Groundwater Application Review Summary Form

Application # G- 18994

GW Reviewer Grayson Fish Date Review Completed: 8/9/2023

Summary of GW Availability and Injury Review:

☐ Groundwater for the proposed use is either over appropriated, will not likely be available in the amounts requested without injury to prior water rights, OR will not likely be available within the capacity of the groundwater resource per Section B of the attached review form.

Summary of Potential for Substantial Interference Review:

☐ There is the potential for substantial interference per Section C of the attached review form.

Summary of Well Construction Assessment:

☒ The well does not appear to meet current well construction standards per Section D of the attached review form. Route through Well Construction and Compliance Section.

This is only a summary. Documentation is attached and should be read thoroughly to understand the basis for determinations and for conditions that may be necessary for a permit (if one is issued).

WATER RESOURCES DEPARTMENT

MEMO **8/9/2023**

TO: **Application** G-**18994**

FROM: **GW:** **Grayson Fish**
(Reviewer's Name)

SUBJECT: Scenic Waterway Interference Evaluation

☒ **YES**
☐ **NO**

The source of appropriation is hydraulically connected to a State Scenic Waterway or its tributaries

☒ **YES**
☐ **NO**

Use the Scenic Waterway Condition (Condition 7J)

☒ Per ORS 390.835, the Groundwater Section is **able** to calculate ground water interference with surface water that contributes to a Scenic Waterway. The calculated interference is distributed below
See attached memo "*Analysis of Groundwater Pumping Impacts on Scenic Waterway Flows*" dated: February 19, 2013

☐ Per ORS 390.835, the Groundwater Section is **unable** to calculate ground water interference with surface water that contributes to a scenic waterway; **therefore, the Department is unable to find that there is a preponderance of evidence that the proposed use will measurably reduce the surface water flows necessary to maintain the free-flowing character of a scenic waterway**

DISTRIBUTION OF INTERFERENCE
Calculate the percentage of consumptive use by month and fill in the table below. If interference cannot be calculated, per criteria in 390.835, do not fill in the table but check the "unable" option above, thus informing Water Rights that the Department is *unable to make a Preponderance of Evidence finding.*

Exercise of this permit is calculated to reduce monthly flows in Klamath Scenic Waterway by the following amounts expressed as a proportion of the consumptive use by which surface water flow is reduced.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
See Attached Memo											

PUBLIC INTEREST REVIEW FOR GROUNDWATER APPLICATIONS

TO: Water Rights Section Date **8/9/2023**

FROM: Groundwater Section **Grayson Fish**
Reviewer's Name

SUBJECT: Application G- **18994** Supersedes review of 9/17/2020
Date of Review(s)

PUBLIC INTEREST PRESUMPTION; GROUNDWATER

OAR 690-310-130 (1) *The Department shall presume that a proposed groundwater use will ensure the preservation of the public welfare, safety and health as described in ORS 537.525.* Department staff review groundwater applications under OAR 690-310-140 to determine whether the presumption is established. OAR 690-310-140 allows the proposed use be modified or conditioned to meet the presumption criteria. **This review is based upon available information and agency policies in place at the time of evaluation**.

A. GENERAL INFORMATION: Applicant's Name: **John Bourdet, Ken Fry, Josanne Pierce** County: **Klamath**

A1. Applicant(s) seek(s) 2.79 cfs from 1 well(s) in the Klamath Basin, Sprague River subbasin

A2. Proposed use: Irrigation (223.3 acres) Seasonality: March 1 – October 31 (244 d)

A3. Well and aquifer data **(attach and number logs for existing wells; mark proposed wells as such under logid)**:

Well	Logid	Applicant's Well #	Proposed Aquifer*	Proposed Rate(cfs)	Location (T/R-S QQ-Q)	Location, metes and bounds, e.g. 2250' N, 1200' E fr NW cor S 36
1	KLAM0001501	1	Bedrock	2.79	35S-10E-21 NENW	1270 ft S, 2620 ft E of NW cor S 21

* Alluvium, CRB, Bedrock

Well	Well Elev ft msl	First Water ft bls	SWL ft bls	SWL Date	Well Depth (ft)	Seal Interval (ft)	Casing Intervals (ft)	Liner Intervals (ft)	Perforations Or Screens (ft)	Well Yield (gpm)	Draw Down (ft)	Test Type
1	4338		63	10/10/1960	925	39	+1-39	-	-	2900		

Use data from application for proposed wells.

A4. **Comments:**

A5. ☐ **Provisions of the** Basin rules relative to the development, classification and/or management of groundwater hydraulically connected to surface water ☐ **are**, *or* ☐ **are not**, activated by this application. (Not all basin rules contain such provisions.)
Comments: There are no basin rules for the Klamath Basin

A6. ☐ **Well(s) #** , , , , , tap(s) an aquifer limited by an administrative restriction.
Name of administrative area:
Comments:

B. GROUNDWATER AVAILABILITY CONSIDERATIONS, OAR 690-310-130, 400-010, 410-0070

B1. **Based upon available data**, I have determined that groundwater* for the proposed use:

a. ☐ **is** over appropriated, ☒ **is not** over appropriated, *or* ☐ **cannot be determined to be** over appropriated during any period of the proposed use. * This finding is limited to the groundwater portion of the over-appropriation determination as prescribed in OAR 690-310-130;

b. ☐ **will not** *or* ☐ **will** likely be available in the amounts requested without injury to prior water rights. * This finding is limited to the groundwater portion of the injury determination as prescribed in OAR 690-310-130;

c. ☐ **will not** *or* ☐ **will** likely to be available within the capacity of the groundwater resource; or

d. ☒ **will, if properly conditioned**, avoid injury to existing groundwater rights or to the groundwater resource:

i. ☒ The permit should contain condition #(s)
7N (Annual SWL); 7T (Measuring Tube); Large Water-Use Reporting;

ii. ☐ The permit should be conditioned as indicated in item 2 below.

iii. ☐ The permit should contain special condition(s) as indicated in item 3 below;

B2. a. ☐ **Condition** to allow groundwater production from no deeper than _____ ft. below land surface;

b. ☒ **Condition** to allow groundwater production from no shallower than **300** ft. below land surface;

c. ☐ **Condition** to allow groundwater production only from the _____ groundwater reservoir between approximately _____ ft. and _____ ft. below land surface;

d. ☒ **Well reconstruction** is necessary to accomplish one or more of the above conditions. The problems that are likely to occur with this use and without reconstructing are cited below. Without reconstruction, I recommend withholding issuance of the permit until evidence of well reconstruction is filed with the Department and approved by the Groundwater Section.

Describe injury –as related to water availability– that is likely to occur without well reconstruction (interference w/ senior water rights, not within the capacity of the resource, etc): _____

B3. **Groundwater availability remarks:** The applicant's proposed POA is an existing well (KLAM0001501) that was drilled in 1960. The total depth of the well is 925 and constructed with a 39 ft seal depth and 39 ft casing depth. The reported yield on the well is 2900 gpm. All but one of the other wells in the vicinity of the proposed POA are less than 500 ft deep and those wells report yields less than or equal to 100 gpm. Only one other well reports a yield of over 100 gpm (KLAM0055530, reported yield = 1000 gpm) and this well is 1080 ft deep. It is likely that these two deeper wells (KLAM0001501 and KLAM0055530) are producing from a separate aquifer than most of the wells in the area. The proposed POA's well log describes the lithology as "clay" to 85 ft then mixed shale and basalt to the total depth, with "shale" being the dominant lithology between 85 and 455 ft and "basalt" being the dominant lithology between 455 ft and the total well depth. Most other well logs (wells less than 500 ft deep) report mixed sedimentary material (e.g., clay, shale) and only rarely report "basalt". The purpose of condition in B2(b) above is to limit comingling of the deep, productive "basalt" zones with the shallower aquifer zones. It is possible that there are multiple, distinct aquifer zones between 300 ft and the total depth of the proposed POA but there is no obvious evidence of that. As such, the 300 ft production condition is a minimum construction condition.

Groundwater levels observed in nearby wells KLAM 1434, KLAM 1499, KLAM 1543 and KLAM 58165 do show evidence of declines. For example, KLAM 1499 indicates that groundwater levels in that well have declined approximately 12 feet between the 1980's and present day. KLAM 1543 shows a declining trend which appears to follow precipitation trends starting after 2017 and beginning to level off in 2023 with 8 feet of decline observed over that period. However, available groundwater level data in the noted wells do not display excessive declines or excessively declining trends, therefore there is not a preponderance of evidence that groundwater of the target aquifer is over appropriated. Similarly, there is not a

preponderance of evidence that the proposed use would not be within the capacity of the resource and so conditions in B1(d) are recommended.

C. GROUNDWATER/SURFACE WATER CONSIDERATIONS, OAR 690-09-040

C1. **690-09-040 (1):** Evaluation of aquifer confinement:

Well	Aquifer or Proposed Aquifer	Confined	Unconfined
1	**Basalt**	☒	☒
2		☐	☐

Basis for aquifer confinement evaluation: The deeper basalt zones within the aquifer system are very likely confined by the mixed clay/shale sediments that overlay them. This finding assumes the basalt zones are the main production zones of the well.

C2. **690-09-040 (2) (3):** Evaluation of distance to, and hydraulic connection with, surface water sources. All wells located a horizontal distance less than ¼ mile from a surface water source that produce water from an unconfined aquifer shall be assumed to be hydraulically connected to the surface water source. Include in this table any streams located beyond one mile that are evaluated for PSI.

Well	SW #	Surface Water Name	GW Elev ft msl	SW Elev ft msl	Distance (ft)	Hydraulically Connected? YES	NO	ASSUMED	Potential for Subst. Interfer. Assumed? YES	NO
1	**1**	**Sprague River**	**4275**	**4285-4295**	**12,350**	☒	☐	☐	☐	☒
						☐	☐	☐	☐	☐

Basis for aquifer hydraulic connection evaluation: Groundwater elevations are similar to surface water elevations implying water can move between the aquifer and surface water; additionally, there are large spring complexes in the Sprague River valley implying significant contributions to the river from groundwater discharge. The distance in the above table is to the nearest point on the Sprague River.

Water Availability Basin the well(s) are located within:
SPRAUGE R > WILLIAMSON R – AT LONE PINE (ID# 70805)

C3a. **690-09-040 (4):** Evaluation of stream impacts for each well that has been determined or assumed to be **hydraulically connected and less than 1 mile** from a surface water (SW) source. Limit evaluation to instream rights and minimum stream flows that are pertinent to that SW source, not lower SW sources to which the stream under evaluation is tributary. Compare the requested rate against the 1% of 80% *natural* flow for the pertinent Water Availability Basin (WAB). If Q is not distributed by well, use full rate for each well. Any checked ☒ box indicates the well is assumed to have the potential to cause PSI.

Well	SW #	Well < ¼ mile?	Qw > 5 cfs?	Instream Water Right ID	Instream Water Right Q (cfs)	Qw > 1% ISWR?	80% Natural Flow (cfs)	Qw > 1% of 80% Natural Flow?	Interference @ 30 days (%)	Potential for Subst. Interfer. Assumed?
		☐	☐	**N/A**		☐		☐		☐
		☐	☐	**N/A**		☐		☐		☐

Comments:

C3b. **690-09-040 (4):** Evaluation of stream impacts by total appropriation for all wells determined or assumed to be **hydraulically connected and less than 1 mile** from a surface water source. **Complete only if Q is distributed among wells**. Otherwise same evaluation and limitations apply as in C3a above.

	SW #		Qw > 5 cfs?	Instream Water Right ID	Instream Water Right Q (cfs)	Qw > 1% ISWR?	80% Natural Flow (cfs)	Qw > 1% of 80% Natural Flow?	Interference @ 30 days (%)	Potential for Subst. Interfer. Assumed?
			☐			☐		☐		☐
			☐			☐		☐		☐

Comments:

C4a. **690-09-040 (5):** Estimated impacts on **hydraulically connected surface water sources greater than one mile** as a percentage of the proposed pumping rate. Limit evaluation to the effects that will occur up to one year after pumping begins. This table encompasses the considerations required by 09-040 (5)(a), (b), (c) and (d), which are not included on this form. Use additional sheets if calculated flows from more than one WAB are required.

Non-Distributed Wells													
Well	SW#	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	**1**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**	**< 1 %**
Well Q as CFS		**0**	**0**	**2.79**	**2.79**	**2.79**	**2.79**	**2.79**	**2.79**	**2.79**	**2.79**	**0**	**0**
Interference CFS		**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**
Distributed Wells													
Well	SW#	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		%	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Well Q as CFS													
Interference CFS													
		%	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Well Q as CFS													
Interference CFS													
(A) = Total Interf.		**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**	**< 0.03**
(B) = 80 % Nat. Q		**264**	**307**	**407**	**576**	**655**	**389**	**207**	**169**	**188**	**223**	**234**	**253**
(C) = 1 % Nat. Q		**2.64**	**3.07**	**4.07**	**5.76**	**6.55**	**3.89**	**2.07**	**1.69**	**1.88**	**2.23**	**2.34**	**2.53**
(D) = (A) > (C)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(E) = (A / B) x 100		**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**	**<< 1%**

(A) = total interference as CFS; (B) = WAB calculated natural flow at 80% exceed. as CFS; (C) = 1% of calculated natural flow at 80% exceed. as CFS; (D) = highlight the checkmark for each month where (A) is greater than (C); (E) = total interference divided by 80% flow as percentage.

Comments: Stream-depletion was estimated using the Hunt-2003 analytical model and parameter values taken from the OWRD Pump Test database, published reports, or values in the expected range for the given material. Given the large distance between the proposed POA and the stream, along with the thickness of the overlying confining layer, low values of stream-depletion is expected.

C4b. **690-09-040 (5) (b) The potential to impair or detrimentally affect the public interest is to be determined by the Water Rights Section.**

C5. ☐ **If properly conditioned**, the surface water source(s) can be adequately protected from interference, and/or groundwater use under this permit can be regulated if it is found to substantially interfere with surface water:

i. ☐ The permit should contain condition #(s)_____;

ii. ☐ The permit should contain special condition(s) as indicated in "Remarks" below;

C6. **SW / GW Remarks and Conditions:** The applicant's proposed POA would be producing from an aquifer system that has been found to the hydraulically-connected to surface water – specifically the Sprague River – at a distance of over 1 mile. Previous investigations by the Department have established that groundwater pumping by wells in the Sprague River basin has a cumulative effect on surface water flows. However, this review is unable to find a preponderance of evidence that the proposed use will have the Potential for Substantial Interference with surface water per OAR 690-0090.

References Used:

Forcella, L. S. 1982. Whiskey Creek Aquifer Test, Klamath County, Oregon. Oregon Water Resources Department. Miscellaneous Report. April 23, 1982. 67p

Gannett, M. W., B. J. Wagner, and K. E. Lite. 2012. *Groundwater Simulation and Management Models for the Upper Klamath Basin, Oregon and California*. USGS Scientific Investigations report 2012-5062.

Gannett, M. W., K. E. Lite, J. L. LaMarche, B. J. Fisher, and D. J. Polette. 2007. *Ground-water Hydrology of the Upper Klamath Basin, Oregon and California*. USGS Scientific Investigations Report 2007-5050

Hunt, B. 2003. *Unsteady Stream Depletion when Pumping from a Semiconfined Aquifer*. Journal of Hydrologic Engineering. Vol 8(1), pp 12-19

Leonard, A. R. and A. B. Harris. 1974. *Ground Water in Selected Areas in the Klamath Basin, Oregon*. Ground Water Report No. 21. Oregon State Engineer

Sherrod, D. R., and L. B. G. Pickthorn. 1992. *Geologic Map of the West Half of the Klamath Falls 1° by 2° Quadrangle, South-Central Oregon*. USGS Miscellaneous Investigations Series Map I-2182.

OWRD Well Log Database – Accessed 08/9/2023

D. WELL CONSTRUCTION, OAR 690-200

D1. **Well #**: 1 **Logid:** KLAM0001501

D2. **THE WELL does not appear to meet current well construction standards based upon:**

a. ☒ review of the well log;

b. ☐ field inspection by _____;

c. ☐ report of CWRE _____;

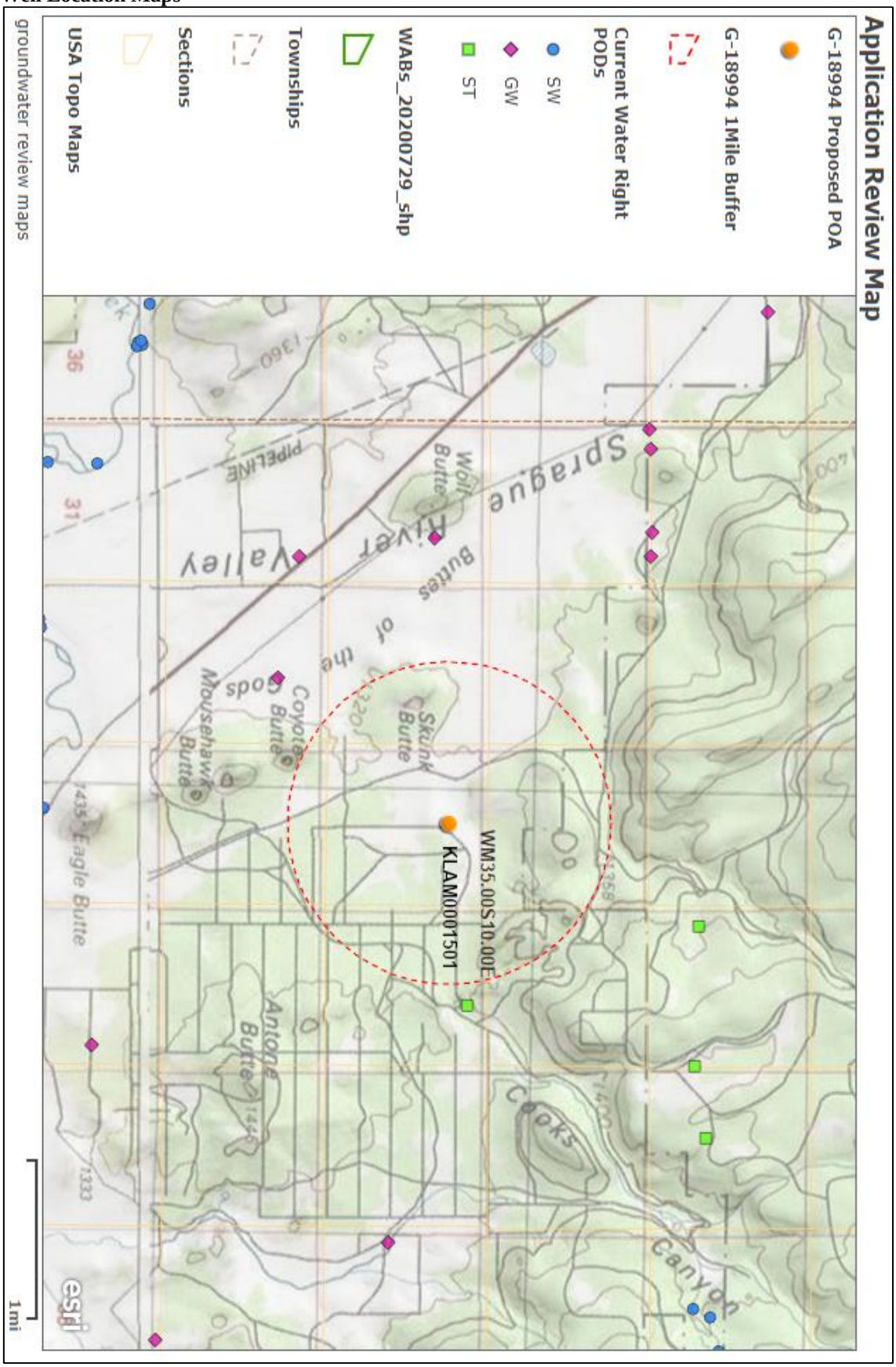
d. ☐ other: (specify) _____

D3. **THE WELL construction deficiency or other comment is described as follows:**

Seal depth appears to be insufficient to eliminate commingling between aquifers.
This finding has been retained from the initial 2020 review for the sake of consistence with established procedures of the time. Regardless, well construction should be reviewed by the Well Construction and Compliance Section.

D4. ☒ **Route to the Well Construction and Compliance Section for a review of existing well construction.**

Well Location Maps



Water Availability Tables

Water Availability Analysis
Detailed Reports

SPRAGUE R > WILLIAMSON R - AT LONE PINE
KLAMATH BASIN
Water Availability as of 8/9/2023

Watershed ID #: 70805 (Map)
Date: 8/9/2023

Exceedance Level: 80%
Time: 11:57 AM

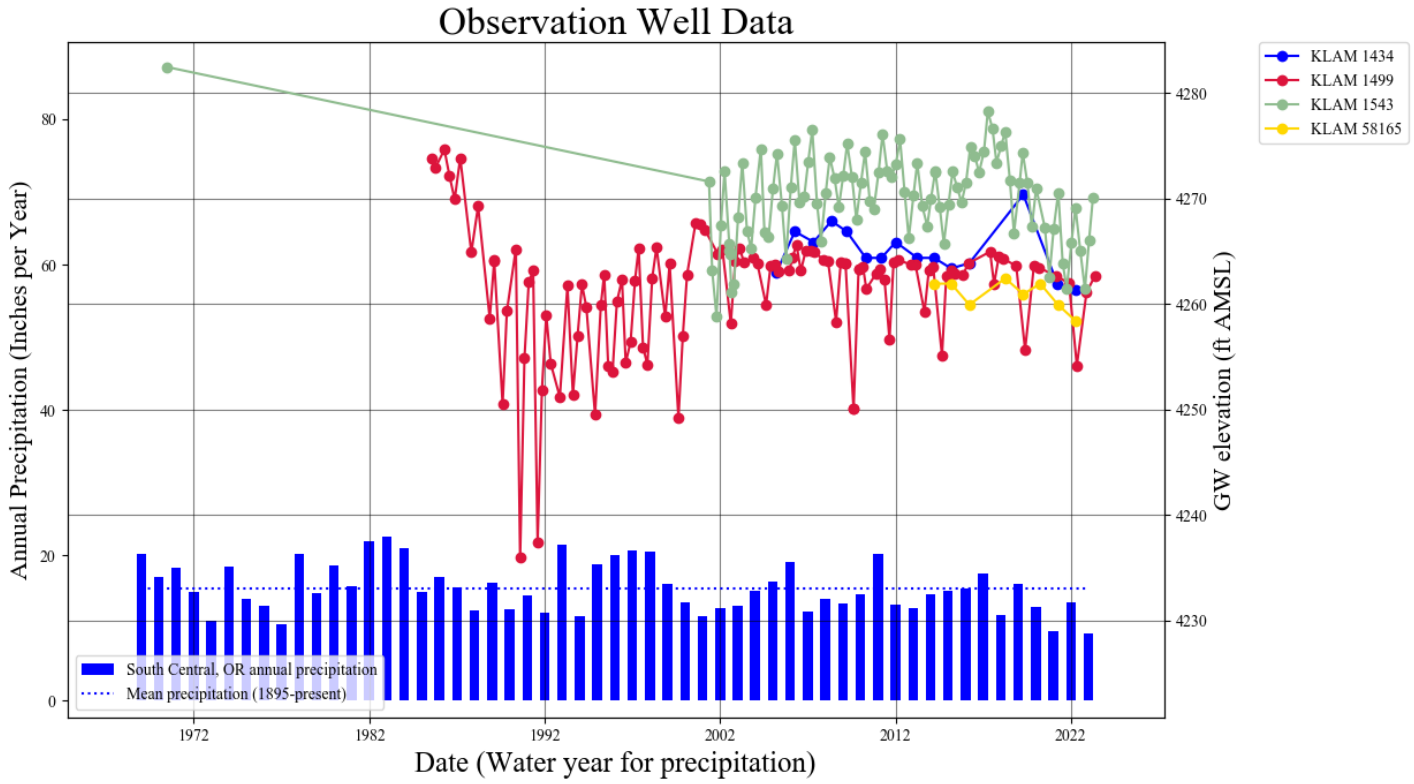
Water Availability Calculation | Consumptive Uses and Storages | Instream Flow Requirements | Reservations | Water Rights | Watershed Characteristics

Water Availability Calculation

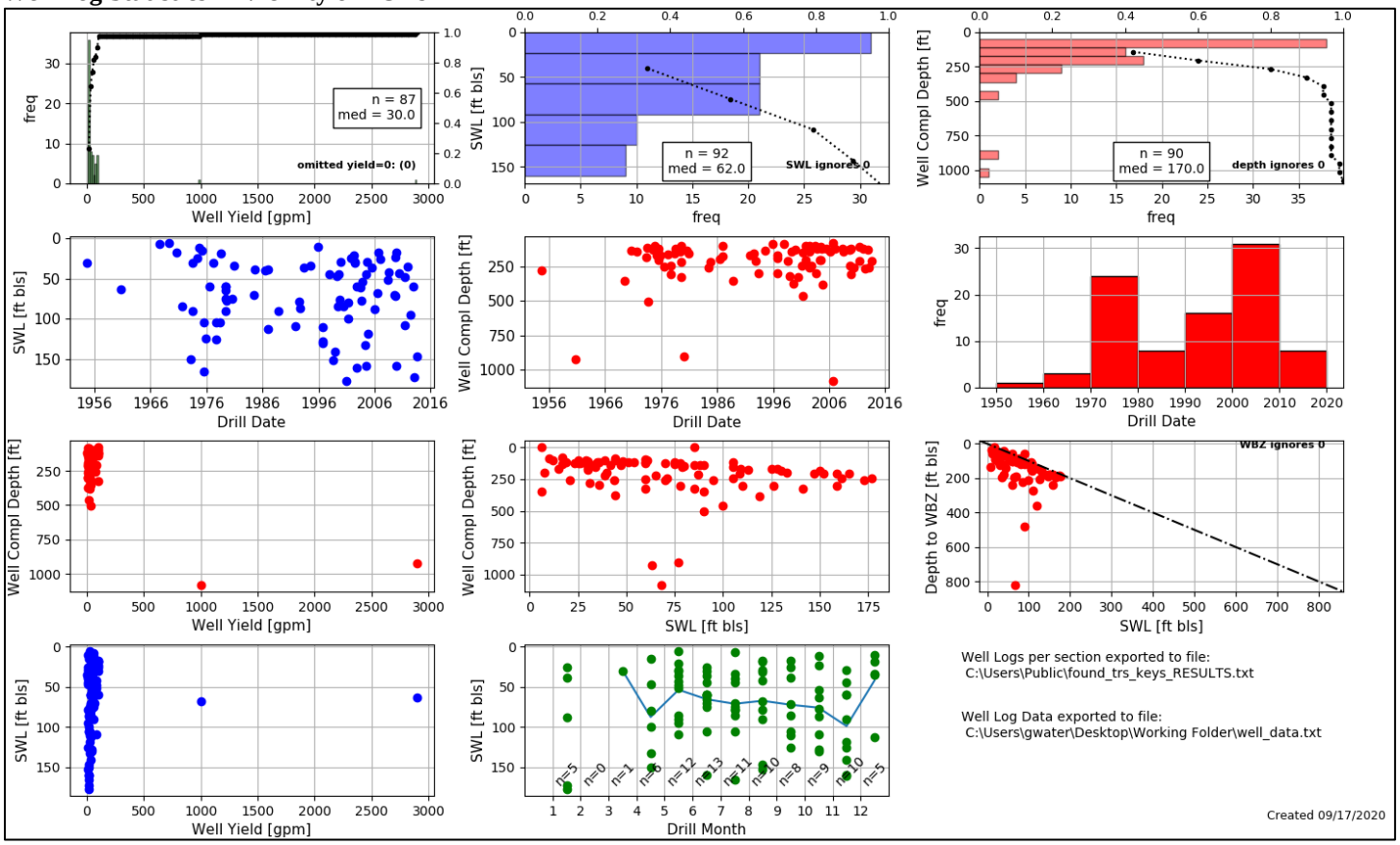
Monthly Streamflow in Cubic Feet per Second
Annual Volume at 50% Exceedance in Acre-Feet

Month	Natural Stream Flow	Consumptive Uses and Storages	Expected Stream Flow	Reserved Stream Flow	Instream Flow Requirement	Net Water Available
JAN	264.00	5.27	259.00	0.00	353.00	-94.30
FEB	307.00	7.14	300.00	0.00	450.00	-150.00
MAR	407.00	30.90	376.00	0.00	479.00	-103.00
APR	576.00	57.00	519.00	0.00	726.00	-207.00
MAY	655.00	111.00	544.00	0.00	818.00	-274.00
JUN	389.00	135.00	254.00	0.00	450.00	-196.00
JUL	207.00	84.20	123.00	0.00	291.00	-168.00
AUG	169.00	50.20	119.00	0.00	222.00	-103.00
SEP	188.00	47.20	141.00	0.00	241.00	-100.00
OCT	223.00	32.50	191.00	0.00	275.00	-84.50
NOV	243.00	4.69	238.00	0.00	306.00	-67.70
DEC	253.00	5.14	248.00	0.00	337.00	-89.10
ANN	337,000.00	34,500.00	303,000.00	0.00	298,000.00	31,500.00

Water-Level Measurements in Nearby Wells



Well Log Statistics in Vicinity of POAs



Stream-depletion Modeling Results

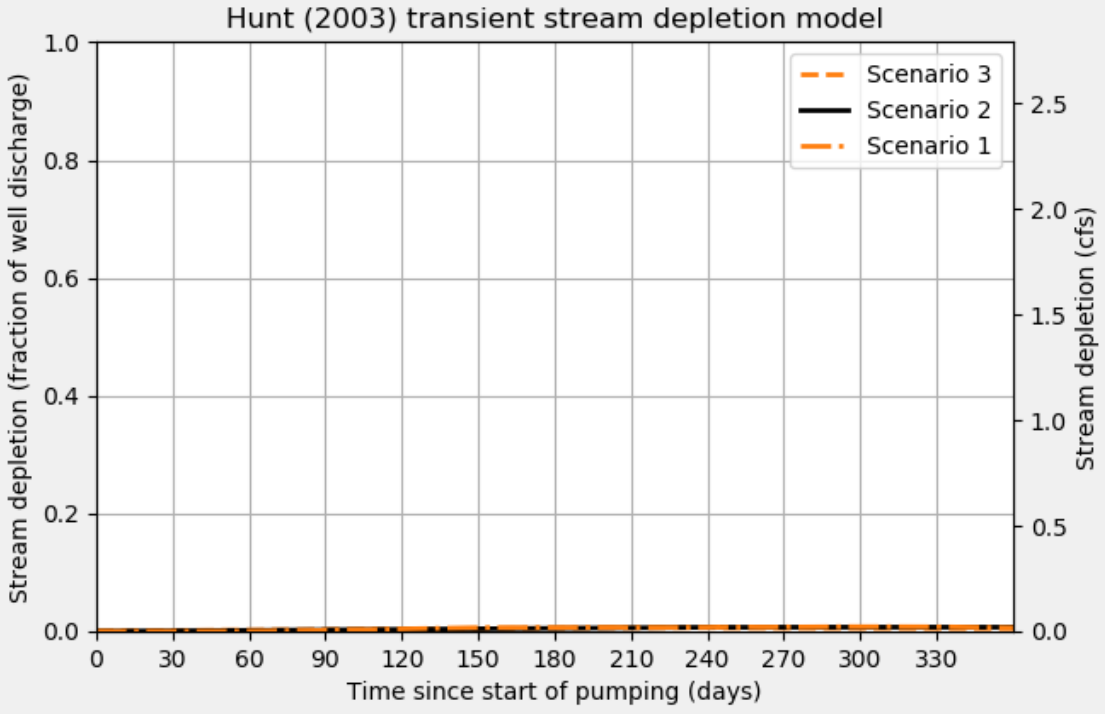
PyHunt stream depletion analysis tool

Application type:	G
Application number:	18994
Well number:	1
Stream Number:	1
Pumping rate (cfs):	2.79
Pumping duration (days):	244.0
Pumping start month number (3=March)	3.0

Parameter	Symbol	Scenario 1	Scenario 2	Scenario 3	Units
Distance from well to stream	a	12350	12350	12350	ft
Aquifer transmissivity	T	10000.0	50000	100000	ft2/day
Aquifer storativity	S	1e-4	1e-5	1e-6	-
Aquitard vertical hydraulic conductivity	Kva	0.5	0.1	0.05	ft/day
Aquitard saturated thickness	ba	30	30	30	ft
Aquitard thickness below stream	babs	30	30	30	ft
Aquitard specific yield	Sya	0.2	0.1	0.05	-
Stream width	ws	50	50	50	ft

Stream depletion for Scenario 2:

Days	10	330	360	30	60	90	120	150	180	210	240	270	300
Depletion (%)	0	1	1	0	0	0	0	0	1	1	1	1	1
Depletion (cfs)	0.00	0.02	0.02	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02



Appendix Memo: Analysis of Groundwater Pumping Impacts on Scenic Waterway Flows

State of Oregon
Water Resources Department

Memorandum

To: Barry Norris – Administrator, Technical Services Division
Dwight French – Administrator, Waterights Division
Tom Paul – Deputy Director
Doug Woodcock – Administrator, Field Services Division

From: Ivan Gall – Manager, Groundwater Section

Date: February 19, 2013

Subject: Analysis of Groundwater Pumping Impacts on Klamath Scenic Waterway Flows

In 1971 the Oregon Legislature created the Scenic Waterway Act, codified by Oregon Revised Statutes 390.805 to 390.925, to preserve for the benefit of the public Waldo Lake and selected parts of the state's free-flowing rivers. The Klamath Scenic Waterway was part of the Act and includes the Klamath River from the John Boyle Dam powerhouse downstream to the Oregon-California border. Under the Act, the Water Resources Commission is allowed to allocate small amounts of surface water for human consumption and livestock watering, as long as issuing the water right does not significantly impair the free-flowing character of these waters in quantities necessary for recreation, fish and wildlife, and the amount allocated may not exceed a cumulative total of one percent of the average daily flow or one cubic foot per second (cfs), whichever is less.

In 1995 the Scenic Waterway Act was modified to address the impact of groundwater uses that, based upon a preponderance of evidence, would measurably reduce the surface water flows within a scenic waterway. "Measurably reduce" means that the use authorized will individually or cumulatively reduce surface water flows within the scenic waterway in excess of a combined cumulative total of one percent of the average daily flow or one cfs, whichever is less.

In 2012 the United States Geological Survey (USGS), in cooperation with OWRD and the US Bureau of Reclamation, completed groundwater flow and management models for the Upper Klamath Basin. The 2012 groundwater flow model uses generally accepted hydrogeologic methods and the relevant field data to model the cumulative effects of groundwater pumping within the Klamath Scenic Waterway, and provides a comprehensive methodology for analyzing the relevant field data necessary to determine whether the cumulative use of groundwater in the Klamath Basin will measurably reduce the surface water flow necessary to maintain the free-flowing character of the Klamath Scenic Waterway.

In September 2012 the OWRD Groundwater Section conducted two model simulations. The two simulations used the 2012 USGS flow model, incorporating groundwater permits issued (61.96 cfs) since adoption of the 1995 Scenic Waterway Act amendment up through 2004. Each simulation was run to steady-state, where inflows and outflows for that model run balanced. An evaluation of the water budgets showed that groundwater discharge to the Klamath Scenic Waterway decreased by 5.88 cfs as a result of the 61.96 cfs of groundwater uses issued between 1995 and 2004. These results indicate to the OWRD that a preponderance of evidence exists to establish that groundwater development occurring in the Upper Klamath Basin in Oregon since 1995 has "measurably reduced" surface water flows within the Klamath Scenic Waterway.

In January 2013 the OWRD Groundwater Section conducted flow model simulations to evaluate impacts to streams from pumping groundwater within the Lost River subbasin. Groundwater pumping was simulated by placing wells in the model that correspond to the center of 39 townships in the southeast part of the Klamath Basin in Oregon. Each of the simulations was run to steady-state, where inflows and outflows for that model run balanced. These results indicate that the scenic waterway is impacted by pumping groundwater in all of the townships evaluated in Oregon in the Lost River subbasin. In summary, a preponderance of evidence exists to establish that groundwater development occurring in Oregon since 1995 in the Upper Klamath Basin and Lost River subbasin has "measurably reduced" surface water flows within the Klamath Scenic Waterway.

References:

Gannett, M.W., Lite, K.E., Jr., La Marche, J.L., Fisher, B.J., and Polette, D.J., 2007. Ground-water hydrology of the upper Klamath Basin, Oregon and California: U.S. Geological Survey Scientific Investigations Report 2007-5050, 84p.

Gannett, M.W., Wagner, B.J., and Lite, K.E., Jr., 2012. Groundwater simulation and management models for the upper Klamath Basin, Oregon and California: U.S. Geological Survey Scientific Investigations Report 2012-5062, 92p.