Groundwater Level Trends in the Proposed Harney Basin Critical Groundwater Area – Summary Statistics by Subarea

Informational Report to the Division 512 Rules Advisory Committee

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Background & Introduction

Delineation of the exterior boundary of the proposed Harney Basin Critical Groundwater Area (HBCGWA) was based on the existing administrative boundary of the Greater Harney Valley Groundwater Area of Concern (GHVGAC) as defined in OAR 690-512 Malheur Lake Basin Program adopted 4/13/2016 and effective as of 4/15/2016. The GHVGAC boundary is an established and widely known administrative boundary that includes the lowland areas of the Silvies River, Silver Creek, and the Donner und Blitzen River, as well as the immediately adjacent upland slopes. The vast majority of groundwater use and areas of known groundwater level decline within the Harney Basin occur within the GHVGAC boundary.

Groundwater within the proposed HBCGWA boundary is hydraulically connected both laterally and vertically throughout the area, however, groundwater occurs in multiple hydraulically connected hydrostratigraphic units, often follows divergent or convergent flow paths, varies spatially in terms of horizontal and vertical hydraulic gradient, and is sourced from different recharge areas around the Harney Basin. As such, groundwater within the proposed HBCWGA responds variably to proximal and distant pumpage, recharge inputs, and other hydrogeologic parameters.

To effectively administer groundwater management within the HBCWGA, fifteen (15) proposed subareas were delineated at the PLSS section-scale (Figure 1). A critical groundwater area subarea is a portion of a groundwater reservoir that shares similar hydrogeologic properties and similar groundwater conditions including groundwater level elevations, seasonal and annual water level trends, and response to natural and human stresses. The subarea boundaries do not represent barriers to groundwater flow – groundwater is hydraulically connected across these boundaries. The intent of dividing a critical groundwater area into subareas is to group wells together that similarly impact the local portion of the groundwater reservoir and where reductions in groundwater pumpage, through voluntary or regulatory action, will have a timely, measurable, efficient, and similar groundwater response within that subarea.

The purpose of this informational report is to provide a summary of groundwater level trends within each of the 15 proposed subareas. Groundwater level trends are variable across the proposed HBCGWA, and variation exists within each of the 15 proposed subareas. Evaluating the relative severity of groundwater level declines within each of the 15 proposed subareas can help facilitate decision-making around prioritization of regulatory or voluntary action within the proposed HBCWGA.

This update for June 2024 supersedes the previous version that was included in the Rules Advisory Committee (RAC) packet for the Division 512 rulemaking RAC meeting #4 on November 29, 2023. This updated version includes the following updates and modifications:

- 2024 annual high measurements are included.
- The groundwater level decline rate evaluation requires a minimum of 4 static groundwater level measurements in the target date range for inclusion in the analysis.
- Additional information about the groundwater level data used for the groundwater level trends analysis is included.
- A list of wells used for the groundwater level trends analysis is included in Appendix 1.
- A list of wells identified as requiring further review, and therefore not included in the analysis is included in Appendix 2.

Groundwater Level Data

Static groundwater level measurements provide the basis for the groundwater level trend analyses described here. These groundwater level measurements are housed in the OWRD Groundwater Information System (GWIS) database. These data include static groundwater level measurements from dedicated observation wells, domestic wells, livestock wells, and irrigation wells. Groundwater level data in GWIS comes from a variety of sources including measurements made by OWRD staff, U.S. Geological Survey staff, water well drillers, and measurements reported to the Department from water rights holders as a part of the permit condition reporting program. Field data-collection procedures used by OWRD staff parallel those outlined in Groundwater Technical Procedures of the U.S. Geological Survey (Cunningham and Schalk, 2011). Data from sources other than the OWRD or the U.S. Geological Survey may not have been collected using these protocols. The Groundwater Section periodically reviews recent data collected by OWRD staff and classifies the quality and accuracy of individual data elements; however, much historic data collected by the Department has not been thoroughly reviewed. Data from outside sources is only reviewed and classified as time permits. These groundwater level data can be explored in the OWRD Groundwater Information System (GWIS).

Data review

For the purposes of the current groundwater level trend analyses, the water level records for wells across the Harney Basin were reviewed for quality and accuracy. A visual inspection of each hydrograph was performed to identify abnormal or inconsistent patterns in the water level record. Where abnormal or inconstant patterns were observed, the water level record was further evaluated to identify if measuring, reporting, or recording errors or inconsistencies were present. Examples of issues identified through this review process include:

- Wells with turbine oil causing difficulty in precise measurement.
- Wells that had been deepened, causing substantial changes in the static water level in the well.
- Wells with static water level measurements reported by numerous individuals over time, with inconsistent measuring point descriptions and heights suggesting some measurements in the record for that well likely correspond to a different well.
- Wells with measurements reported after abandonment of the well, indicating the measurements correspond to a different well.
- Wells with measurement comments suggesting the measurements correspond to a different well.
- Water levels reported by well drillers on well logs that are affected by the drilling process (i.e. not static).

In some cases, these issues could be resolved by additional review or through conversation with the individuals reporting the measurements, but in many cases, there was not sufficient documentation to resolve the issue prior to completing this water level trends analysis. Complete resolution of all issues identified was beyond the scope of this analysis. After thorough review of all available groundwater level data there were 79 wells with data covering the required period of record that were identified as needing further review and therefore were not included in this analysis (Appendix 2).

Groundwater Level Trends

Groundwater level trends for wells across the 15 proposed subareas can be evaluated to better understand how groundwater level declines vary between subareas as well as the variation that exists within an individual subarea. Two primary groundwater level trend metrics are summarized here:

1. Groundwater level decline magnitude
2. Groundwater level decline rate

For both groundwater level trend metrics there are several possible approaches to making the calculation. The groundwater level trends summarized here represent groundwater level decline magnitude calculated as the total groundwater level change from the highest measured to the most recent annual high, and groundwater level decline rate calculated as the Sen's slope (Sen, 1968), also known as the Theil-Sen estimator. Sen's slope, which is insensitive to outliers, is a robust method of determining the slope via the median of the slopes of all lines that can be drawn through the data points.

Calculating these groundwater level trend metrics requires specifying several parameters that have a significant impact on the overall results of the calculation. For example, calculation of groundwater level decline rate requires specifying the period of time over which the rate of interest will be calculated. As groundwater level decline rates in the basin have changed over time, we are most interested in calculating the decline rate over the most recent period of record, rather than calculating what the decline rate might have been between 1990 and 1995, for example. Additionally, for both groundwater level decline magnitude and groundwater level decline rate it is important to minimize the effects of seasonal variation when pumping impacts cause groundwater levels to be drawn down. To address this, only annual high groundwater level measurements are used in most cases (generally January – May). The parameters specified for the groundwater level trend metrics presented here are described below.

Groundwater Level Decline Magnitude:

- Calculated as change in water level from the highest measured to the most recent annual high.
- The most recent annual high measurement must be in the range 2016 – 2024.
- The most recent annual high can be measured in any month if it is shallower than the most recent January-May annual high.
- The highest measured can be measured in any month.

Groundwater Level Decline Rate:

- Calculated as Sen's slope (Sen, 1968).
- Decline rate only calculated for annual high measurements in the range 2016 – 2024.
- Minimum 4 data points required for inclusion in the analysis.

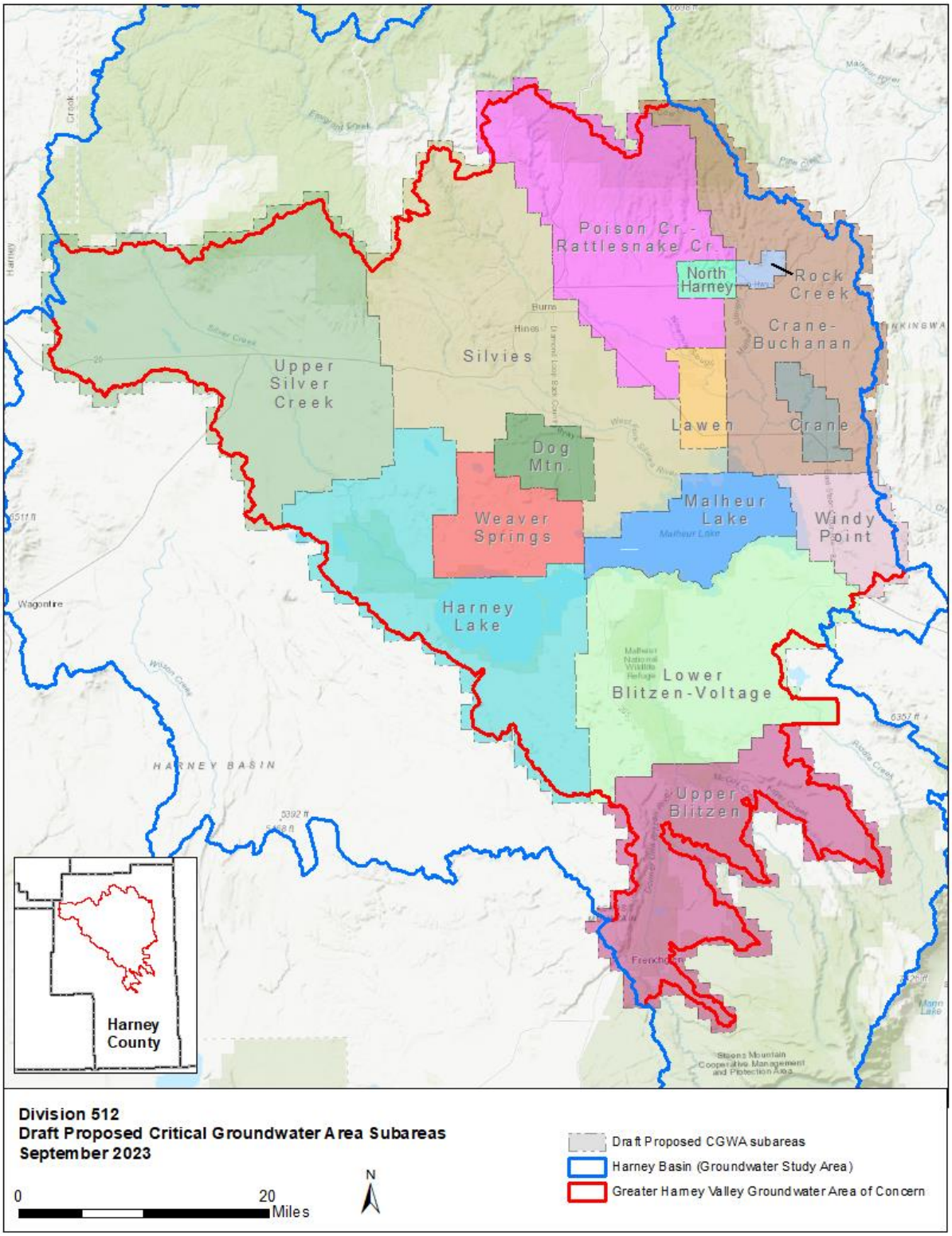

Figure 1: Draft proposed critical groundwater area subareas.

Summary Statistics of Groundwater Level Trends

Summary statistics for groundwater level trends can be used to evaluate the relative severity of groundwater level declines across the 15 proposed subareas. Table 1 provides maximum, minimum, average, and median values for groundwater level decline magnitude for each subarea and Table 2 provides maximum, minimum, average, and median values groundwater level decline rate for each subarea. A total of 424 wells are included in the groundwater level decline magnitude analysis, and 266 wells are included in the decline rate analysis.

Note: negative values presented throughout this document represent declining trends.

Table 1: Summary statistics of groundwater level decline magnitude by subarea. Negative values indicate a declining trend. (n= the number of wells for which decline magnitude could be calculated).

Subarea	Minimum Magnitude (feet)	Maximum Magnitude (feet)	Average Magnitude (feet)	Median Magnitude (feet)
Weaver Springs (n=68)	-116.9	0.0	-47.0	-48.6
Rock Creek (n=16)	-69.8	-0.5	-21.5	-19.1
Crane (n=26)	-68.8	-1.7	-22.5	-20.1
North Harney (n=9)	-66.8	-9.1	-35.9	-31.3
Crane-Buchanan (n=58)	-52.0	0.0	-14.7	-10.3
Lawen (n=23)	-51.7	-0.1	-18.5	-18.3
Poison Ck-Rattlesnake Ck (n=35)	-45.3	0.0	-10.9	-10.6
Lower Blitzen-Voltage (n=54)	-39.8	0.0	-4.9	-2.9
Dog Mountain (n=21)	-31.8	0.0	-15.4	-11.5
Silvies (n=37)	-29.3	0.0	-4.9	-2.6
Windy Point (n=15)	-26.0	0.0	-13.4	-14.2
Upper Silver Creek (n=32)	-23.1	0.0	-5.4	-3.5
Upper Blitzen (n=10)	-10.4	0.0	-1.6	-0.7
Harney Lake (n=18)	-9.3	0.0	-2.9	-2.5
Malheur Lake (n=2)	-1.0	-0.5	-0.8	-0.8

Table 2: Summary statistics of groundwater level decline rate by subarea. Negative values indicate a declining trend. (n= the number of wells for which decline rate could be calculated).

Subarea	Minimum Rate (ft/year)	Maximum Rate (ft/year)	Average Rate (ft/year)	Median Rate (ft/year)
Weaver Springs (n=34)	-10.5	-0.5	-4.7	-4.3
Lawen (n=16)	-7.0	0.4	-2.1	-2.2
Dog Mountain (n=19)	-5.5	-0.4	-1.9	-1.6
Rock Creek (n=12)	-5.0	-0.6	-3.1	-3.3
Crane (n=20)	-4.7	1.3	-1.2	-0.9
Upper Silver Creek (n=23)	-4.4	-0.1	-0.5	-0.4
North Harney (n=7)	-4.0	-0.9	-2.3	-2.2
Crane-Buchanan (n=40)	-3.8	4.9	-1.3	-1.4
Poison Ck-Rattlesnake Ck (n=20)	-3.0	0.7	-0.9	-0.8
Windy Point (n=6)	-2.2	-0.7	-1.1	-0.9
Silvies (n=26)	-1.1	0.6	-0.3	-0.3
Lower Blitzen-Voltage (n=27)	-1.1	0.4	-0.3	-0.3
Harney Lake (n=11)	-0.9	-0.1	-0.4	-0.4
Upper Blitzen (n=4)	-0.2	0.1	0.0	0.1
Malheur Lake (n=1)	0.3	0.3	0.3	0.3

The distribution of decline magnitude and decline rate values across the 15 proposed Harney Basin Critical Groundwater Area subareas is shown in Figure 2. These maps can also be explored interactively online on the Harney Basin Critical Groundwater Area Process Interactive Map.

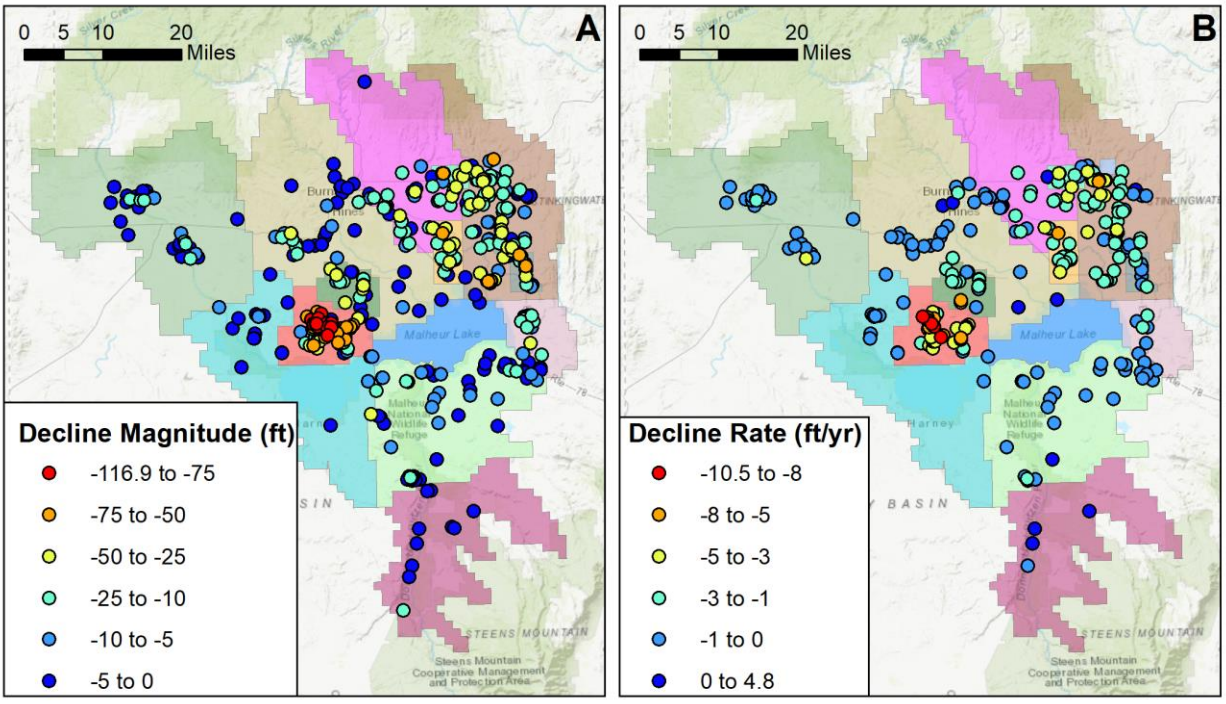

Figure 2: Maps showing the distribution of decline magnitude values (A) and decline rate values (B) across the proposed Harney Basin Critical Groundwater Area.

An important consideration when evaluating groundwater level decline magnitude data is the period of record over which the value was calculated, especially in areas where groundwater level declines have been occurring over a long period of time. The total magnitude of decline calculated for wells with a short period of record likely do not accurately reflect the true total magnitude of groundwater level decline for that part of the aquifer system. Wells that do not have recent annual high groundwater level data in the range 2016 – 2024 are not included in the groundwater level decline magnitude analysis. Wells with POR = 0 indicate that the most recent annual high measurement in the range 2016 - 2024 is the highest annual high measurement in the record for that well, in which case the change in water level from the highest measured to the most recent annual high is zero.

Table 3: Summary statistics for the periods of record used to calculate decline magnitude by subarea (POR = period of record). Wells with POR = 0 indicate that the most recent annual high measurement is the highest measurement in the record for that well.

Subarea	Minimum POR (years)	Maximum POR (years)	Average POR (years)	Median POR (years)
Silvies	0	63	12	6
Dog Mountain	0	62	14	7
Upper Silver Ck	0	61	13	5
Lower Blitzen-Voltage	0	60	9	10
Poison Ck-Rattlesnake Ck	0	59	12	8
Crane	1	55	21	15
Crane-Buchanan	0	50	11	8
Harney lake	0	48	11	6
Rock Creek	1	47	11	6
North Harney	4	46	22	22
Weaver Springs	0	45	13	9
Lawen	1	45	12	7
Windy Point	0	41	15	11
Upper Blitzen	0	39	7	2
Malheur Lake	1	7	4	4

The groundwater level trend data can also be evaluated graphically using box and whisker plots. A box and whisker plot, also known as a boxplot, is a graphical method of displaying variation in a set of data by showing how the data is distributed based on percentiles and identifying outliers. Any data value that is greater than 1.5 times the interquartile range, the difference between the 75th and 25th percentiles of the data (the Upper Quartile and Lower Quartile in Figure 3, respectively), is defined as an outlier. This is a standard statistical method for determining outliers in a box and whisker plot. Figure 3 provides an explanation of how to interpret a box and whisker plot. Figure 4 is a box and whisker plot showing groundwater level decline magnitude by subarea calculated as change in groundwater level from the highest measured to the most recent annual high measurement. Figure 5 is a box and whisker plot showing groundwater level decline rate by subarea calculated as Sen's slope. In both Figure 4 and Figure 5, negative values indicate a declining trend. Subareas are listed from left to right in order of increasing median value.

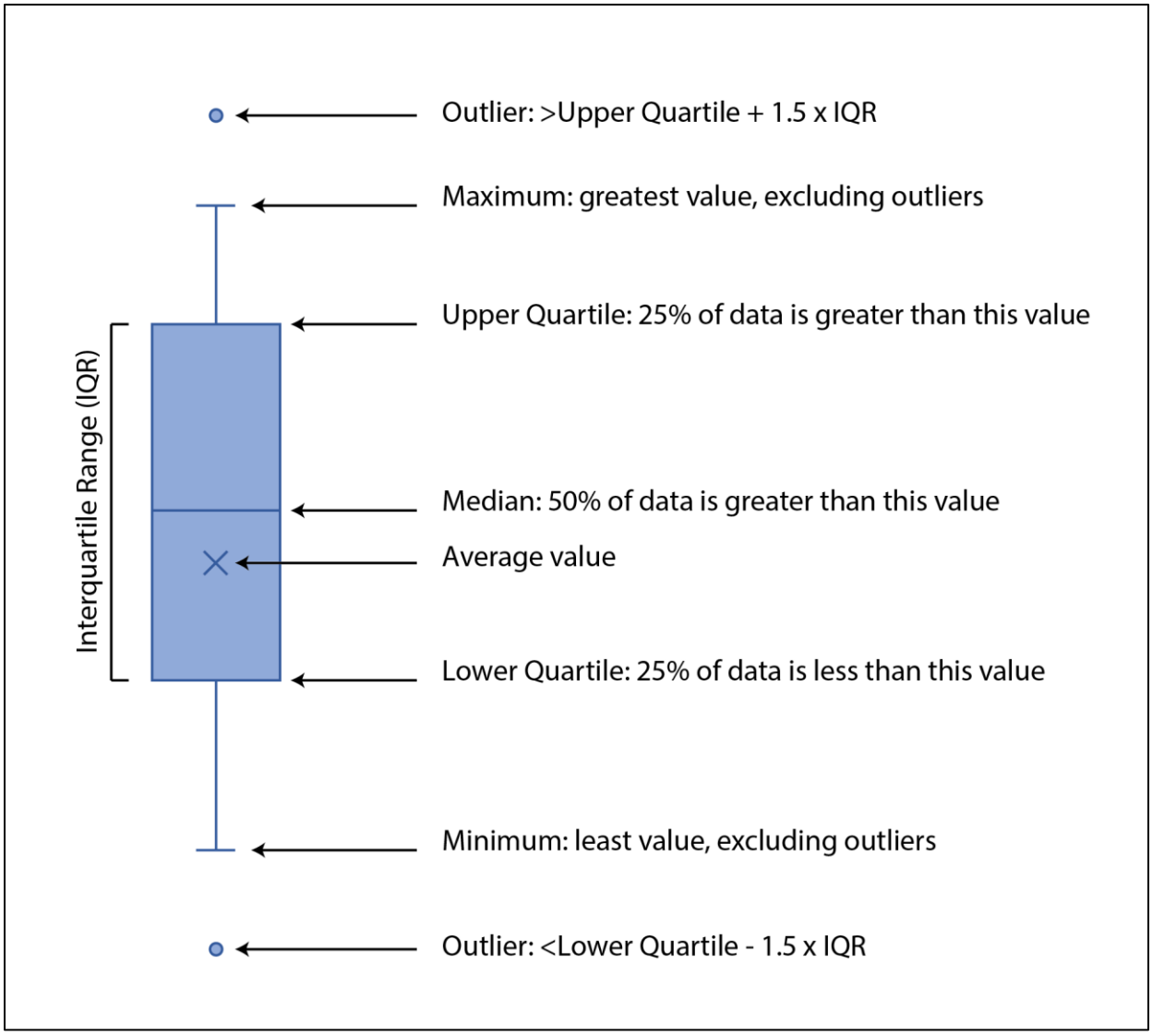

Figure 3: Explanation of box and whisker plots.

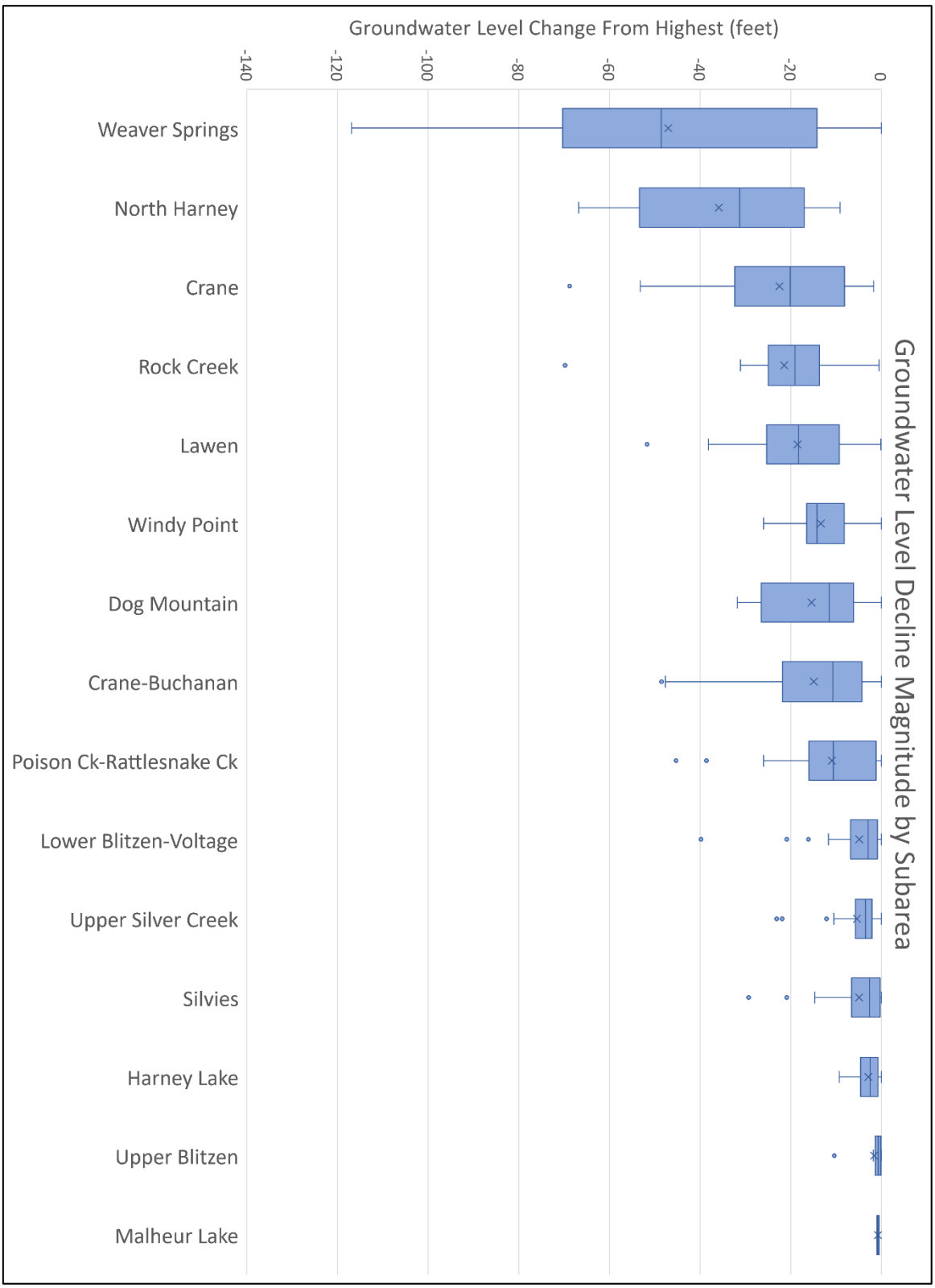

Figure 4: Box and whisker plot showing groundwater level decline magnitude by subarea. Negative values indicate declining trend. Subareas are listed from left to right in order of increasing median value. Number of wells per subarea noted in Table 1.

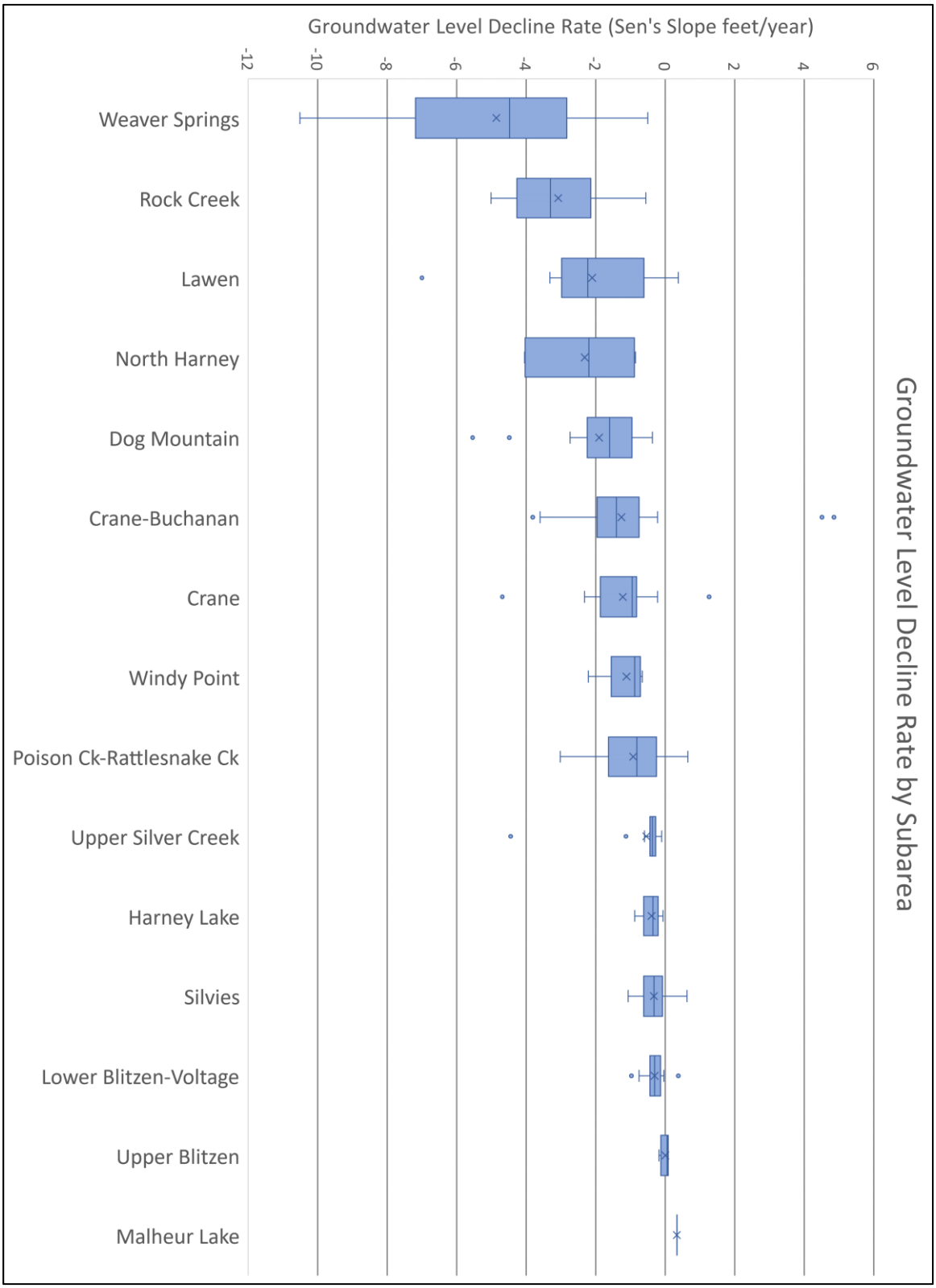

Figure 5: Box and whisker plot showing groundwater level decline rate by subarea. Negative values indicate declining trend. Subareas are listed from left to right in order of increasing median value. Number of wells per subarea noted in Table 2.

Other considerations

It is important to recognize that each individual well has a unique groundwater level record in terms of the overall period of record, frequency of measurement, and source of measurement. Additionally, each well has a unique well construction and well construction history. Well deepenings in particular can have a significant impact on the groundwater level record, particularly in areas with significant vertical hydraulic gradients. The data summaries provided here are a valuable tool for evaluating groundwater level trends across the basin, however for any individual well it may be important to review the specific groundwater level record and well construction history for that well to fully interpret and understand the calculated groundwater level trend metrics. The summary statistics provided here do not fully capture every unique situation, and in some cases may misrepresent the overall water level record for an individual well simply due to the unique characteristics of each well's measurement and construction history and the parameters specified for calculating the groundwater level trend metrics.

OWRD groundwater data links

Harney Basin Critical Groundwater Area Process Interactive Map:
https://experience.arcgis.com/experience/2db5f0d5e50142138304801e09b72fb7/

Groundwater Information System (GWIS):
https://apps.wrd.state.or.us/apps/gw/gw_info/gw_info_report/gw_search.aspx

GWIS Mapping Tool:
https://apps.wrd.state.or.us/apps/gw/gw_info/gw_map/Default.aspx

OWRD Groundwater Hydrographs:
https://apps.wrd.state.or.us/apps/gw/gw_info/gw_hydrograph/Hydrograph.aspx

Well Report Database:
https://apps.wrd.state.or.us/apps/gw/well_log/Default.aspx

References

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 p.

Sen, P. K., 1968, Estimates of the Regression Coefficient Based on Kendall's Tau. Journal of the American Statistical Association, 63(324), 1379–1389.

Appendix 1: List of wells used for the groundwater level trend analysis

1A. List of wells used for the groundwater level decline magnitude analysis

Crane

HARN0001061	HARN0001245	HARN0050804	HARN0050751	HARN0051237	HARN0051238
HARN0051004	HARN0051478	HARN0051846	HARN0052050	HARN0052064	HARN0001028
HARN0000991	HARN0000992	HARN0000994	HARN0050407	HARN0052111	HARN0001004
HARN0001006	HARN0002065	HARN0050201	HARN0000988	HARN0051076	HARN0051722
HARN0052520	HARN0052983				

Crane-Buchanan

HARN0000219	HARN0000986	HARN0000982	HARN0000985	HARN0000657	HARN0051587
HARN0051585	HARN0051701	HARN0051586	HARN0051584	HARN0051532	HARN0051931
HARN0051883	HARN0051932	HARN0052029	HARN0001020	HARN0052027	HARN0052001
HARN0052010	HARN0052011	HARN0051989	HARN0051925	HARN0051485	HARN0051552
HARN0000696	HARN0000726	HARN0050237	HARN0000621	HARN0051510	HARN0051015
HARN0051014	HARN0051589	HARN0051545	HARN0051549	HARN0051550	HARN0052031
HARN0051835	HARN0050178	HARN0050179	HARN0051013	HARN0050514	HARN0051890
HARN0052494	HARN0052502	HARN0052232	HARN0052063	HARN0051782	HARN0052049
HARN0052498	HARN0052746	HARN0052762	HARN0052760	HARN0051131	HARN0050790
HARN0000722	HARN0051205	HARN0052530	HARN0052757		

Dog Mountain

HARN0000844	HARN0050368	HARN0051332	HARN0001116	HARN0001117	HARN0050339
HARN0051409	HARN0051942	HARN0001125	HARN0052606	HARN0052629	HARN0052633
HARN0052518	HARN0052646	HARN0051707	HARN0052055	HARN0052696	HARN0052877
NLOG0057977	HARN0052225	NLOG0057978			

Harney Lake

HARN0001304	HARN0001085	HARN0052452	HARN0001309	HARN0050233	HARN0001084
HARN0001078	HARN0051086	MALH0002322	HARN0052022	HARN0052534	HARN0052599
HARN0052657	HARN0051010	HARN0052603	HARN0050497	HARN0051188	HARN0052913

Lawen

HARN0050789	HARN0050285	HARN0051276	HARN0052235	HARN0052234	HARN0051524
HARN0000960	HARN0000958	HARN0000959	HARN0051855	HARN0051972	HARN0051547
HARN0052428	HARN0051944	HARN0052215	HARN0051825	HARN0052490	HARN0052454
HARN0052456	HARN0052482	HARN0052624	HARN0052907	HARN0052927	

Lower Blitzen-Voltage

HARN0001363	HARN0001408	HARN0001477	HARN0001393	HARN0001461	HARN0001405
HARN0051886	HARN0051923	HARN0051070	HARN0051069	HARN0051764	HARN0001464
HARN0001472	HARN0001474	HARN0001482	HARN0001540	HARN0051382	HARN0001537
HARN0001467	HARN0001548	HARN0050507	HARN0050795	HARN0051611	HARN0001458

HARN0001459	HARN0051950	HARN0051848	HARN0001471	HARN0001460	HARN0050728
HARN0051387	HARN0050634	HARN0051875	HARN0001356	HARN0051800	HARN0051832
HARN0050151	HARN0001541	HARN0051892	HARN0051895	HARN0051894	HARN0050707
HARN0052616	HARN0051841	HARN0052507	HARN0052802	HARN0050318	HARN0001473
HARN0051849	HARN0052101	HARN0052617	HARN0052808	HARN0052801	HARN0052819

Malheur Lake

HARN0050719	HARN0051697

North Harney

HARN0050422	HARN0050362	HARN0051738	HARN0000198	HARN0052021	HARN0050766
HARN0000637	HARN0050460	HARN0052175			

Poison Ck-Rattlesnake Ck

HARN0000547	HARN0000607	HARN0000440	HARN0000441	HARN0051340	HARN0000503
HARN0001895	HARN0052035	HARN0050301	HARN0000901	HARN0051466	HARN0050515
HARN0051353	HARN0051405	HARN0051822	HARN0051917	HARN0051887	HARN0052032
HARN0051008	HARN0051922	HARN0000557	HARN0052604	HARN0052619	HARN0052620
HARN0052431	HARN0052142	HARN0052611	HARN0052792	HARN0051617	HARN0052233
HARN0052255	HARN0052524	HARN0052143	HARN0052697	HARN0052942	

Rock Creek

HARN0051275	HARN0000227	HARN0051823	HARN0051987	HARN0052189	HARN0052187
HARN0052708	HARN0052754	HARN0052789	HARN0052765	HARN0052767	HARN0052771
HARN0052770	HARN0000226	HARN0052827	HARN0052834		

Silvies

HARN0000323	HARN0000463	HARN0000813	HARN0000841	HARN0001979	HARN0051143
HARN0001936	HARN0051503	HARN0000812	HARN0000837	HARN0051327	HARN0000296
HARN0051734	HARN0051735	HARN0051736	HARN0051335	HARN0051622	HARN0051557
HARN0051613	HARN0052136	HARN0051797	HARN0051343	HARN0050891	HARN0052492
HARN0052416	HARN0050904	HARN0051651	HARN0051724	HARN0052685	HARN0051963
HARN0052602	HARN0051885	HARN0052485	HARN0051941	HARN0052748	HARN0052747
HARN0052749					

Upper Blitzen

HARN0001588	HARN0001611	HARN0001643	HARN0051017	HARN0050598	HARN0050612
HARN0050474	HARN0001603	HARN0052440	HARN0051040		

Upper Silver Ck

HARN0000755	HARN0000756	HARN0000260	HARN0000243	HARN0052102	HARN0050184
HARN0050192	HARN0051756	HARN0050958	HARN0000751	HARN0050381	HARN0050251
HARN0051921	HARN0051990	HARN0000754	HARN0001981	HARN0001903	HARN0001894

HARN0052118 HARN0052116 HARN0000255 HARN0052634 HARN0052626 HARN0052484
HARN0052495 HARN0052627 HARN0052628 HARN0052635 HARN0052717 HARN0052718
HARN0050936 HARN0053004

Weaver Springs

HARN0001990 HARN0051233 HARN0001094 HARN0050472 HARN0051146 HARN0051448
HARN0051445 HARN0051760 HARN0051765 HARN0051817 HARN0051605 HARN0051508
HARN0051259 HARN0050640 HARN0001348 HARN0051272 HARN0050887 HARN0051544
HARN0050315 HARN0050777 HARN0001096 HARN0050620 HARN0001318 HARN0051674
HARN0001098 HARN0001097 HARN0001323 HARN0001322 HARN0051784 HARN0001336
HARN0001335 HARN0050399 HARN0050734 HARN0050741 HARN0051693 HARN0051507
HARN0051720 HARN0001324 HARN0051871 HARN0051970 HARN0051904 HARN0051924
HARN0052169 HARN0051973 HARN0051767 HARN0052154 HARN0051761 HARN0051864
HARN0052631 HARN0052630 HARN0051836 HARN0052028 HARN0052121 HARN0052170
HARN0050950 HARN0051700 HARN0051694 HARN0052640 HARN0052004 HARN0051791
HARN0052639 HARN0052003 HARN0052807 HARN0052774 HARN0001319 HARN0051339
HARN0051603 HARN0052875

Windy Point

HARN0001387 HARN0002072 HARN0050236 HARN0051075 HARN0051154 HARN0051805
HARN0001414 HARN0001431 HARN0050040 HARN0001298 HARN0051837 HARN0051869
HARN0051610 HARN0001959 HARN0051443

1B. List of wells used for the groundwater level decline rate analysis

Crane

HARN0001061	HARN0001245	HARN0050751	HARN0051237	HARN0051238	HARN0051004
HARN0051478	HARN0052050	HARN0052064	HARN0001028	HARN0000991	HARN0000992
HARN0050407	HARN0001004	HARN0001006	HARN0002065	HARN0050201	HARN0000988
HARN0051076	HARN0052520				

Crane-Buchanan

HARN0000219	HARN0000986	HARN0000985	HARN0000657	HARN0051587	HARN0051585
HARN0051701	HARN0051586	HARN0051584	HARN0051532	HARN0051883	HARN0051932
HARN0052029	HARN0052027	HARN0052001	HARN0052010	HARN0052011	HARN0000722
HARN0050237	HARN0000621	HARN0051015	HARN0051589	HARN0051545	HARN0051549
HARN0051550	HARN0050178	HARN0050179	HARN0051013	HARN0051205	HARN0050514
HARN0051890	HARN0052494	HARN0052502	HARN0052232	HARN0051782	HARN0052049
HARN0052498	HARN0052746	HARN0052762	HARN0052757		

Dog Mountain

HARN0000844	HARN0050368	HARN0051332	HARN0001116	HARN0001117	HARN0051409
HARN0051942	HARN0051783	HARN0052606	HARN0052629	HARN0052633	HARN0052518
HARN0052646	HARN0051707	HARN0052055	HARN0052696	HARN0052877	NLOG0057977
NLOG0057978					

Harney Lake

HARN0001085	HARN0001309	HARN0050233	HARN0001084	MALH0002322	HARN0052534
HARN0052599	HARN0052657	HARN0051010	HARN0052603	HARN0052913	

Lawen

HARN0050789	HARN0050285	HARN0052235	HARN0052234	HARN0051524	HARN0051972
HARN0051547	HARN0052428	HARN0051944	HARN0052215	HARN0051825	HARN0052490
HARN0052454	HARN0052456	HARN0052482	HARN0052624		

Lower Blitzen-Voltage

HARN0001363	HARN0001408	HARN0051886	HARN0051923	HARN0050318	HARN0051764
HARN0001464	HARN0001472	HARN0001482	HARN0001540	HARN0051382	HARN0001537
HARN0001467	HARN0051611	HARN0050728	HARN0051387	HARN0050634	HARN0051875
HARN0051800	HARN0050151	HARN0001541	HARN0051892	HARN0051895	HARN0051894
HARN0052617	HARN0051841	HARN0052507			

Malheur Lake

HARN0050719

North Harney

HARN0050422	HARN0050362	HARN0051738	HARN0000198	HARN0050766	HARN0050460

HARN0052175

Poison Ck-Rattlesnake Ck

HARN0000547	HARN0000607	HARN0000440	HARN0000441	HARN0051340	HARN0000503
HARN0052035	HARN0000901	HARN0051617	HARN0051353	HARN0051405	HARN0051917
HARN0051887	HARN0052032	HARN0052604	HARN0052619	HARN0052620	HARN0052431
HARN0052611	HARN0052792				

Rock Creek

HARN0051275	HARN0051823	HARN0051987	HARN0052189	HARN0052708	HARN0052754
HARN0052789	HARN0052765	HARN0052767	HARN0052771	HARN0052770	HARN0000226

Silvies

HARN0000323	HARN0000463	HARN0000813	HARN0000841	HARN0001979	HARN0051143
HARN0001936	HARN0051503	HARN0000812	HARN0000837	HARN0051963	HARN0000296
HARN0051734	HARN0051736	HARN0051335	HARN0051622	HARN0051557	HARN0052136
HARN0051343	HARN0050891	HARN0051885	HARN0052485	HARN0052685	HARN0052749
HARN0052748	HARN0052747				

Upper Blitzen

HARN0001588	HARN0001603	HARN0051017	HARN0050598

Upper Silver Ck

HARN0000756	HARN0000260	HARN0000243	HARN0052102	HARN0050192	HARN0051756
HARN0050381	HARN0051921	HARN0051990	HARN0000754	HARN0001981	HARN0001894
HARN0052118	HARN0052116	HARN0052634	HARN0052626	HARN0052484	HARN0052495
HARN0052627	HARN0052628	HARN0052635	HARN0052717	HARN0052718	

Weaver Springs

HARN0001990	HARN0001094	HARN0050472	HARN0051445	HARN0051760	HARN0051259
HARN0050640	HARN0001348	HARN0001096	HARN0001335	HARN0050399	HARN0050734
HARN0050741	HARN0051693	HARN0051507	HARN0051720	HARN0051871	HARN0051904
HARN0051924	HARN0052169	HARN0051973	HARN0051767	HARN0051761	HARN0052631
HARN0052630	HARN0050950	HARN0051700	HARN0052121	HARN0052170	HARN0052640
HARN0051791	HARN0052639	HARN0052003	HARN0052807	HARN0052774	

Windy Point

HARN0001387	HARN0051805	HARN0001414	HARN0051837	HARN0051869	HARN0051610

Appendix 2: List of wells identified as needing further review

HARN0000106	HARN0000143	HARN0000246	HARN0000615	HARN0000645	HARN0000921
HARN0000967	HARN0000983	HARN0001014	HARN0001016	HARN0001019	HARN0001026
HARN0001118	HARN0001128	HARN0001274	HARN0001319	HARN0001384	HARN0001867
HARN0001913	HARN0001959	HARN0001961	HARN0002000	HARN0002056	HARN0002068
MALH0002323	HARN0050135	HARN0050194	HARN0050238	HARN0050406	HARN0050516
HARN0050633	HARN0050663	HARN0050936	HARN0051141	HARN0051291	HARN0051322
HARN0051339	HARN0051344	HARN0051351	HARN0051378	HARN0051408	HARN0051410
HARN0051473	HARN0051474	HARN0051475	HARN0051541	HARN0051542	HARN0051565
HARN0051573	HARN0051577	HARN0051588	HARN0051603	HARN0051604	HARN0051606
HARN0051637	HARN0051704	HARN0051770	HARN0051821	HARN0051830	HARN0051843
HARN0051847	HARN0051849	HARN0051859	HARN0051867	HARN0051941	HARN0051991
HARN0052007	HARN0052015	HARN0052048	HARN0052052	HARN0052168	HARN0052221
HARN0052225	HARN0052421	HARN0052469	HARN0052479	HARN0052504	HARN0052805