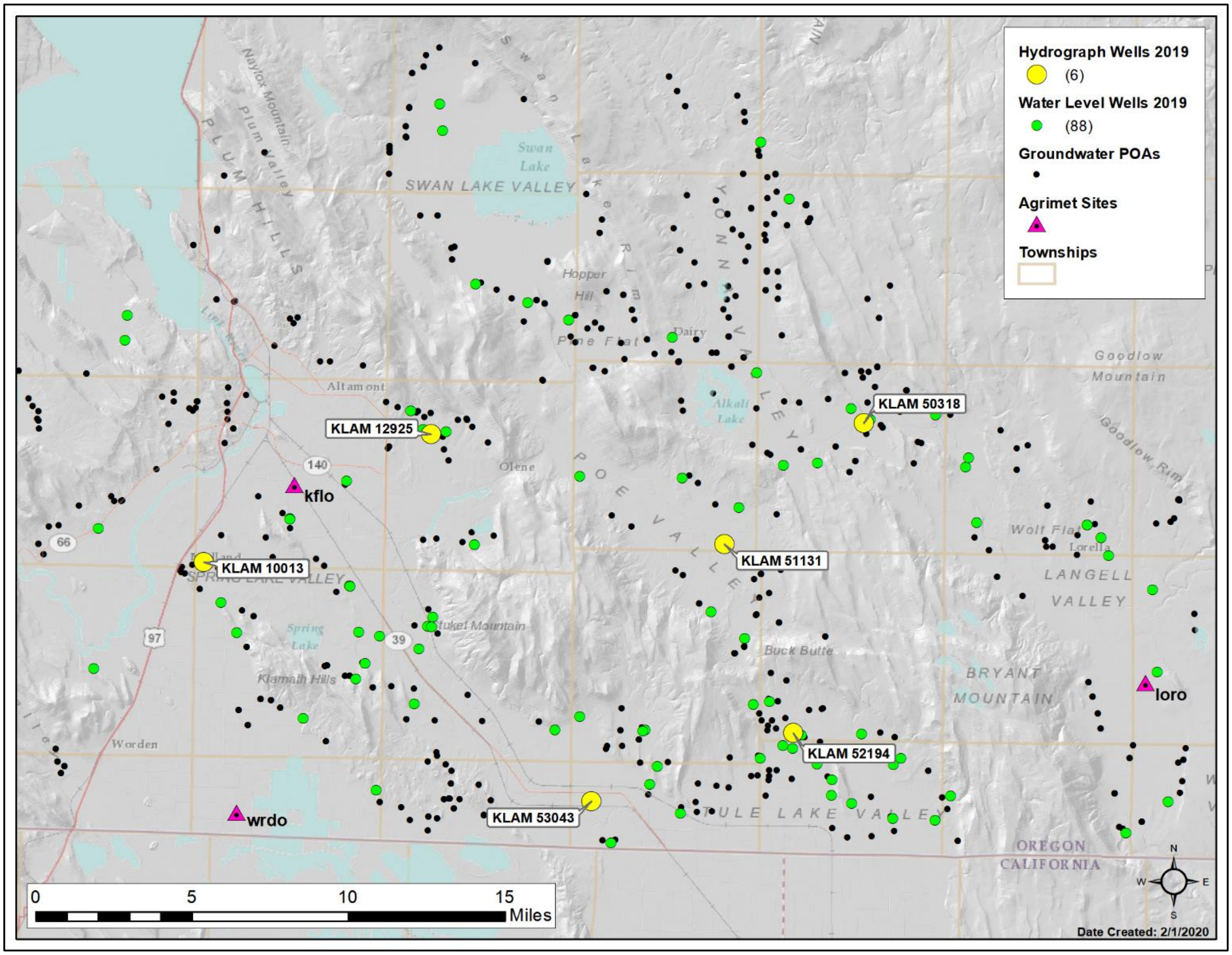

Figure 3: Map of study area wells with measured water levels in 2019. Also shown are permitted groundwater POAs; yellow circles highlight wells with hydrographs featured in this report

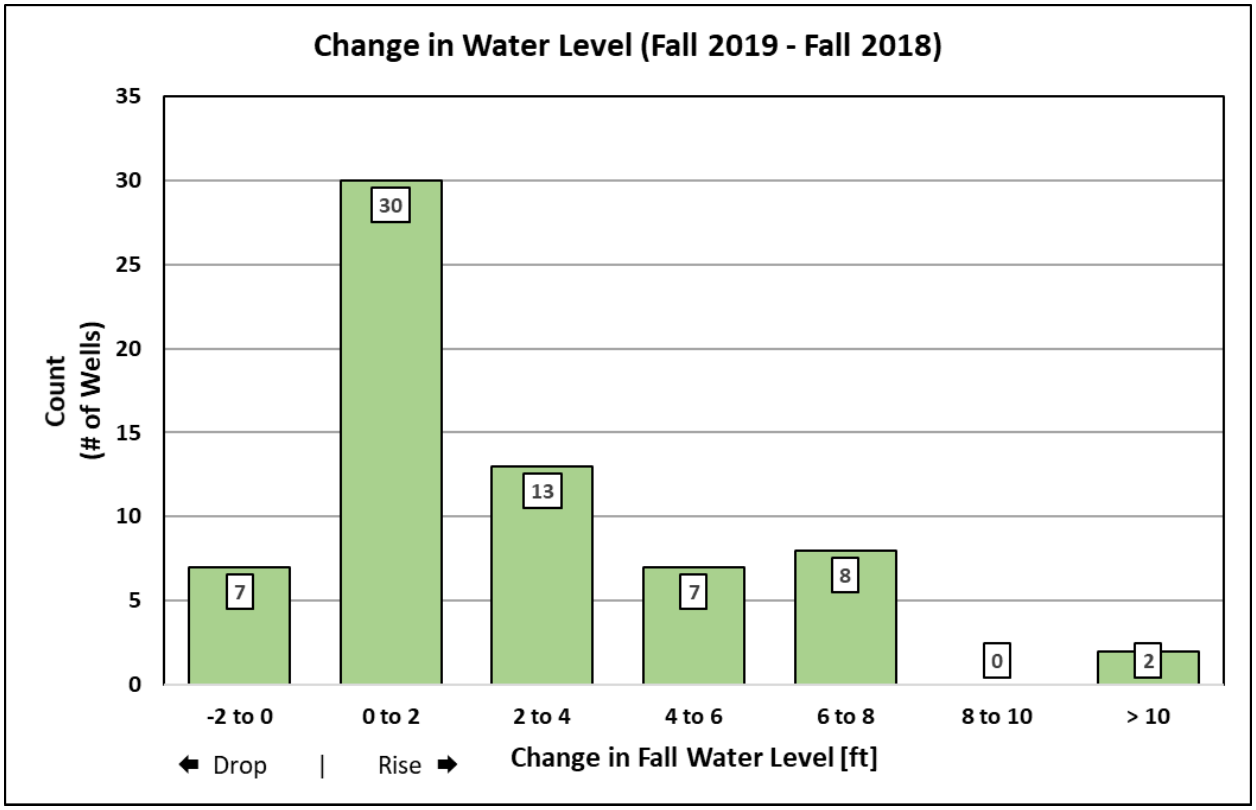

Figure 4: Distribution of change in groundwater level between fall 2018 and fall 2019 for wells measured in both years

Aquifer Response to Groundwater Pumping

Groundwater level records from representative wells within the study area (Figure 3) are presented in this section along with analysis of water level trends. These records generally show a long-term response to variations in annual precipitation, punctuated by seasonal pumping response and response to multi-year groundwater pumping trends. Water levels in recent years where groundwater pumping has been less severe show much smaller summer declines and relatively flat year-to-year trends but, as yet, no evidence of significant long-term water level recovery. Recharge from canal leakage has been documented in the Project Area by Pischel and Gannett (2015) as a mechanism to influence water levels in proximal wells and it has been speculated that connection to the Klamath River is partially responsible for smaller declines observed in the western portion of the study area.

Table 3 presents pumping data from the KWAPA Water Bank program from wells in both Oregon and California from 2005 through 2015, when the program ended, and metered groundwater pumping recorded by OWRD from 2010 through 2019. Annual precipitation records from three

AGRIMET stations in Oregon are also shown (see Figure 3 for station locations). As expected, there is a general correlation between water-year precipitation and groundwater pumping (Figure 5) as less surface water is available for irrigation during dryer years. Deviation from this dominant trend occurred in 2018 when, despite low precipitation comparable to 2013 and 2014, significantly less groundwater was pumped than previous dry years. This was in large part due to restrictions on permitted duty for drought permits (typically 3.0 AF per acre, reduced to 1.0 AF per acre in 2018) and closure of certain areas where the largest declines have been observed to drought permits, but also due to late-season surface water becoming available for the Project Area (Figure 6). Water-year precipitation in 2019 was significantly higher than the average over the last 15 years and so groundwater pumping was greatly reduced (Figure 5).

Table 3: Water Bank and metered pumping estimates and water-year precipitation since 2005

Year	Total Water Bank Pumping, OR and CA[1] (acre-feet)	Total OWRD Metered Pumping (acre-feet)	Total Water-Year Precipitation – Agrimet Stations[2] (inches)		
			Klamath Falls, OR KFLO	Worden, OR WRDO	Lorella, OR LORO
2005	65,710		10.92	10.95	12.85
2006	32,740		15.58	13.47	17.62
2007	47,621		11.25	8.21	10.51
2008	–		10.70	8.17	8.98
2009	–		10.78	7.41	7.95
2010	128,740	78,920	8.10	9.32	9.49
2011	–	18,377	13.00	12.64	13.56
2012	30,363	35,864	9.21	8.05	8.58
2013	64,688	58,048	9.55	10.89	12.06
2014	83,456	72,574	10.16	8.13	9.45
2015	37,742	61,645	12.71	15.56	12.29
2016	N/A	19,409	13.66	13.01	12.21
2017	N/A	17,358	14.93	12.22	18.26
2018	N/A	28,448	9.46	7.88	10.74
2019	**N/A**	**13,734**	**15.48**	**12.05**	**14.85**

[1]Pumping data for 2001–2007 collected by USBR, data for 2010–2015 collected by KWAPA, Water Bank program not operational during 2008 and 2009 while transitioning from USBR to KWAPA administration.

[2]Refer to Figure 3 for Agrimet station locations.

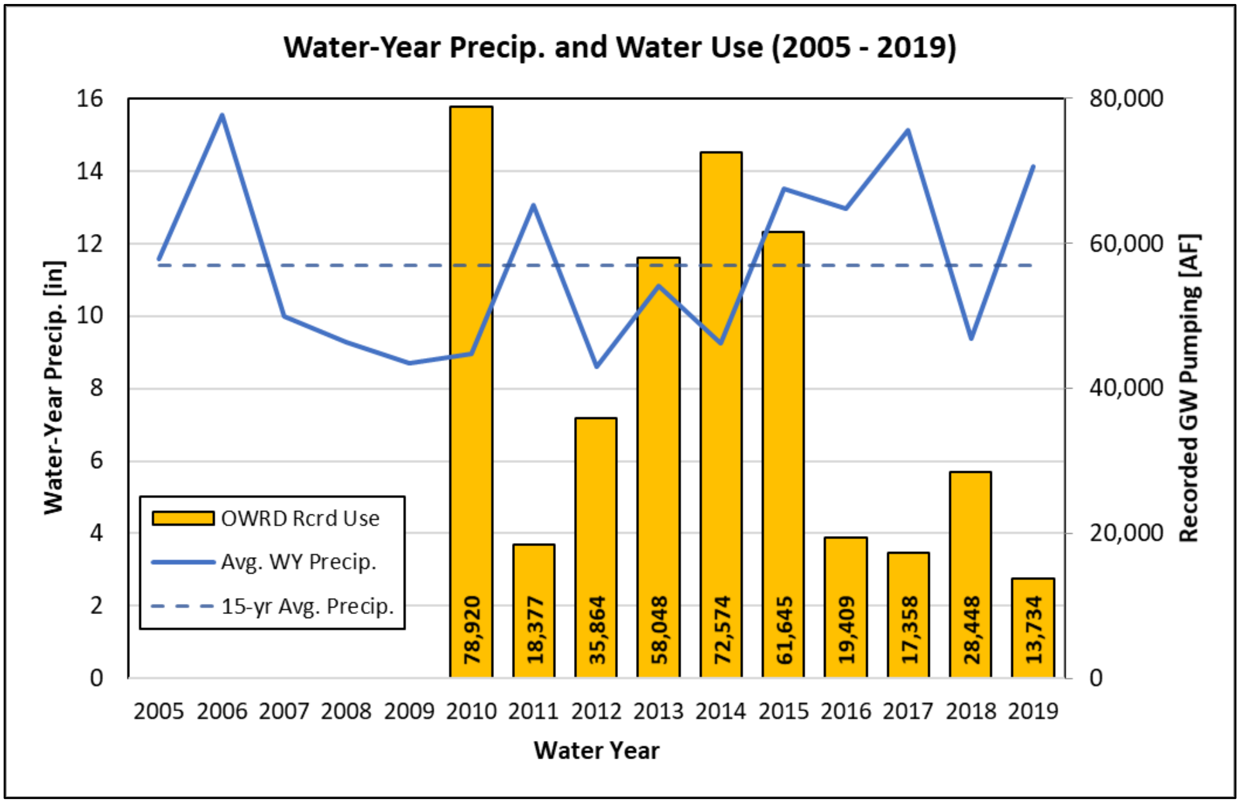

Figure 5: Water-year precipitation (average of all three AGRIMET sites) (solid blue) and 15-year average (dashed blue); recorded groundwater pumping by OWRD (bars)

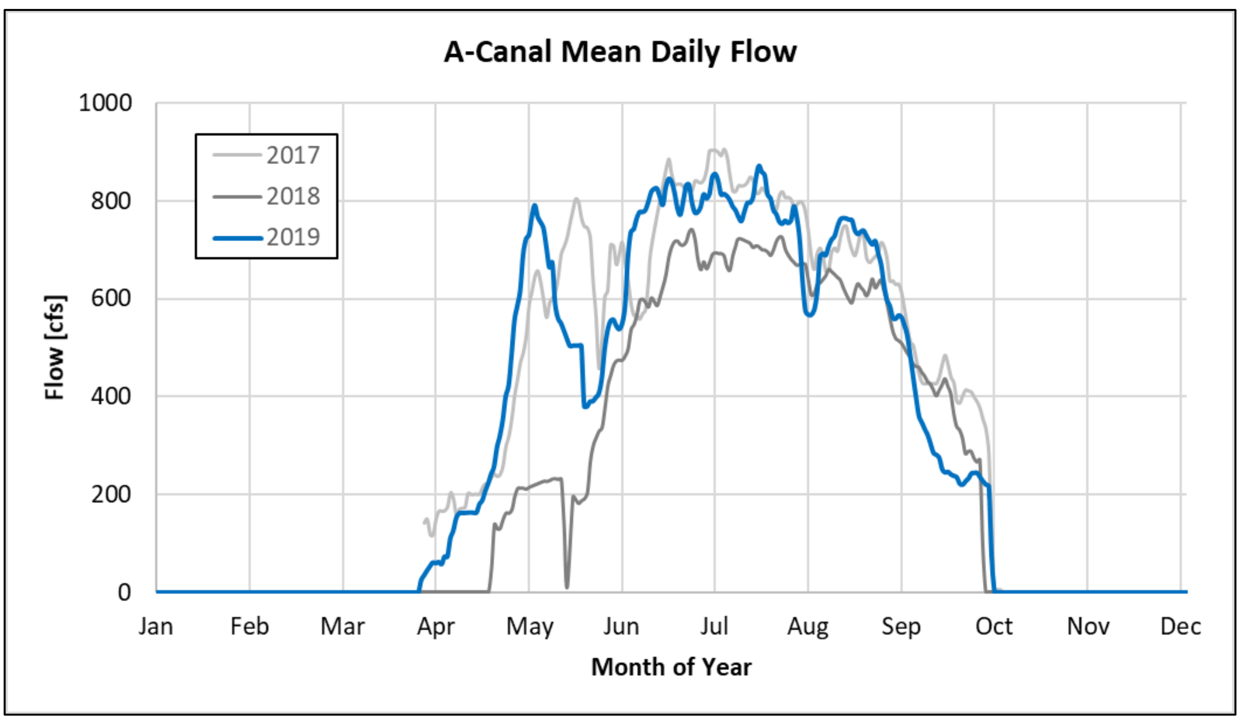

Figure 6: Mean Daily Flow for A-Canal, which is the major diversion from the Klamath River to the Project Area, for the last three years

Observed Hydrograph Trends

Observed groundwater level trends correlate strongly and predictably to historic water use and trends are similar across much of the study area. The main observed groundwater level trends are as follows:

- Increased supplemental irrigation pumping beginning in 2001 correlates with a trend of generally-declining groundwater levels. Wells that are strongly influenced by surface waters, such as leaky canals or the Klamath River, experienced some recovery after the 2001 irrigation season while wells utilizing deep regional aquifers experienced persistent water level declines after 2001. Unfortunately there was limited water level data collected prior to 2010.

- The Water Bank program did not operate during 2008 and 2009 while administration of the program was transferred from USBR to KWAPA. The reduction in supplemental pumping appears to have resulted in relatively constant water levels or minor water level recovery in some area wells, most-strongly in those wells suspected to be influenced by canal leakage.

- A sharp increase in supplemental pumping during 2010, 2013, 2014, and 2015 resulted in punctuated seasonal declines and incomplete recovery between irrigation seasons and overall declines in groundwater levels (Figure 7).

- The 2016 water-year marked the first year without the Water Bank program and, along with 2017, a return to average precipitation. Hydrographs reflect reduced pumping stress with stable or slightly-higher fall water levels in 2016 and 2017 compared to 2015 (Figure 7), and far less seasonal drawdown than observed in previous years.

- The 2018 water-year saw significantly less precipitation across the study area and a significant increase in the amount of pumping compared to recent years but less than previous years with similar precipitation (see Figure 5). By June, stored surface water was being delivered to the Project Area at near the accustomed rate (Figure 6) and many users reduced or ceased groundwater pumping. Subsequently, water levels declined most between spring and summer but by the time fall measurements were made it was clear that water levels were beginning to recover.

- The 2019 water-year saw slightly above-average precipitation as well as surface water deliveries that were more typical (see Figure 6). Consequently, groundwater pumping was substantially less than previous years and water levels seemed to continue on an upward trend (recovery) that began in fall 2018 (Figure 7).

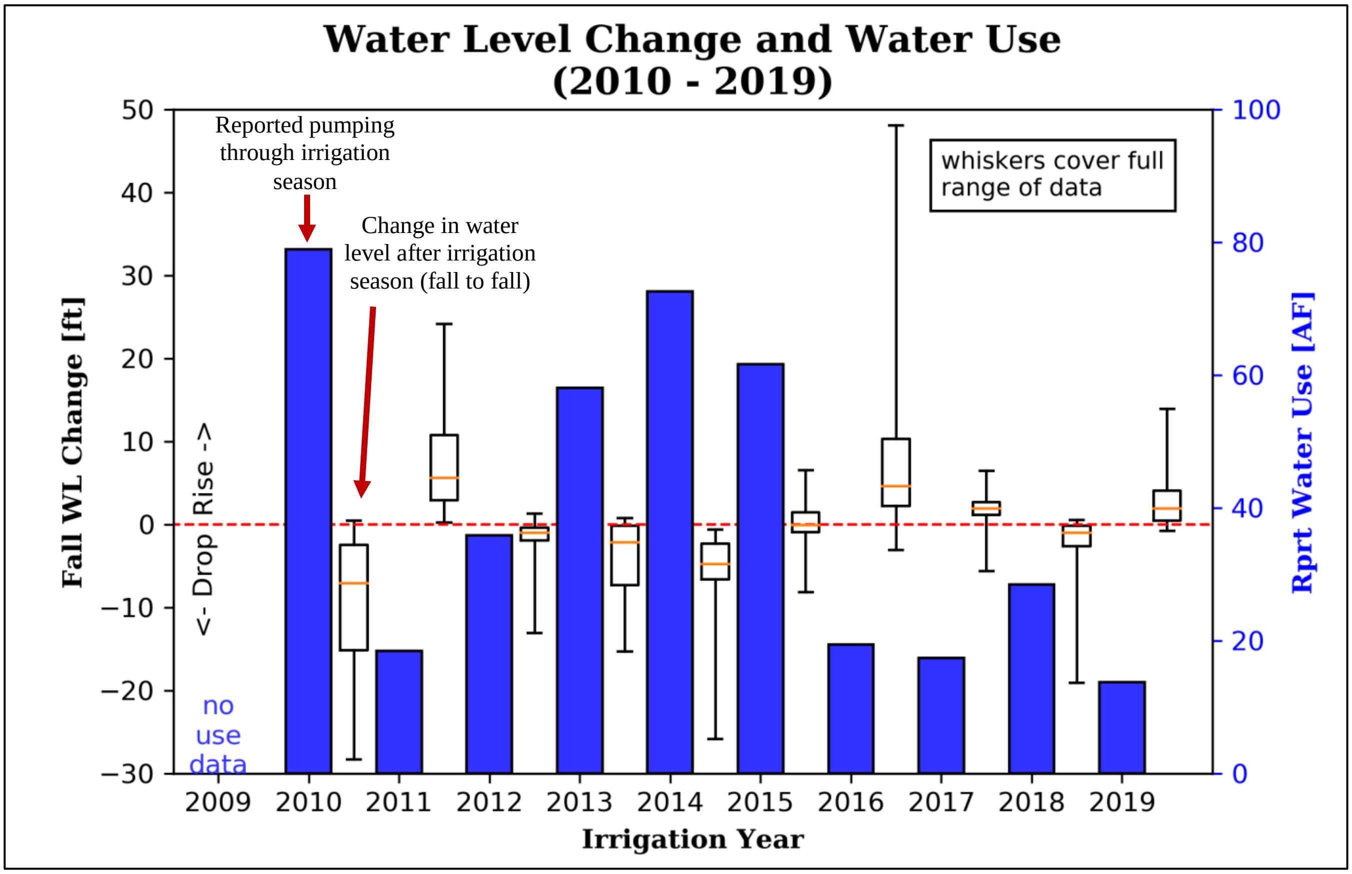

Figure 7: Reported annual pumping since 2010 (bars) and box-and-whisker plot of fall-to-fall change in water levels for each year for wells in the study area; e.g., box-and-whisker immediately right of 2010 pumping volume represents distribution of all water level changes from fall-2009 to fall-2010

Specific Hydrographs in the Study Area

KLAM 52194 is an observation well constructed by OWRD about 3.8 miles north of the state line near Malin, OR in the Shasta View Irrigation District. Seasonal fluctuations in the hydrograph (Figure 8) are a response to groundwater pumping in the area. The hydrograph shows groundwater level declines of nearly 30 feet from spring 2001 through spring 2016. Seasonal fluctuations were substantially less in 2008 and 2009, and again in 2016 and 2017, as a result of the absence of excessive groundwater pumping by irrigation wells in the area. Pumping during the 2010 irrigation season resulted in over 20 ft of seasonal decline at this well. Pumping during 2013, 2014, and 2015 produced 10-20 ft of decline in each year and incomplete recovery between years. Pumping in 2018 produced slightly over 5 ft of decline early in the irrigation season but the well has shown recovery through the 2019 irrigation season.

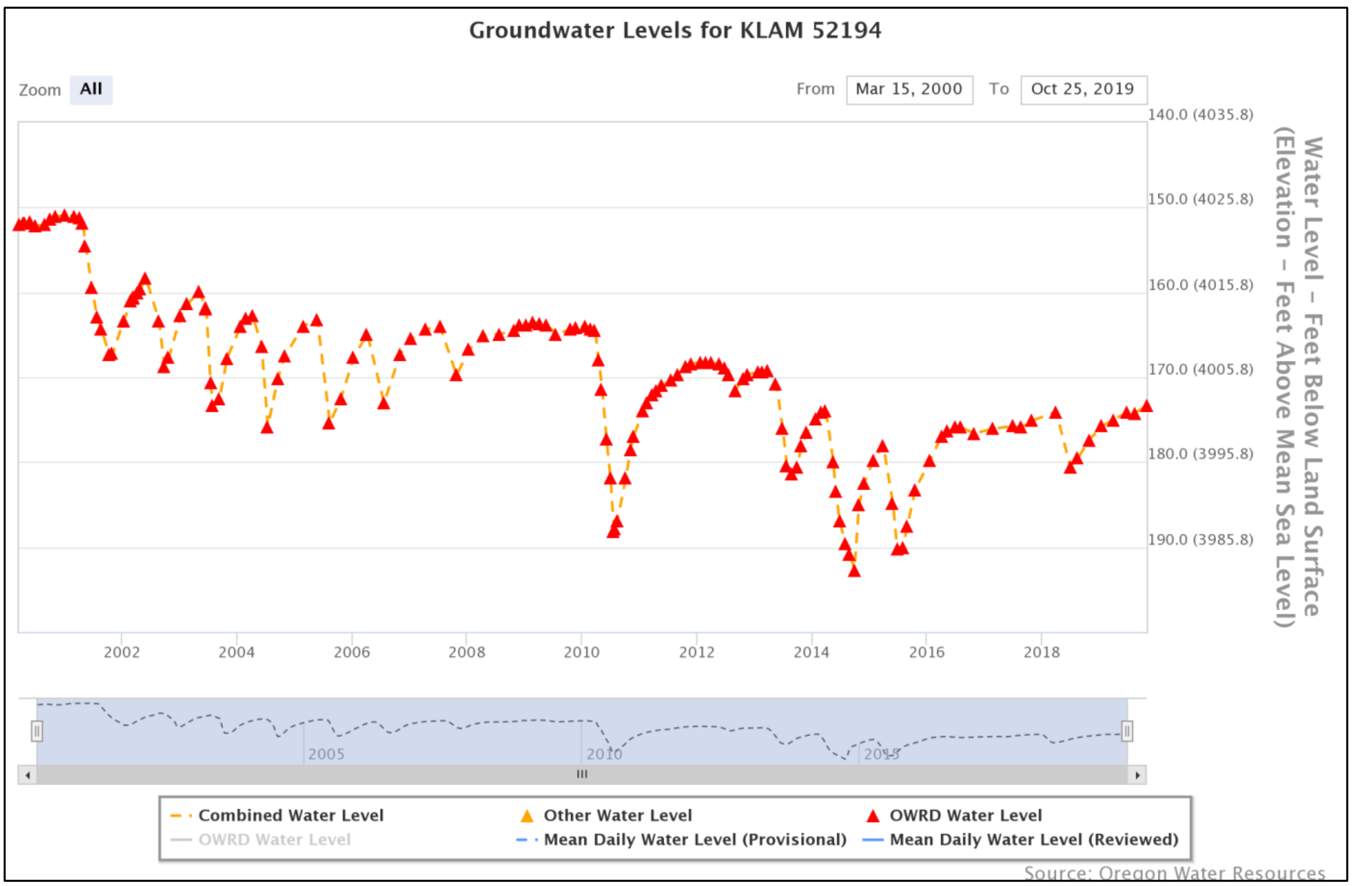

Figure 8: Hydrograph for well KLAM 52194 near Malin, OR

KLAM 53043 is an irrigation well drilled in 2001 about 1.5 miles east of Merrill, OR and just over one mile north of the Oregon-California state line. This well is subject to drawdown interference from the Tulelake Irrigation District wellfield located in California along the state line. The hydrograph from this well (Figure 9) displays seasonal and long-term water-level declines from 2002 through 2007 followed by partial recovery coincident with reduced groundwater pumping in 2008 and 2009. The 2010 irrigation season resulted in a 20 ft seasonal decline with only 15 ft of recovery. Groundwater levels showed slight recovery between spring 2016 and spring 2018, followed by approximately 5 ft of seasonal decline in 2018 and nearly stable water levels through 2019. Overall, spring groundwater levels have dropped approximately 13 ft since the spring of 2003.

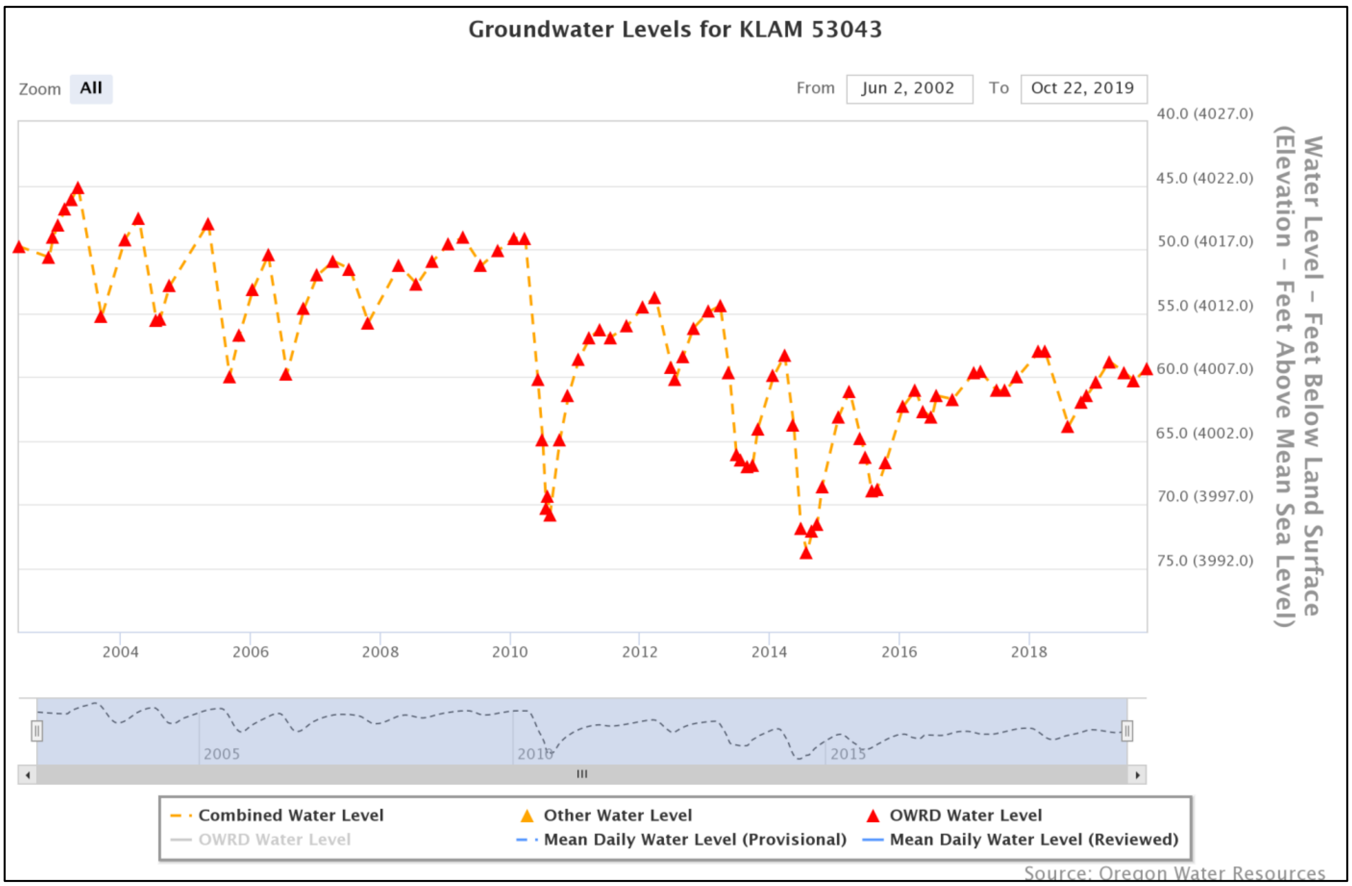

Figure 9: Hydrograph for well KLAM 53043 east of Merrill, OR

KLAM 10013 is a domestic well located just east of the town of Midland, OR in the western portion of the study area. Historically, this area has been the source of multiple concerns from local well owners about declining groundwater levels and well-to-well interference. KLAM 10013 is a shallow well that develops water from the volcanic aquifer which is the primary-production aquifer for the area. Water levels at this well (Figure 10) are likely affected by recharge from the Klamath River or canal leakage which accounts for a generally-stable long-term trend. However, this well still shows sharper seasonal declines due to groundwater pumping for irrigation, the sharpest being concurrent with years of increased groundwater pumping (2010, 2013-2015). Since 2016 this well has shown seasonal fluctuations that were considerably muted compared to previous years, with only a 2 ft drop during the 2019 irrigation season.

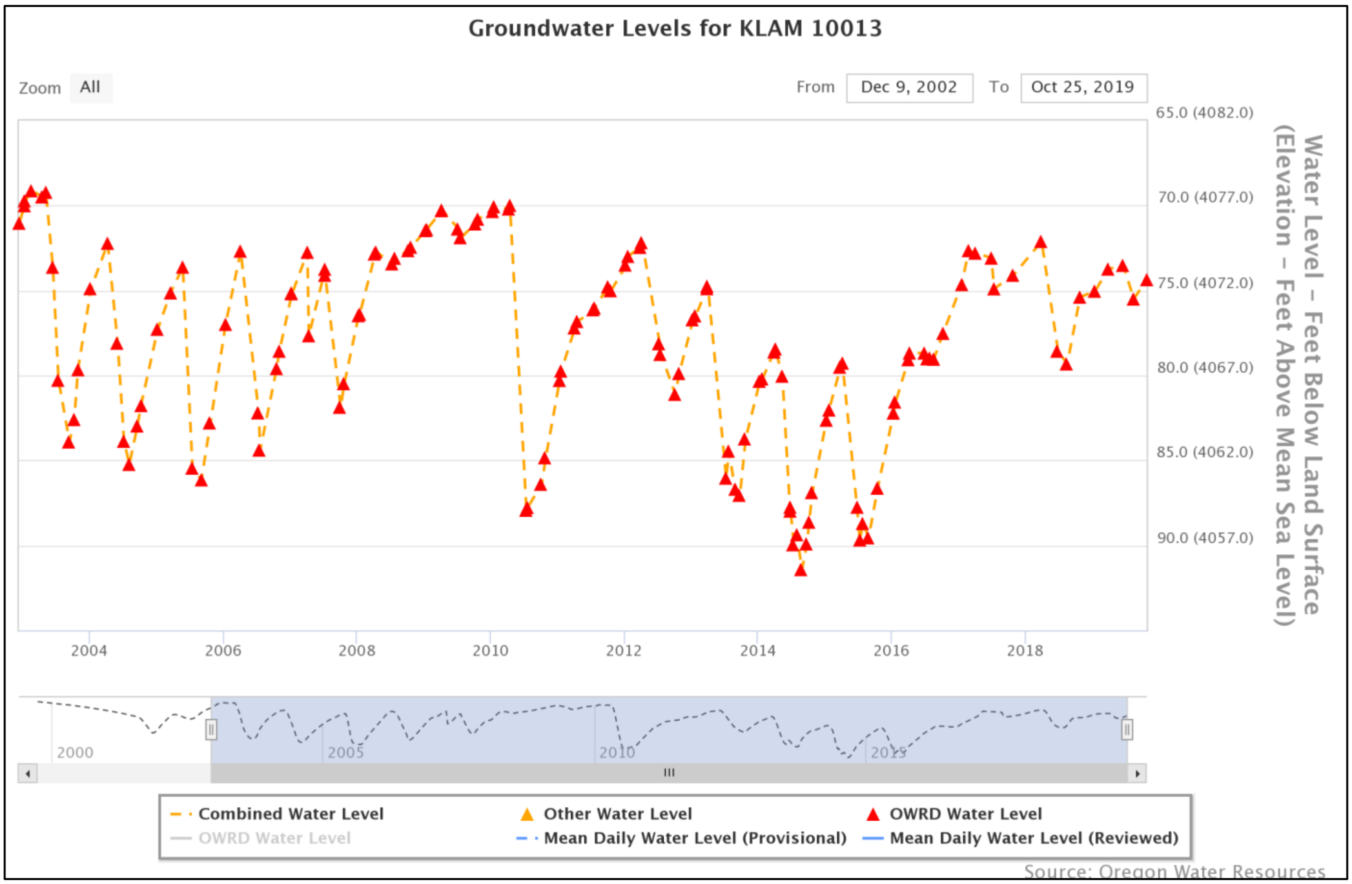

Figure 10: Hydrograph for well KLAM 10013 near Midland, OR

KLAM 12925 is a domestic and stock well located in the Pine Grove area southeast of Klamath Falls, OR where groundwater levels in the volcanic aquifer and the overlying sediments are strongly influenced by supplemental groundwater pumping in the surrounding area. The hydrograph for this well (Figure 11) displays a trend similar to that observed in wells located along the state line and in the Klamath Valley (e.g., KLAM 52195). Water levels declined approximately 10 ft at this well between 2010 and 2015, with no additional decline, but no significant recovery, since 2015.

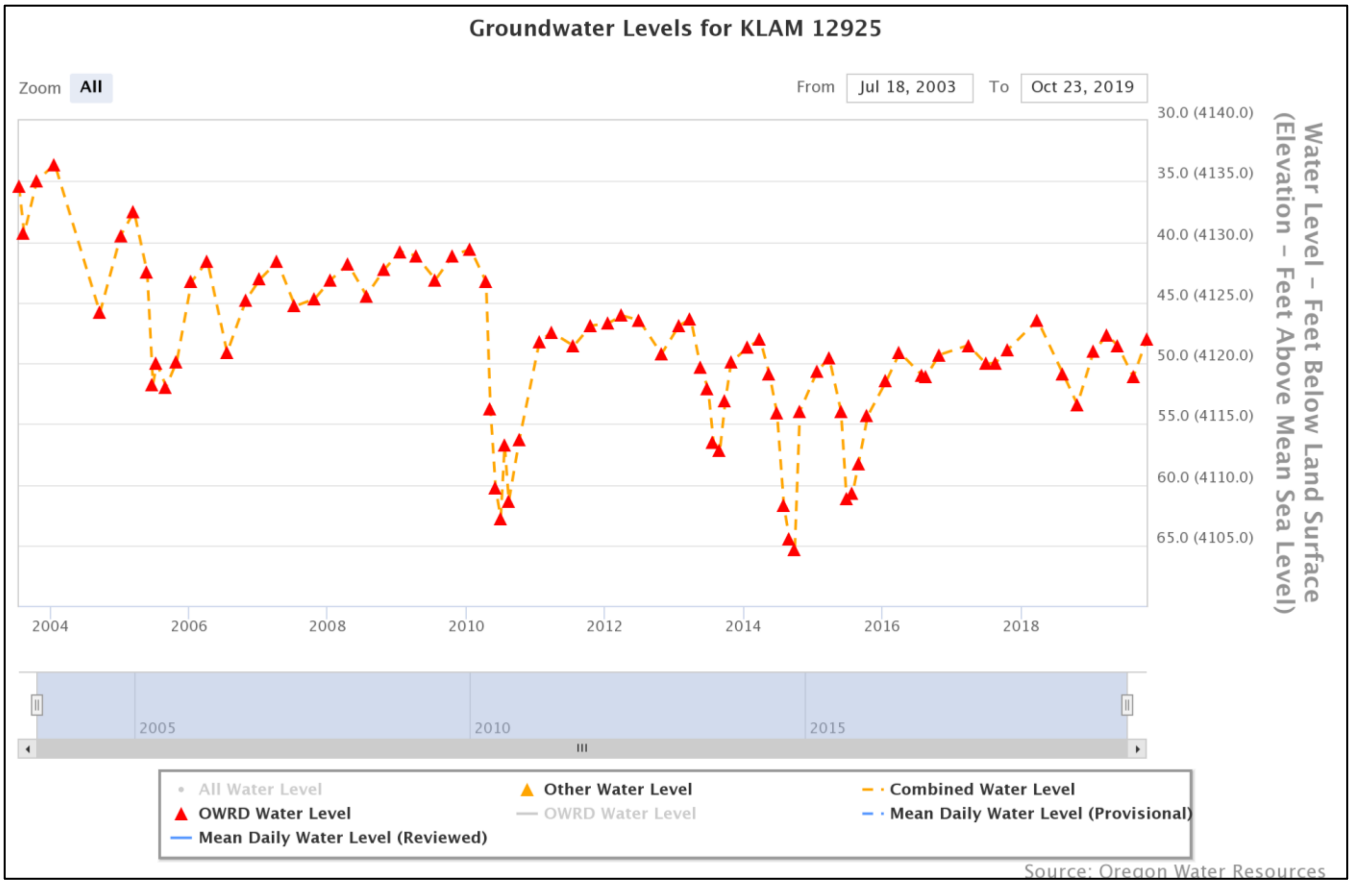

Figure 11: Hydrograph for well KLAM 12925 in the Pine Grove area

KLAM 51131 is an unused irrigation well located in South Poe Valley approximately 2,000 ft from the main channel of the Lost River. The well develops water from both the sedimentary and volcanic aquifers and receives recharge from numerous surrounding surface water features including irrigation canals, lakes, and the Lost River. The hydrograph (Figure 12) displays a fairly stable, but still declining, water level trend following the extensive groundwater pumping in 2010. Regulation of unauthorized groundwater pumping in the area and greater availability of surface water from the Lost River resulted in a significant reduction in groundwater use in mid-season 2010, which likely supported this trend. However, water levels still declined 7 ft between 2010 and 2016, with large seasonal declines in 2014, 2015, and 2018 but otherwise stable water levels. This well was equipped with a pressure transducer from 2000 – 2002 and since 2017.

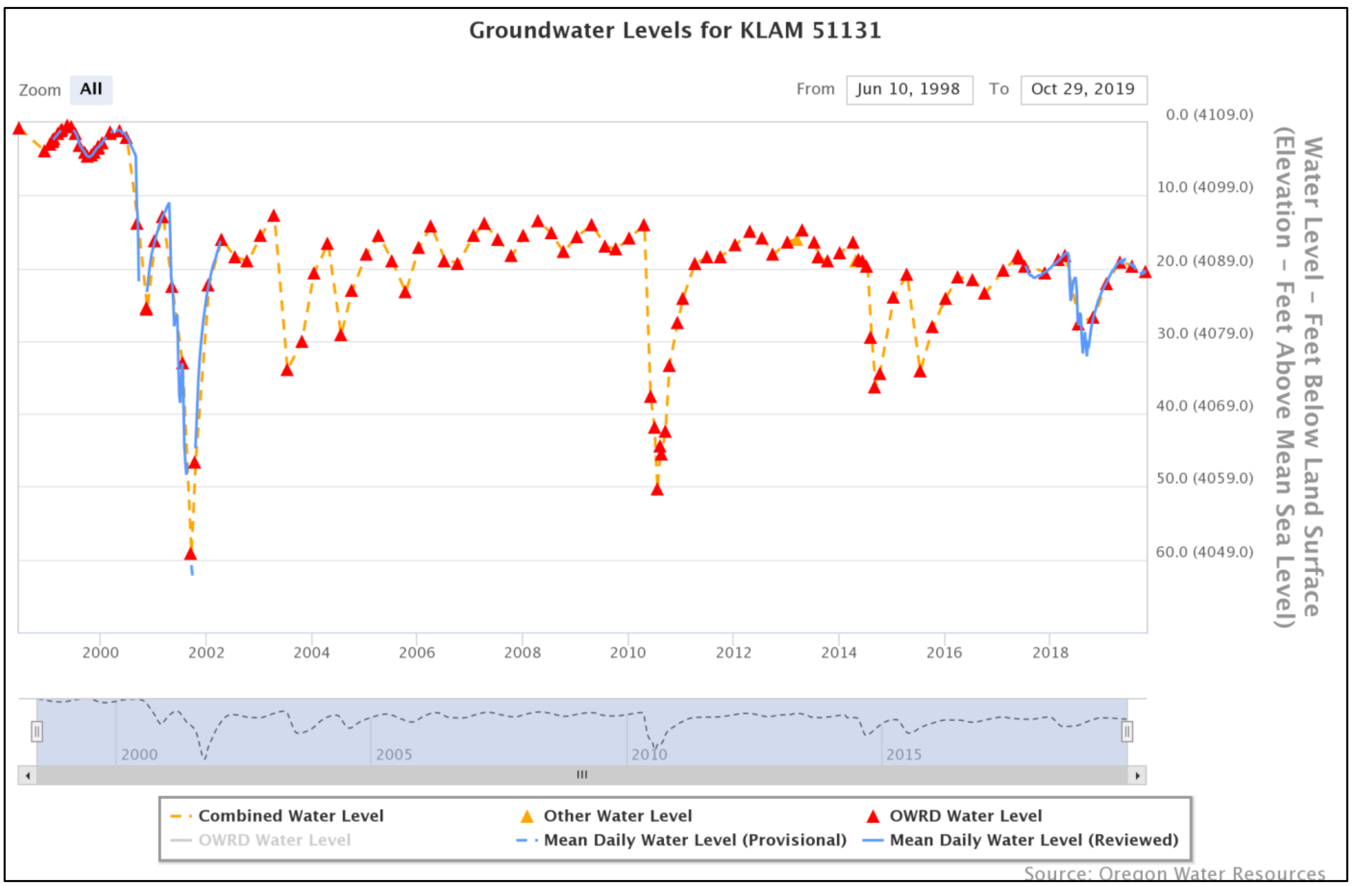

Figure 12: Hydrograph for well KLAM 51131in South Poe Valley

KLAM 50318 is a shallow unused well located in a groundwater discharge area adjacent to the Lost River and near Bonanza, OR and Bonanza Big Springs. The hydrograph (Figure 13) shows a seasonal response to pumping with year-to-year spring high water levels that are relatively stable and appear to reflect climate fluctuations (refer to Table 3 for water-year precipitation values). The seasonal drawdown of groundwater levels was larger during the 2010, 2014, and 2015 irrigation seasons due to increased groundwater pumping in the area. Seasonal drawdowns were similar to previous years in 2016 through 2019.

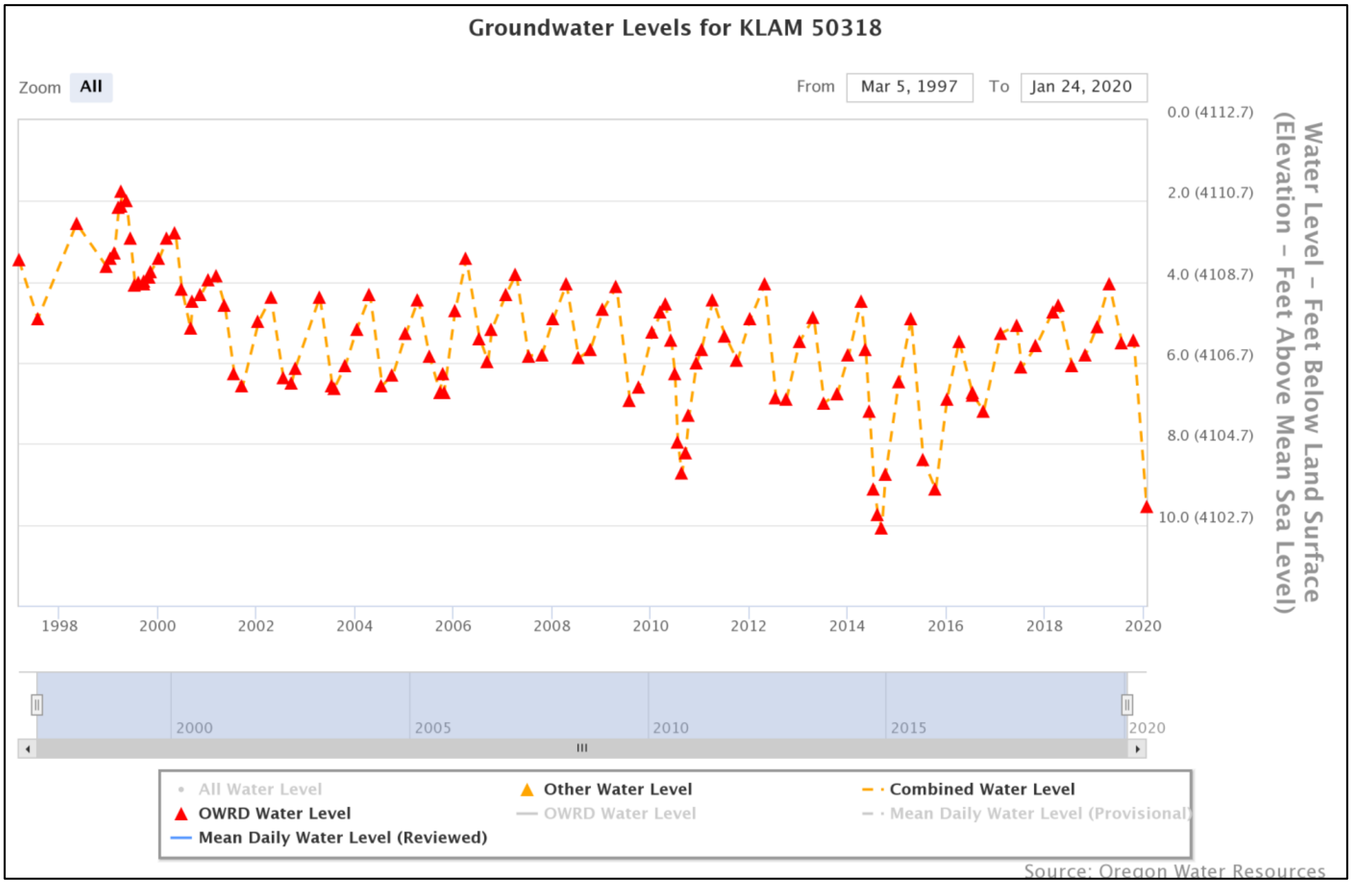

Figure 13: Hydrograph for well KLAM 50318 near Bonanza, OR

The water level in KLAM 50318 is representative of the head in the part of the aquifer that drives flow to Bonanza Big Springs and thus represents a local discharge zone, which partly explains the low seasonal variability and stable long-term trends observed in the hydrograph. Lower groundwater levels at this well are coincident with lower discharge at the spring outflow adjacent to the river. Groundwater levels generally observe a smooth annual cycle (rising through the fall, lowering through the summer) while river stage often shows discrete changes (rapid increase or decrease in stage). Stage elevation at this location is partly controlled by a diversion structure (Harpold Dam) on the Lost River downstream of the gaging station and groundwater elevation is above river stage elevation for most of the year (Figure 14). When the river stage elevation exceeds the groundwater level elevation, primarily in summer months when there is increased stage behind the dam and the hydraulic gradient is reversed. At which point surface water can flow into the aquifer via Bonanza Big Springs and potentially contaminate nearby water wells. Consequently, when groundwater levels get less than 0.5 ft above river stage, a subset of nearby irrigation wells are curtailed and stage behind Harpold Dam may be reduced to limit groundwater contamination. For all of 2018 and 2019, groundwater levels in KLAM 50318 were above Lost River stage and came within the 0.5 ft threshold once in 2018 and only came to within 1 ft of Lost River stage in 2019. In many of the previous years, groundwater elevation dropped below river stage for several days (Figure 14).

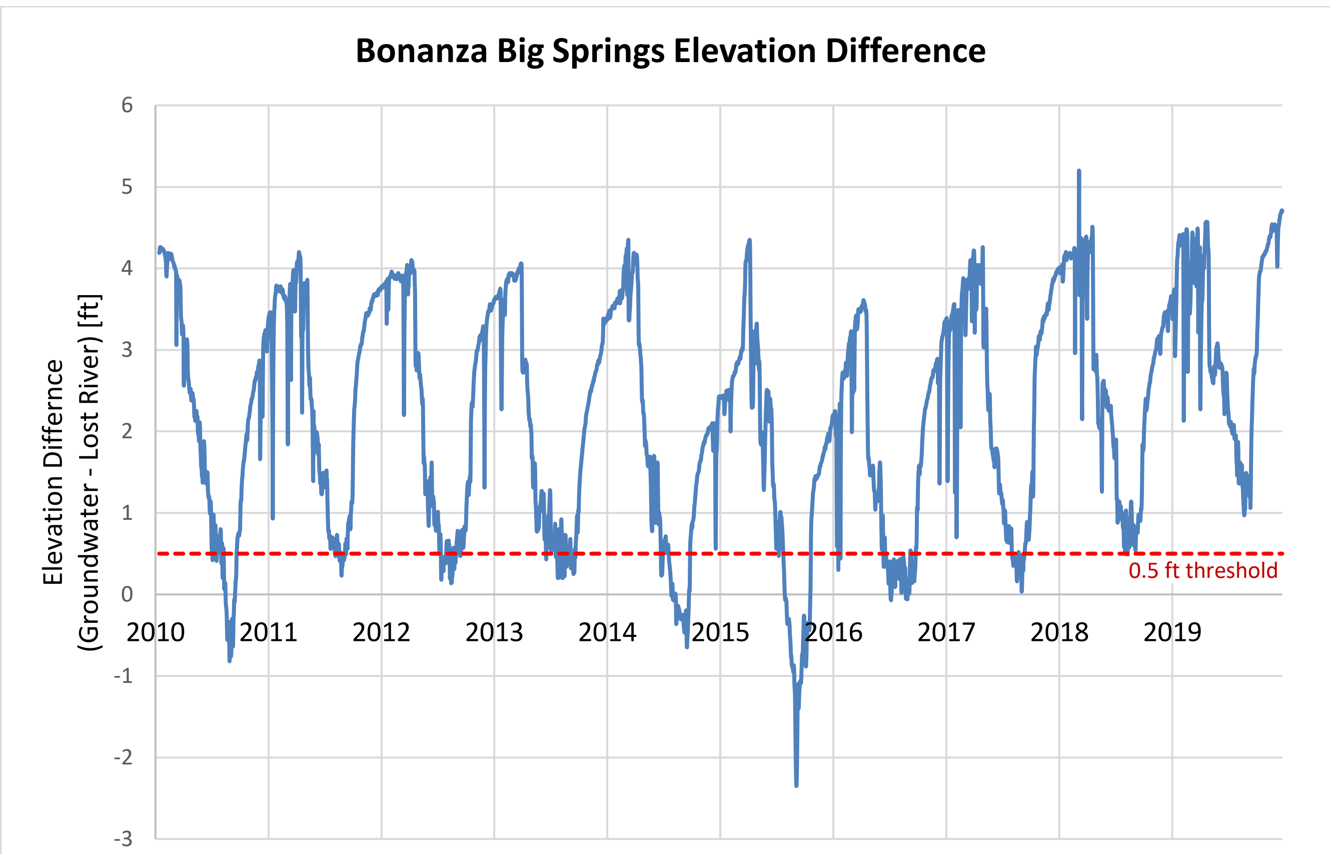

Figure 14: Hydrograph showing the difference in stage between Bonanza Big Springs (measured at KLAM 50318) and the Lost River since 2010

Summary and Conclusion

Significant reliance on supplemental groundwater pumping since 2001 has resulted in long-term groundwater level declines marked by punctuated seasonal declines and incomplete annual recovery in the Lost River Subbasin and Klamath Project Area. The 2019 irrigation season saw slightly above-average precipitation and subsequently “normal” surface water deliveries to the Project Area. The result was substantially less groundwater pumping in 2019 compared to previous years and the lowest recorded groundwater pumping since this monitoring project began. From flowmeter data collected between October 2019 and January 2020, there was a recorded 13,734 AF of groundwater pumped in the 2019 irrigation season. In January 2019, the number of flowmeters read was fewer than in recent years due to severe weather and unfavorable road conditions. Therefore, the reported 13,734 AF is likely more of an underestimate than previous years. However, a comparison of water use data for the same set of wells from 2018 to 2019, along with a general rise in water levels throughout the study area between fall 2018 and fall 2019, strongly support the conclusion that 2019 was one of the lowest water-use years since this monitoring began. Overall, 78% of wells with 2018 and 2019 water use data reported less water use, and 90% of wells with fall water level data reported a rise in water levels. Some wells show continuing recovery but most wells show only a stable trend in 2019.

The data presented in this report suggest that large supplemental groundwater withdrawals have resulted in large seasonal declines in some areas and persistent groundwater level declines across most of the study area. Despite the lowest recorded groundwater use in 2019, water-level data show only minor trends toward recovery or stable trends through 2019, implying that a single year of low groundwater pumping is not sufficient to substantially recover water levels. Overall, water levels remain several feet to tens-of-feet below pre-2001 conditions. These groundwater level declines can result in reduced groundwater discharge to – and in some cases induced recharge from – streams, springs, and drains, which exacerbates already stressed surface water supplies. Additionally, persistent seasonal drawdown can reduce storage potential in aquifers. Seasonal and long-term water level declines also result in increased pumping costs incurred by groundwater users. These impacts are not limited only to the Oregon part of the Klamath Project Area, or only to those that use water for agricultural purposes. Impacts extend to off-project users and those reliant on groundwater as a domestic supply, including municipalities.

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Appendix A

List of wells visited as part of 2019 Flowmeter Synoptic

Well ID	*Latitude*	*Longitude*	*Flowmeter*	*Flowmeter Status*	*Flowmeter Analyzed*	*Water Level Well*	*Permitted Well**
KLAM0002263	42.36097	-121.64585	Yes	NOFM			Yes
KLAM0002277	42.34171	-121.66779				Yes	
KLAM0002286	42.32957	-121.66566				Yes	
KLAM0002289	42.32651	-121.68852	Yes		Yes		Yes
KLAM0002373	42.33554	-121.47727	Yes	NOAC			Yes
KLAM0002374	42.32603	-121.46735				Yes	Yes
KLAM0010013	42.12839	-121.81058	Yes	NOFM		Yes	Yes
KLAM0010080	42.34923	-121.52022	Yes	NOFM			Yes
KLAM0010082	42.34013	-121.68664	Yes	NEW			Yes
KLAM0010181	42.34023	-121.47744	Yes		Yes		Yes
KLAM0010242	42.20642	-121.39868	Yes		Yes		Yes
KLAM0010252	42.15699	-121.47808				Yes	Yes
KLAM0010258	42.17680	-121.45080				Yes	
KLAM0010292	42.15845	-121.49249	Yes		Yes		Yes
KLAM0010331	42.15636	-121.86196	Yes	NOFM			Yes
KLAM0010336	42.29044	-121.66797	Yes		Yes		Yes
KLAM0010352	42.21980	-121.40189	Yes		Yes		Yes
KLAM0010353	42.01059	-121.68060	Yes		Yes		Yes
KLAM0010357	42.21762	-121.40191	Yes		Yes		Yes
KLAM0010362	42.13664	-121.24808				Yes	
KLAM0010364	42.13664	-121.25375	Yes	NOFM			Yes
KLAM0010368	42.25340	-121.48702	Yes		Yes		Yes
KLAM0010378	42.19189	-121.39916	Yes		Yes		Yes
KLAM0010395	42.20218	-121.37843	Yes		Yes		Yes
KLAM0010416	42.20389	-121.39297	Yes		Yes		Yes
KLAM0010421	42.21994	-121.41279	Yes		Yes		Yes
KLAM0010431	42.18449	-121.41147	Yes		Yes		Yes
KLAM0010432	42.18403	-121.43425	Yes		Yes		Yes
KLAM0010440	42.20376	-121.38058	Yes		Yes		Yes
KLAM0010441	42.00999	-121.66537	Yes		Yes		
KLAM0010449	42.05710	-121.68285	Yes		Yes		Yes
KLAM0010454	42.06005	-121.44746	Yes		Yes		Yes
KLAM0010460	42.20805	-121.42329	Yes		Yes		Yes
KLAM0010461	42.21369	-121.39398	Yes		Yes		Yes
KLAM0010462	42.03873	-121.42801	Yes		Yes	Yes	Yes
KLAM0010467	42.14361	-121.28717	Yes		Yes		Yes
KLAM0010473	42.05645	-121.20358	Yes	NOFM			Yes

Well ID	*Latitude*	*Longitude*	*Flowmeter*	*Flowmeter Status*	*Flowmeter Analyzed*	*Water Level Well*	*Permitted Well**
KLAM0010475	42.20634	-121.44031	Yes		Yes		Yes
KLAM0010478	42.04703	-121.44903	Yes		Yes	Yes	Yes
KLAM0010491	42.23051	-121.44865	Yes		Yes		
KLAM0010498	42.18307	-121.46039	Yes		Yes		Yes
KLAM0010506	42.03666	-121.52680				Yes	Yes
KLAM0010518	42.06408	-121.67844	Yes		Yes	Yes	Yes
KLAM0010526	42.15960	-121.28596	Yes		Yes		Yes
KLAM0010539	42.01334	-121.35416	Yes		Yes	Yes	Yes
KLAM0010574	42.00819	-121.23573				Yes	
KLAM0010608	42.14056	-121.28246	Yes	SHAR			Yes
KLAM0010634	42.14057	-121.28647	Yes	NOFM			Yes
KLAM0010641	42.06387	-121.25320	Yes	NOAC			Yes
KLAM0010642	42.01371	-121.22578	Yes		Yes		Yes
KLAM0010699	42.12639	-121.31692	Yes		Yes		Yes
KLAM0010712	42.26633	-121.45559	Yes		Yes		Yes
KLAM0010748	42.02673	-121.24272	Yes		Yes		Yes
KLAM0010814	42.18117	-121.33572				Yes	
KLAM0010822	42.20461	-121.83795	Yes		Yes		Yes
KLAM0010870	42.32235	-121.46863	Yes		Yes		Yes
KLAM0010896	42.01439	-121.62171	Yes		Yes		Yes
KLAM0010988	42.11246	-121.50040	Yes	NOFM			Yes
KLAM0011008	42.05178	-121.37963	Yes		Yes		Yes
KLAM0011139	42.23532	-121.52104				Yes	
KLAM0011254	42.02084	-121.40594	Yes	NOFM		Yes	Yes
KLAM0011544	42.24184	-121.86072	Yes		Yes	Yes	Yes
KLAM0011643	42.27550	-121.65918	Yes	NOFM			Yes
KLAM0012221	42.25053	-121.61138				Yes	Yes
KLAM0012224	42.24260	-121.58562				Yes	Yes
KLAM0012283	42.28771	-121.45003	Yes	NOAC			Yes
KLAM0012390	42.29298	-121.48721	Yes	NOFM			Yes
KLAM0012404	42.27006	-121.50770	Yes		Yes		Yes
KLAM0012415	42.25497	-121.48184	Yes				Yes
KLAM0012454	42.22423	-121.51637	Yes	NOFM			Yes
KLAM0012457	42.23627	-121.48562	Yes	NOFM			Yes
KLAM0012828	42.14467	-121.67838	Yes	NOAC			Yes
KLAM0012847	42.19955	-121.68315				Yes	
KLAM0012893	42.19021	-121.66106				Yes	Yes
KLAM0012925	42.18921	-121.67043				Yes	
KLAM0013315	42.13838	-121.66558	Yes	NOFM			Yes
KLAM0013326	42.21223	-121.37444	Yes	NOFM			Yes
KLAM0013353	42.20328	-121.40899				Yes	

Well ID	Latitude	Longitude	Flowmeter	Flowmeter Status	Flowmeter Analyzed	Water Level Well	Permitted Well*
KLAM0013400	42.20074	-121.35653	Yes	NOFM		Yes	
KLAM0013403	42.18771	-121.36523	Yes	NOAC			Yes
KLAM0013427	42.17791	-121.42966	Yes	BRKQ		Yes	Yes
KLAM0013456	42.21954	-121.46810				Yes	
KLAM0013458	42.22219	-121.48351	Yes	NOFM			Yes
KLAM0013472	42.18623	-121.47022	Yes		Yes		Yes
KLAM0013491	42.17029	-121.51386				Yes	
KLAM0013556	42.16152	-121.25907	Yes	NOFM			Yes
KLAM0013582	42.15113	-121.33030				Yes	
KLAM0013583	42.13865	-121.32235	Yes	NOFM			Yes
KLAM0013585	42.15270	-121.20917	Yes	NOFM			Yes
KLAM0013600	42.14491	-121.25288				Yes	
KLAM0014559	42.05661	-121.74723	Yes	NOFM		Yes	Yes
KLAM0014580	42.04928	-121.74361	Yes	NOFM			Yes
KLAM0014581	42.04869	-121.74054	Yes	NOFM			Yes
KLAM0014731	42.10871	-121.49483				Yes	Yes
KLAM0014736	42.09647	-121.47349	Yes	NOFM		Yes	Yes
KLAM0014754	42.06196	-121.46386	Yes		Yes		Yes
KLAM0014763	42.05336	-121.54974	Yes		Yes		Yes
KLAM0014777	42.05316	-121.53633	Yes	NOFM		Yes	Yes
KLAM0014819	42.06489	-121.42551	Yes		Yes		Yes
KLAM0014820	42.06467	-121.42395	Yes	NOAC			Yes
KLAM0014821	42.06790	-121.41706	Yes		Yes		Yes
KLAM0014829	42.06753	-121.45788				Yes	Yes
KLAM0014838	42.06411	-121.42084	Yes		Yes		Yes
KLAM0014844	42.05289	-121.40040				Yes	
KLAM0014864	42.11772	-121.30101	Yes	NOFM			Yes
KLAM0014873	42.07806	-121.25929	Yes	NOAC			Yes
KLAM0014882	42.12083	-121.22050				Yes	
KLAM0014889	42.08299	-121.21719				Yes	
KLAM0014891	42.08379	-121.21639	Yes		Yes		Yes
KLAM0014896	42.05030	-121.19908	Yes		Yes		Yes
KLAM0014914	42.02392	-121.70113	Yes	NOFM		Yes	Yes
KLAM0014939	42.01221	-121.66848	Yes	NOFM			Yes
KLAM0014943	42.02056	-121.64927	Yes	NOFM			Yes
KLAM0014952	42.02019	-121.62981	Yes	NOFM			Yes
KLAM0014956	42.01331	-121.63391	Yes		Yes		Yes
KLAM0014984	42.00579	-121.66860	Yes		Yes		Yes
KLAM0014992	42.03889	-121.52004	Yes		Yes		Yes
KLAM0015045	42.03884	-121.38057	Yes		Yes	Yes	Yes
KLAM0015050	42.04184	-121.37572	Yes	BRKQ		Yes	Yes

Well ID	*Latitude*	*Longitude*	*Flowmeter*	*Flowmeter Status*	*Flowmeter Analyzed*	*Water Level Well*	*Permitted Well**
KLAM0015051	42.04188	-121.40459				Yes	
KLAM0015072	42.02438	-121.41876				Yes	
KLAM0015111	42.06773	-121.45246	Yes		Yes		Yes
KLAM0015114	42.02462	-121.34467	Yes		Yes	Yes	Yes
KLAM0015129	42.04902	-121.23164	Yes		Yes		Yes
KLAM0015130	42.02308	-121.20963	Yes		Yes	Yes	Yes
KLAM0016807	42.17060	-121.57751				Yes	
KLAM0050168	42.05372	-121.38868	Yes		Yes		Yes
KLAM0050318	42.19678	-121.40116				Yes	
KLAM0050341	42.25484	-121.55148	Yes		Yes		Yes
KLAM0050445	42.33140	-121.68865	Yes		Yes		Yes
KLAM0050464	42.08161	-121.73280	Yes		Yes		Yes
KLAM0050493	42.25880	-121.64381				Yes	
KLAM0050623	42.12557	-121.51232	Yes		Yes		Yes
KLAM0050763	42.00423	-121.33961	Yes		Yes		Yes
KLAM0050934	42.30009	-121.44923				Yes	
KLAM0051034	42.28297	-121.46384	Yes		Yes		Yes
KLAM0051131	42.14012	-121.48693				Yes	
KLAM0051157	42.04970	-121.73849	Yes	NOFM			Yes
KLAM0051179	42.30413	-121.45770	Yes		Yes		Yes
KLAM0051231	42.12758	-121.80924	Yes		Yes		Yes
KLAM0051602	42.05194	-121.43764	Yes		Yes	Yes	Yes
KLAM0051611	42.03169	-121.41851	Yes		Yes	Yes	Yes
KLAM0051612	42.01389	-121.38032	Yes		Yes	Yes	Yes
KLAM0051675	42.20280	-121.81589	Yes		Yes		Yes
KLAM0051783	42.15611	-121.86282	Yes	NOFM			Yes
KLAM0051795	42.06593	-121.46786				Yes	
KLAM0051920	42.17678	-121.33741	Yes		Yes	Yes	Yes
KLAM0051922	42.19834	-121.39697				Yes	
KLAM0052096	42.15068	-121.26145				Yes	
KLAM0052194	42.05307	-121.44280				Yes	
KLAM0052204	42.15068	-121.26145				Yes	
KLAM0052633	42.19499	-121.38919	Yes		Yes		Yes
KLAM0052646	42.03853	-121.53749	Yes		Yes		Yes
KLAM0052647	42.07144	-121.67847	Yes		Yes		Yes
KLAM0052650	42.07693	-121.71848	Yes		Yes		Yes
KLAM0052651	42.07681	-121.72156	Yes		Yes		Yes
KLAM0052686	42.22194	-121.73357	Yes		Yes		Yes
KLAM0052697	42.10004	-121.67088	Yes		Yes	Yes	Yes
KLAM0052701	42.14625	-121.26729	Yes		Yes		Yes
KLAM0052703	42.18216	-121.66176	Yes		Yes		Yes

Well ID	*Latitude*	*Longitude*	*Flowmeter*	*Flowmeter Status*	*Flowmeter Analyzed*	*Water Level Well*	*Permitted Well**
KLAM0052706	42.04101	-121.46313	Yes		Yes	Yes	Yes
KLAM0052711	42.05684	-121.66549	Yes		Yes		Yes
KLAM0052759	42.04244	-121.46340	Yes		Yes		Yes
KLAM0052761	42.02853	-121.53153	Yes		Yes	Yes	Yes
KLAM0052765	42.04958	-121.42545	Yes	NOFM			Yes
KLAM0052776	42.15176	-121.76161	Yes		Yes		Yes
KLAM0052778	42.15278	-121.55685	Yes		Yes		Yes
KLAM0052787	42.13082	-121.91018	Yes		Yes		Yes
KLAM0052790	42.05363	-121.53468	Yes		Yes	Yes	Yes
KLAM0052795	42.01514	-121.51236	Yes		Yes	Yes	Yes
KLAM0052797	42.08256	-121.70938	Yes		Yes	Yes	Yes
KLAM0052806	42.17599	-121.52341	Yes		Yes		Yes
KLAM0052816	42.14210	-121.68459	Yes	NOAC	Yes		Yes
KLAM0052817	42.11553	-121.72770	Yes		Yes		Yes
KLAM0052818	42.15557	-121.64922	Yes		Yes		Yes
KLAM0052824	42.09691	-121.71357	Yes		Yes	Yes	Yes
KLAM0052825	42.11840	-121.71954	Yes		Yes	Yes	Yes
KLAM0052830	42.09537	-121.70064	Yes		Yes	Yes	Yes
KLAM0052831	42.12726	-121.73470	Yes		Yes		Yes
KLAM0052835	42.22250	-121.73942	Yes		Yes		Yes
KLAM0052864	42.14303	-121.87657				Yes	
KLAM0052910	42.05941	-121.57561	Yes		Yes	Yes	Yes
KLAM0052911	42.16206	-121.55358	Yes		Yes		Yes
KLAM0052916	42.10650	-121.78603	Yes		Yes		Yes
KLAM0052918	42.12187	-121.51208	Yes		Yes		Yes
KLAM0052923	42.07536	-121.71487	Yes		Yes	Yes	Yes
KLAM0052925	42.12925	-121.74630	Yes		Yes		Yes
KLAM0052932	42.05699	-121.60048	Yes		Yes		Yes
KLAM0052935	42.00589	-121.39327	Yes		Yes		Yes
KLAM0052941	42.13115	-121.74225	Yes		Yes		Yes
KLAM0052942	42.03994	-121.38419	Yes	NOFM			Yes
KLAM0052964	42.00831	-121.37933	Yes		Yes		Yes
KLAM0052970	42.10981	-121.79943	Yes		Yes	Yes	Yes
KLAM0052972	42.02394	-121.53203	Yes		Yes		Yes
KLAM0052973	42.10448	-121.66775	Yes		Yes	Yes	Yes
KLAM0053043	42.02046	-121.56759	Yes		Yes	Yes	Yes
KLAM0053045	42.00128	-121.55492				Yes	
KLAM0053080	42.11816	-121.51246	Yes		Yes		Yes
KLAM0053137	42.08116	-121.73418	Yes		Yes		Yes
KLAM0053142	42.14894	-121.75733	Yes		Yes	Yes	Yes
KLAM0053144	42.14223	-121.64782	Yes	NOAC			

Well ID	*Latitude*	*Longitude*	*Flowmeter*	*Flowmeter Status*	*Flowmeter Analyzed*	*Water Level Well*	*Permitted Well**
KLAM0053188	42.15917	-121.77718	Yes		Yes		Yes
KLAM0053201	42.01830	-121.51177	Yes		Yes		Yes
KLAM0053206	42.16525	-121.72321	Yes	NOFM	Yes		Yes
KLAM0053209	42.09983	-121.66826				Yes	
KLAM0053234	42.14041	-121.77180	Yes		Yes		Yes
KLAM0053250	42.00540	-121.40815	Yes		Yes		Yes
KLAM0053269	42.02060	-121.50263	Yes		Yes		Yes
KLAM0053320	42.14485	-121.87571	Yes		Yes		Yes
KLAM0053340	42.01901	-121.34638	Yes		Yes		Yes
KLAM0053531	42.14878	-121.75732				Yes	
KLAM0053571	42.14446	-121.87497	Yes		Yes		Yes
KLAM0053717	42.05298	-121.59066	Yes		Yes	Yes	Yes
KLAM0053732	42.14872	-121.75740	Yes		Yes		Yes
KLAM0053737	42.14248	-121.63093	Yes		Yes		Yes
KLAM0053738	42.03145	-121.37374	Yes		Yes		Yes
KLAM0053747	42.04070	-121.55583	Yes		Yes		Yes
KLAM0053755	42.19130	-121.67525	Yes		Yes	Yes	Yes
KLAM0053757	42.03174	-121.40837	Yes		Yes		Yes
KLAM0053758	42.02848	-121.49006	Yes		Yes		Yes
KLAM0053771	42.09584	-121.78937				Yes	
KLAM0053778	42.07815	-121.87776	Yes		Yes	Yes	Yes
KLAM0053779	42.16845	-121.51312	Yes		Yes		Yes
KLAM0053792	42.04593	-121.46021	Yes		Yes		Yes
KLAM0053936	42.07223	-121.69290	Yes		Yes		Yes
KLAM0053940	42.12601	-121.78265	Yes		Yes	Yes	Yes
KLAM0053953	42.19446	-121.32639	Yes	NOFM			
KLAM0054078	42.17725	-121.65910	Yes		Yes		Yes
KLAM0054088	42.16690	-121.72236				Yes	
KLAM0054337	42.23019	-121.86172	Yes		Yes	Yes	Yes
KLAM0054529	42.13818	-121.64240				Yes	
KLAM0054561	42.09701	-121.69792	Yes		Yes		Yes
KLAM0054829	42.07997	-121.68855	Yes		Yes		Yes
KLAM0055311	42.11877	-121.67880	Yes	NOAC			Yes
KLAM0055747	42.04890	-121.74200	Yes		Yes		Yes
KLAM0055767	42.00225	-121.56071	Yes	NEW			Yes
KLAM0056125	42.09707	-121.66419	Yes		Yes		
KLAM0056330	42.05485	-121.53652	Yes		Yes		
KLAM0056425	42.02915	-121.50158	Yes		Yes		Yes
KLAM0056426	42.02755	-121.48240	Yes		Yes		Yes
KLAM0056490	42.13135	-121.76683	Yes	NOAC	Yes		Yes
KLAM0056562	42.01137	-121.66295	Yes	NOFM			Yes

Well ID	*Latitude*	*Longitude*	*Flowmeter*	*Flowmeter Status*	*Flowmeter Analyzed*	*Water Level Well*	*Permitted Well**
KLAM0057323	42.01622	-121.65276	Yes		Yes		Yes
KLAM0057366	42.01654	-121.49259	Yes		Yes		Yes
KLAM0057367	42.14780	-121.54483	Yes		Yes		Yes
KLAM0057371	42.03296	-121.46827	Yes		Yes		Yes
KLAM0057372	42.04586	-121.44304	Yes		Yes	Yes	Yes
KLAM0057387	42.00173	-121.52201	Yes		Yes		Yes
KLAM0057403	42.02579	-121.50804	Yes		Yes		Yes
KLAM0057409	42.06301	-121.43782	Yes		Yes		Yes
KLAM0057410	42.00167	-121.58431	Yes		Yes		Yes
KLAM0057412	42.11821	-121.71939				Yes	Yes
KLAM0057431	42.03778	-121.52647	Yes		Yes		Yes
KLAM0057529	42.01648	-121.50416	Yes				Yes
KLAM0057564	42.02971	-121.89687	Yes		Yes		Yes
KLAM0057565	42.03522	-121.89919	Yes		Yes		Yes
KLAM0057566	42.26620	-121.46234	Yes	NOFM			Yes
KLAM0057567	42.23451	-121.50585	Yes	NOFM			Yes
KLAM0057568	42.22863	-121.49576	Yes	NOFM			Yes
KLAM0057569	42.22867	-121.49328	Yes	NOFM			Yes
KLAM0057660	42.07137	-121.25644	Yes		Yes		Yes
KLAM0058135	42.11565	-121.81370	Yes		Yes		Yes
KLAM0058142	42.02765	-121.39361	Yes		Yes		Yes
KLAM0058146	42.03628	-121.35830	Yes		Yes		
KLAM0058293	42.00139	-121.55125	Yes		Yes		Yes
KLAM0058533	42.02744	-121.63742	Yes		Yes		Yes
KLAM0058594	42.01600	-121.50197	Yes		Yes		Yes
KLAM0058839	42.11003	-121.19410	Yes		Yes		Yes
LAKE0051215	42.08970	-121.67610	Yes		Yes	Yes	Yes

*** Permitted Wells includes wells on recent drought permits**

Flowmeter Status	
BRK	Flowmeter Broken or possibly broken
NEW	New flowmeter or different flowmeter from last visit
NOAC	No access to well or flowmeter
NOFM	No flowmeter located
SHAR	Shared flowmeter between > 1 well